MEASURING THE CONTRIBUTION OF UNPAID OVERTIME IN THE GROSS VALUE ADDED OF UK INDUSTRIES:

An Assessment Using Data Envelopment Analysis and Statistical Methods

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Abstract

This dissertation attempts to measure the contribution of unpaid overtime in relation to UK industries (SIC codes)' economic output (Gross Value Added) for the period 2002-2012, based on data from the Labour Force Survey (LFS) and the Office for National Statistics (ONS). The study provides the different theoretical approaches of unpaid labour's definition, and more specifically those of mainstream economic approaches (eg. neoclassical) in comparison to the Marxist categories. Acknowledging that it is not always possible to construct Marxist variables with orthodox datasets, the dissertation uses the Marxist theory to attempt to explain the movement in the orthodox statistics. Unpaid overtime's effect on the UK industries' product (GVA) is not examined by wage-based approaches as the mainstream scholars and practitioners tend to do, but by an output-based one, using working-time as the measure of industries' contribution. In this attempt, both parametric (Statistical regression methods) and non-parametric approaches (Data Envelopment Analysis) are used in order to account for unpaid overtime's contribution to the UK industries product (GVA) as it is estimated by the orthodox statistics of Britain.

Keywords: unpaid overtime; Marxist Political Economy; neoclassical economics; surplus value; labour remuneration.

I dedicate my thesis to my late father, Dimitris, who left while this research was taking place

and

to my beloved son, Ares, who temporarily interrupted this research with his arrival bringing happiness and troubles to our lives!

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CONTENTS

LIST OF SYMBOLS/ABBREVIATIONS

BHPS:	British Household Panel Survey
BREXIT:	British Exit (from European Union)
BSD:	Business Structure Database
BUSHR:	Basic Working Weekly Hours excluding overtime
CAPCONS:	Capital Consumption
CP:	Current Prices
CS:	Citizenship Survey
CVM:	Chained Volume Measures
DEA:	Data Envelopment Analysis
DMU:	Decision Making Units
EU:	European Union
GCS:	Gross Capital Stock
GDP:	Gross Domestic Product
GFCF:	Gross Fixed Capital Formation
GLS:	Generalised Least Squares
GVA:	Gross Value Added
ILO:	International Labour Organisation
inecac05:	Economic activity (International definition)
IoP:	Index of Production
LFS:	Labour Force Survey
MRS:	Marginal Rate of Substitution
NCS:	Net Capital Stock
NVA:	Net Value Added
OECD:	Organisation of Economic Corporation and Development
OLS:	Ordinary Least Squares
ONS:	Office of National Statistics
overT:	Overtime Hours
OVRTME1:	the rate in which overtime is paid
PIM:	Perpetual Inventory Method
PIM-DEA:	Performance Improvement Management – Data Envelopment Analysis
QLFS:	Quarterly Labour Force Survey
SFA:	Stochastic Frontier Analysis
SIC:	Standard Industrial Classification
SIC03:	Standard Industrial Classification 2003
SIC07:	Standard Industrial Classification 2007
SIC92:	Standard Industrial Classification 1992
Translog:	Transcendental Logarithmic
TTUSHR:	Total Working Weekly Hours including overtime
TUC:	Trade Union Congress
UK:	United Kingdom
UKHLS:	UK Household Longitudinal Study
UN:	United Nations
VML:	Virtual Microdata Laboratory
VIF	Variance Inflation Factors

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INTRODUCTION

The debate regarding employees' remuneration and working hours is an ongoing one for decades. Many economists, practitioners, trade unionists, people in every country's government have analysed, implement, and fought for the one or the other theory of wages and its policy implication. This dissertation attempts to focus on one part of employees' life: the overtime hours and particularly those that remain unpaid.

According to Trade Unions Congress (TUC, 2018), 'over five million people at work in the UK regularly do unpaid overtime, giving their employers £31.2 billion of free work' for 2017. According to ONS (2018) the seasonally adjusted GDP for 2017 was calculated to be around £492.7 billion. In other words, the worth of unpaid overtime is equal to 6.33% of British GDP. This fact immediately rises questions on 'fair' pay of workers, income distribution and the length of working day.

However, answering the above questions economists provide completely different approaches not only in their policy suggestions, but also in the very definition and description of phenomena. Although, unpaid overtime seems to be a simple term to understand, economists disagree. What is considered to be unpaid and what is paid is still an object of dispute. In the science of economic analysis, the mainstream approaches and particularly the neoclassical school of thought do not recognise the term 'unpaid' labour, because ultimately everything is somehow paid. On the other hands, heterodox schools of thought and particularly the Marxist analysis argue that any capitalistically organised labour of dependent contract is partially unpaid. Of course there are so many other theories analysing the terms paid-unpaid differently. However, the focal point of this analysis is based on the Marxist assumptions.

Depending on the school of thought, there are respective methodologies that each scholar or practitioner follows. Wage-based and output-based approaches are the existing approaches for evaluating 'unpaid' activities (domestic labour, volunteering and unpaid overtime), with the former being more popular than the latter. Therefore, most scholars and practitioners (See TUC above) attempt to assign a wage for those activities that are unpaid. However, the aspect of labour productivity is most of the times completely neglected. Labour is not analysed with respect to the output it produces, and by output we do not mean the individual output of every worker but the aggregate output within a national economy. This dissertation is analysing labour with an output-based approach.

Additionally, because of the restricted information regarding the available data, this dissertation is focusing on the movements of data in orthodox (mainstream) statistics to interpret economic phenomena and categories as defined by the Political Economy tradition and particularly the Critique of Political Economy. These restricted data also did not allow us for a firm level analysis, but only for an industrial analysis. Therefore, the national statistics from ONS are decomposed to the industrial level as the minimum level that they can be decomposed, and the individual data from LFS are extrapolated to industrial.

Apart from that, acknowledging that industries are not homogenous units certain assumptions are made. In addition, in order to have a clearer picture of the qualitative features of industries, in various parts of our empirical analysis we group industries to Manufacturing and Services, and/or to Productive and Unproductive, taking also into account that the latter grouping is highly disputed. The outburst of 2007-8 crisis is also taken into account in every chapter.

Finally, Data Envelopment Analysis (DEA) is used as a non-parametric method to measure the Gross Value Added produced by labour and particularly the unpaid overtime. The results are also complemented by the use of Regression Analysis that as parametric one provides average values of labour contribution.

This thesis is structured in six different chapters. In Chapter 1, the philosophy and epistemology of dissertation are presented. The anti-positivist and anti-post-modernist stance of this research is originally outlined, because contemporary economic analysis is overwhelmed by these two streams. By the end of the Chapter 1, the philosophy of Dialectical Materialism is presented as the one based on which the thesis arguments will be. This Chapter in philosophy is essential because it highlights the importance of a structural and historical analysis of the data too.

In the Chapter 2, we can find the literature review of different topics. Since this research is an inter-disciplinary one, different topics need explanation. The first topic discussed is the working time and the main theories that are proposed in order to explain its patterns over time. The second topic discussed is the wage and the theories that are also proposed to explain its determination. Another topic that Chapter 2 is examining is the definitions of payment and non-payment according to one or the other school of thought. Additionally, the main literature of measuring ‘unpaid’ activities is analysed and also the theoretical and practical difficulties of the orthodox statistics when measuring labour and capital - that are presented later on - as economic categories that are used to describe the capitalist production. Moreover, the advantages and limitations of industrial research are also presented. In this part we give the definition of Productive and Unproductive industries with a Marxist approach.

In Chapter 3, there is a thorough presentation of data. The different datasets (ONS and LFS) are examined together with the limitations of the orthodox statistics. A fair description of the process that we followed in organising and clearing the LFS is outlined, and a short justification of our choice of variables are given. By the end of the Chapter 3, the descriptive statistics of the raw data (without removing outliers) are provided giving the reader an idea of the following analysis.

In Chapter 4, which is the biggest chapter of the dissertation, the Data Envelopment Analysis is conducted providing a lot of details regarding labour productivity of UK industries. The Chapter is divided in three parts. The first part analyses the Marginal Rates of Substitution (MRS) between labour and capital and focuses mainly on the contribution of labour as a total towards Gross Value Added (GVA). In the second part, we decompose labour into three components: basic working hours, paid overtime and unpaid overtime. We try to detect the MRSs between these kinds of labour and also discover each kind's contribution towards the GVA. In the third part of Chapter 4, we use a regression analysis of the target-input values (suggested by the DEA analysis) in order to see 'what would the contribution of each kind of labour would be if the industries were efficient'.

In Chapter 5, we present the Regression Analysis of our real data (not the target values) in order to see what the contribution of each variable towards GVA is. This part of our analysis contains all the inefficiencies that industries might have. Contrary to the DEA chapter that provided detailed values for every industry over the 11 years that examined, the Regression analysis provides an 'average' contribution for each labour variable describing all industries.

Finally, in Chapter 6, the discussion over the previously derived results is conducted. The comparison between empirical results and theory is taking place. Additionally, the comparison of DEA with Regression analysis results is also provided, and ultimately the main findings of this thesis are presented.

Chapter 1: The underlying philosophy

Table 1.1 – Outline of Dissertation's Philosophy, Theory and Methodology

DISSERTATION	Title	Key words
Economic Analysis	*Measuring Unpaid Overtime Contribution in UK industries output 2002-2012*	Unpaid Overtime, Working Hours, Political Economy, Labour Economics, Dialectical Materialism, Econometric Analysis, Data Envelopment Analysis
Ontology	*Materialistic*	Objective Reality Matter prior to spirit
Epistemology	*Dialectical Materialism*	*Knowability* of reality (Scientific Knowledge) Dialectics: i. the interpenetration of opposites ii. the transformation of quantity to a new quality iii. the negation of the negation Anti-Metaphysics Anti-positivist Anti-postmodernist
Methodology	*Historical Materialism*	<u>Structural Analysis – *Synchronic*</u> • Structural Analysis • Critical Deconstruction • Assessment of ideological underpinnings • Dialectically 'logical' construction of the history from the totalistic perspective <u>Historical Analysis – *Diachronic*</u> • Evolution of Structures with inner links • Not Exogenous History • Not random conjunction of events <u>Empirical Sources</u> • Critical use • Theory of the Critique of Political Economy explaining the movement in the orthodox statistics
Paradigm	*The Critique of Political Economy*	Labour Theory of Value Working Time Spheres of Production – Distribution - Exchange
Tools	- *Parametric* - *Non-parametric Approaches*	- Econometric Analyses (Pooled OLS, GLS) – Software: STATA 13.0 - Data Envelopment Analysis – Software: PIM-DEA
Context	<u>*Place:*</u> *UK industries* <u>*Time:*</u> *2002-2012*	<u>Databases:</u> Office of National Statistics Labour Force Survey <u>Focal Point:</u> Industries (*Standard Industrial Classification 2007)*

1.1 Political Economy or Economics: Unpaid overtime under the discipline of economic analysis?

The existence of unpaid overtime is an important problem not only for those that are subjected to it, but also for the discipline of Economic Analysis. Generally, the existing dispute over the epistemology, methodology and even axiology of the discipline of economic analysis has its implications on the phenomenon of unpaid overtime too. More specifically, the discipline that started as *Political Economy* and evolved/mutated to *Economics* are two different terms which vindicate the correct rendering of the science of economic analysis. *Political Economy* was established by Adam Smith (1776, *An Inquiry into the Nature and Causes of the Wealth of Nations*), extended by Ricardo and criticised by Marx. *Economics* on the other hand were introduced by Alfred Marshal (1890, *Principles of political economy*), substituting Political Economy. Although the notion of *homo economicus* by John Stuart Mill (1844, *Essays on some unsettled questions of political economy*) had paved the way much earlier for this subsequent substitution, Economics as a discipline rejected the main principles of Political Economy. However, Economics are not defined clearly. Backhouse and Medema (2009) in their paper regarding Economics mention that there is no single definition. However, in contemporary textbooks the definition is related to the study of economy, the process of coordination, the results of scarcity, the science of choice and the study of human behaviour. According to Jacob Viner[1] 'economics is what economists do', allowing a great variety of related issues with this kind of *circular reasoning* definition. The implication of such a vagueness in labour and productivity allows an analysis of overtime based on a range from physiological to a mode of production analysis.

The differences between *Political Economy* and *Economics* could be briefly summarised in their approaches regarding *methodological individualism* or *structural analysis* (classes, institutions etc), *individuals* or *classes, non-intended actions* or *historicity of economic laws* and construction of *economic categories,* the relationship between individuals with commodities *(subjectivity)* or *the social relations between commodities (objectivity),* the notion of *equilibrium* or the notion of *dialectical contradictions,* the notion of *price* or the notion of *value* and *the harmony of economic*

[1] Backhouse and Medema (2009) report the difficulty to find this statement in Viner's publications, but they mention a remark by Kenneth Boulding (1941, p. 1), a student of Viner's in 1932–3, suggests that it arose in conversation (Kenneth Boulding, 1941, Economic Analysis, Harper & Brothers; 3rd single edition, 1955 ;4th ed. part II, 1966)

systems or *the continuous war amongst them*. Therefore, working time and its remuneration, that are attempted to be analysed in this dissertation, are examined critiquing the mainstream and highlighting alternative scopes. However, the basic characteristic of the dispute between Economics and Political Economy may lie in the rejection of the *Labour Theory of Value*. Classical Political Economy and its Critique (Smith, Ricardo, and Marx) related the value of a good to the quantity of labour (already *embodied* or socially necessary *abstract*) to produce it (*objectivity*). However, the introductory of Economics (Jevons, Menger, and Walras) claimed that the value of a good is determined by its utility (subjectivity). In other words, according to Theocharakis (2005) the *Objective Labour Theory of Value* was replaced by the *Subjective Theory of Utility Value*. Consequently, an analysis over working time and the value produced etc is totally undermined in Economics. In other words, this Paradigm shift from Political Economy to Economics has an adverse effect on a complete analysis of working time and its remuneration too. This dissertation analyses unpaid overtime critiquing the main Paradigm and providing the Paradigm of Political Economy, especially its Marxist version.

> According to Kuhn (1962) paradigms are the achievements which
>
> '*sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity*' and which '*are sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve*'. In fact, they are 'accepted examples of actual scientific practice' which include '*law, theory, application and instrumentation together' and 'provide models from which spring particular coherent traditions of scientific research*'.

This shift of Paradigm in economic analysis lies in different ontological, epistemological, methodological and even axiological principles as mentioned above, having an impact on economic analysis over working time, overtime and the concept of unpaid labour.

1.2 Ontological and Epistemological issues with implications in working time analysis and productivity

In social sciences there are different theories lying in different ontologies and epistemologies. This research is based on a *materialistic* ontology, admitting that there is an objective reality regardless of subjective sensations. Thus, perceptions claiming that the world is an exteriorisation of mind are rejected. In other words, this dissertation neither denies the reality of an external world nor is run by the belief that consciousness is the ground of all beings. It is also opposed to the post-modernist approach that different explanations (by humans) can lead to different realities (eg as expressed in Heidegger, 1949.). The immediate implication of such an ontological perception is that subjectivity streams of thought like 'interpretivism' are rejected. Thus, being based on the materialistic ontology that objective reality does exist away from humans' conceptions, has its implications in the statement of economic issues as well, like in the contemporary phenomenon of unpaid overtime. Theories and methods that are used for analysing it and are based on subjectivist analysis are rejected. For instance, the amount of working hours in economy is not interpreted by individuals own subjective world views (*gift exchange, signalling theory* etc), but it is aimed to be analysed by the objective causes that rule this economy[2], such as productivity, profitability etc.

For instance, this principle is reflected in Marx and Engels's (1969) contribution regarding economic relations *(Contribution to the Critique of the Political Economy, Selected Works, Vol. 1)*:

> *'Just as our opinion of an individual is not based on what he thinks of himself, so can we not judge of such a period of transformation by its own consciousness; on the contrary, this consciousness must be explained rather from the contradiction of material life, from the existing conflict between the social productive forces, and the relations of production.'*

Moreover, analysing facts on a materialistic ontology comes to a contradiction with some post-modernist perceptions (ruling the contemporary economic analysis too) claiming that reality might exist but this is irrelevant to humans. In other words, how humans behave is not related to the external environment. Particularly, in economic analysis there are approaches admitting the existence of real and general economic factors -that can affect eg. working time and its remuneration- but there are totally ignored when analysing the phenomenon of unpaid overtime [Bell et al. (1999, 2000), Anger (2008) etc, For more details see Papagiannaki (2014)] because they are seen as irrelevant. However, this research does project that there are no *externalities* of that kind, and that economic environment does not just affect individuals' behaviour externally, but the two different levels of analysis – *individual* and *general economic* - are intactly united. For example, whether individual workers 'choose' to signal or exchange gifts with their employers by

[2] Accepting individuals' subjective world views should not to be confused with the importance of qualitative approaches in the production of scientific knowledge.

working unpaid overtime is totally linked with the objective prevailing mode f production (capitalism) and the labour processes [eg. post-Fordism, Van Echtelt, et al. (2007)] in production and the falling tendency of industries' rate of profit.

Epistemology or philosophy of science could be defined as 'the section of theoretical researching on nature, content or other aspects of mental activity' (Liodakis 1992). Epistemology is usually conceived as science of sciences. Regarding the more specific epistemological categories, *knowability* is a basic requirement for the following analysis to be valid. That is to say that there is a human ability of knowing reality. Unlike various streams of thought in academia and more specifically in social sciences that deny the existence of this ability this dissertation perceives knowledge as 'the product of theoretical practice' (Bukharin 1931).

However, this research among the various kinds of knowledge that one can propose accepts only the scientific knowledge as its only valid form. This statements comes to oppose to any kind of metaphysical speculation. Science is considered as a product of human society rejecting its abstraction from the social and historical circumstances in which it develops. Science is not what scientists do, but it has intact link with the grounds t flourishes. On the other hand, most Marxists do not adopt the view that science is merely a social construct. In other words, science, which is regarded as the systematic human effort to understand and transform reality and consists of the only means of perceiving reality away from beliefs and imagination [Marx (1975), Murray (1988), Sheehan (2018)]. The immediate implication of such a principle lies in the relevant 'trust' in statistics and data collection as means of knowing the reality. Therefore statistics are not regarded as inappropriate means of analysing reality.

Although there are a lot of approaches within materialistic ontology (positivism, objectivism, realism etc) this thesis is based on *dialectical materialistic* epistemology. In addition, the tool for pursuing this scientific knowledge, that this dissertation is trying to achieve, is provided by what is known as *Dialectics*. Dialectical logic comes to a contrast to the method of formal logic, urging us to identify contradictions in every phenomena. Particularly, the three principles: i. *the interpenetration and struggle of opposites*, ii. *the transformation of quantity to a new quality* and iii. *the negation of negation* (Engels 1877). are the consisting principles of *Dialectics*. These principles are applicable in both nature and society. Dialectical logic can be A≠A, contrary to formal logic where A=A and A≠-A.

To begin with, the first principle of dialectics is the *interpenetration and struggle of the opposites*. Based on this principle, every phenomenon – natural or social – is ruled by an interpenetration of its inner among each other. For instance, there is a unity and a struggle between the economic *intensions* and *economic* outcomes. They are both united because the intentions define the outcome and the desirable outcome leads the intentions. For example, if the majority of individual capitalists intend to have higher profits, they will occupy their employees for longer hours. Intensions and economic outcome are also united in the reverse way; if their outcome is increased profits, this might lead to a reduction in working hours in order to preserve the efficient labour productivity that led to these profits. However, there is a struggle between intensions and outcomes too. As a class, capitalists want the working day reduction because it leads to increased labour productivity, but the competition among them urges for an increasing working day, and thus lowering labour productivity (Saad Filho 2002). And the latter consists of a struggle or a contradiction between the two united categories. The interpenetration of the opposites is also a basic principle that prevents this dissertation from adopting the assumption in neoclassical economics that the group, industry or national level is a mere aggregation of individuals. But class is not a mere aggregation of individuals: Based on the above example, all individuals do A, but as class want –A. So aggregating is not 100 As is not 100A. It can be A+(-A)=0. This can be also explained by Game theory, and more specifically Prisoner's dilemma. A possible implication of such a principle is the difficulty in aggregated production function from a firm to a national level.

Moreover, the second principle of dialectics, *the transformation of quantity to a new quality,* can be also applicable to economic analysis. In other words, Sticking with the abovementioned example about working time, a typical application of transformation of quantity to new quality is the case of the working day's extension. During an average working day, the quality of labour from the 3rd to the 4th working is quite possible that does not change. However after being occupied 9 hours, the quality usually changes. Thus, moving from the 9th to the 10th working hour, labour productivity is lowered. Therefore, this amount of extra working time has been established as overtime, representing a different lower quality of labour product. And this is how transformation of quantity (amount of working hours) to new quality (overtime labour) can take place too. This principle is important because, it does also reject the mainstream economic analysis that tends to examine working hours as inputs of the same quality. Moreover, neoclassical economics analysis rejects the existence of history as qualitative changes. They do perceive history as a mere order of different units of time. Thus, crises (new quality) – that this dissertation takes into account - are just random events and do not represent an accumulation (quantities) of production's contradictions the previous periods. In other words, crises are not random events in some sequential order but cumulative effects of previous economic periods, expressing contradictions in production. In this dissertation, changes in capital and labour that are different from the previous periods are examined not as a mere sequence but as 'pauses' and 'bursts' of the same economic phenomena within a historical framework.

Regarding the third principle, *the negation of negation* or what is called *thesis-antithesis-synthesis/new thesis*, it is the climax of the dialectics laws. This principle means that every phenomenon, due to its interpenetration of the opposites and due to the transformation of quantities to new quality, contains forces that negate itself again and again. For instance, during the 19th century the working day was unspeakably long due to the structure of production and the needs of the 'young' capitalism (*thesis*). However, this fact was negated by the observed general reduction in working hours globally in early 20th century due to the Fordist method of production (*antithesis*), while the latter has been *negated* by an increase in working hours especially after 70s decade due to the Post-fordist processes of production (*synthesis/new thesis*). This principle is also important since it rejects the dominant view in economic analysis regarding change in different systems, different labour processes, and periods [see Boettke (1996)]. This principle is also important since it does not consider exogenous factors (eg crisis as exogenous event), but instead it incorporates everything in a net of evolving contradictions.

Consequently, due to the materialistic ontology and the dialectic epistemology, the research 'paradigm' that this dissertation is attempted to be based on is *Dialectical Materialism*. Dialectical materialism that is expressed in a series of works including the Critique of Political Economy (as expressed in *the Critique of Political Economy, The Capital, The Civil War in France, The eighteenth brumaire of Louis Bonaparte, Anti-Durhing*) does not subtract science from reality. However, this stream of epistemology is not very popular in contemporary research in economic analysis, since *positivism* and *post-modernism* are the dominant ones in contemporary research in social sciences. However, a lot of outstanding scientists tend to adopt this dialectical materialism's principles 'sub-consciously' or 'spontaneously' without necessarily being aware of it.

1.3 Anti-positivist approach regarding working time and labour productivity

Based on David Hume's principles, *positivism* is the epistemological approach that empirical research based on sensorial data can be the only source of scientific knowledge. According to positivists any objective reality independent from sensors is rejected. Thus, an assertion can be regarded as scientific (empirically) valid if it can be confirmed by inductive methods or inference (Hume et al. 1739). Our scientific sensors (tools and methods), that are always developing and still historically and technologically restricted might not be able to generate a uniform measure of man-power working hour so far. Allowing for science's progress, in the future these sensors will be less restricted. Therefore, for the time being we have to assume that a shoe needs 2 average productivity working hours. In the future we would not need this assumption, but some more complicated (than today) calculations. From a Marxist perspective, 'average' productivity can be tested on a macro level, contrary to Ricardian arguments that claim the opposite (ie. only in micro can be tested with accuracy). Moreover, this perception does not seem to be concerned with examining the ontological background of these particular empirical data, whose validity is supposed to be unchallenged. For instance, what is considered as capital in orthodox economics and statistics is highly debatable. Therefore, the capacity of these data to interpret economy can also be challenged.

Additionally, data on working time were extremely rare and inaccurate for modes of production before capitalism (eg feudalism or slavery-based economy) This should not prevent anthropologists, historians, political economists from making speculations and constructing theories based on their restricted information. Particularly, when examining an era where 'working time' does not consist of a concept, or at least is not defined as strictly as today. Especially in slavery-based economy, all day could be a working day mixed with the 'personal' time of the slave.

Moreover, an exogenous relation between science and reality is one of the main positivist principles. During first decades of 20th century, positivism was the philosophy of sciences which commands that science's relations with reality is exogenous or parallel, maintaining the subject-object dichotomy, as the typical positivist -perception. An economist should be completely independent o the question. In other words, the subject (researcher) is perceived as something outside the sphere of reality (outside any social determinism (Glinos 1982). In other words, if science and reality are subtracted then the timing and the way that a theoretical problem arises depends on when and how the relevant event appeared in real life.

This exogeneity is also reflected in positivism's analysis on phenomena, inherent to a specific system. In economic analysis, this exogeneity leads the mainstream analysis (*Economics*) to perceive themselves as objective observers. They actually reject the link of the subject-economist with the current system of economic relations-reality (eg. capitalism), and project themselves as objective away from any socio-political influence. This is why in mainstream economic analysis of working time is examined away from historical and socio-political conditions (falling rate of profit, labour processes, class conflict etc), but merely as a result of technically economic decisions, eg. substitution and income effects in working time preferences, non-optima bargaining outcomes etc.

Apart from these, positivism that embraces the main stream in economic analysis tends to reject causalities. In other words, phenomena tend to be examined based on events 'constant conjunctions' (Hume 2000), rather than due to their innerly generated causal relation. For instance, although there has been attempts to attribute different causes to the phenomenon of unpaid overtime (for increasing future earnings, as Pareto improvement, as human capital acquisition ect), the generating force that makes this phenomenon permanent appearance in a series of different countries, industries, cultures etc in a specific historical time fails to be revealed with positivist analysis. More specifically, output and profit tendencies have been totally overlooked as the permanent generating forces contributing to the existence and increase of the phenomenon unpaid overtime.

Although Karl Popper proposed a change in sciences' methodology in the first part of the 20th century by criticising positivism and introducing 'Critical Rationalism', there are still significant limitations in his work because of his still strong links with the positivist methodology. Popper criticised Hume's arguments of not proving that a theory cannot be refuted by observation. More specifically, the positivistic *verifiability criterion* that maintains that a statement must, in principle, be empirically verifiable in order that it be both meaningful and scientific was substituted by the *falsifiability criterion* (Popper 1959) where an assertion or a system is possible in principle to establish that it is false. Thus any assertion immune to its refutability belongs to metaphysics. However, Popper is not as distinct from positivism as presented due to a series of positivistic epistemological principles defining his approach. For instance, according to Popper the fact that a scientific proposition must be at least in variance with observation in order to be rejected or not, puts to the epicentre again the existence of sensorial data.

However, both the verifiability and the falsifiability criteria are regarded as formalistic and their validity appears to be historically determined (Naletov 1984, Bitsakis 1987). In other words, the tools and methods that have been historically developed at each specific stage restrict the phenomena that can be rejected or not. For instance, stating that 'unpaid overtime is not proved to have any contribution to industries output because of its high collinearity with 'normal' working hours', betrays the current level of development of statistic methods. Allowing some time for historical progress in the science of statistics or other methods might enable unpaid overtime's contribution. If it was not for other methods and techniques, eg. Data Envelopment Analysis and efficiency studies, highly correlated categories could not be analysed within the framework of existing statistics. Therefore, this dissertation addresses a similar critique to the above-mentioned towards Popper's epistemology too.

Generally, positivism and the streams related to it contributed massively in separating the discipline of economic analysis from the rest of social sciences. Highly and only mathematical version of economic analysis are regarded as scientific, failing to incorporate the strong and contradicting dialectics of reality. Consequently, the previously mentioned substitution of Political Economy from Economics was mainly facilitated by positivism as the prevailing 'paradigm' in sciences.

1.4 Anti-post-modernist approach regarding working time and labour productivity

However, the discipline of economic analysis and its constituting theories have been defined also by the late 20th century's developments in methodology of social sciences, especially by the work of Kuhn's analysis regarding science. Kuhn claimed that *science* is both *exogenous* to reality and its *non-accumulative* in nature. Contrary to Popper who believed that science evolves linearly, Kuhn argued that it evolves in waves, reflecting the current developments of quantic physics the previous period. In other words, Kuhn's work encompassed a substantial contribution regarding sciences' evolution. Moreover, another difference to Popper's approach is related to 'impersonality' of science that the former proposes. However, Kuhn attributes a 'human element' in his analysis. He claims that the evolution of science cannot be seen outside by its subjects, the scientific community. Thus, Kuhn's opposition to the possibility of objectivity was one of the characteristics of his work. Kuhn's idea can be summarised actually in the sentence 'that our experience of the world is radically conditioned by our theories, which in turn depend on the paradigm' according to Sohal (2010, p.192). Consequently, contrary to the assumption of the independent observer, we have the assumption of a scientist 'politicised' in favour one or the other school of thought.

Although, these perceptions appeared to be opposites, their similarities towards the separation of science and reality (see *exogeneity* above) rule their epistemology. Kuhn's analysis due to its emphasis on the subjects of science paved the way for forthcoming theories of philosophy that regard science merely as subjects' (scientists) construct. Moreover, *postmodernism* that has overwhelmed social sciences, are not only rejecting previous philosophical principles of modernity in total, but also rejecting any universal analyses favouring 'shorter' explanations. Although the post-modernist tradition originates from the disappointed French radical scholars (Foucault, Derrida, Lyotard etc) in late 60s, Kuhn's approach was stated a decade earlier, can be claimed that facilitated the spread of post-modernist approaches and provided a means for social scientists to skip hard philosophical inconsistences in their theories.

Post-modernists main claim can be summarised in the sentence that there cannot be objective criteria for assessing the truth. Post-modernists perceptions vary from the total rejection of reality (as an existing category outside a human mind) to the claim that even if reality exists it is irrelevant to humans (See above). The claim that different explanations shape different realities (Mavroudeas, 2006) is important in economic analysis, since *material relations* are downgraded to the degree that only *discourse* plays an important role. Thus, narratives in economic analysis can be easily subtracted from economic reality. Neoclassical economics have been criticised by a lot of post-modernists, the former's currently prevailing *paradigm* adopts principles of the later, such as science's exogeneity, sorter narratives, and methodological individualism etc. In case of unpaid overtime, this trend is reflecting in explanatory theories, such as unpaid overtime as a signalling device according to Anger (2008) or as gift exchange according to Bell et al. (2000).

1.5 Methodological issues in working time and labour productivity analysis

Methodology could be defined as 'the process of research and choice of theoretical categories, analytical relationships and ways or methods of organising scientific research aiming the advancement of scientific knowledge' (Liodakis 1992). Alternatively, methodology could also be perceived as 'the choice of mind-generated categories and methods of organising research' (Liodakis 1992). Both positivist and post-modernist methodology will be avoided in this dissertation. However, some terminology of the two abovementioned streams will be used for explanatory and comparison purposes.

The forthcoming economic analysis's is attempted to be a *historically materialistic* approach, as expressed by Marx, especially in the famous three books on France (*The Civil War in France, The eighteenth brumaire of Louis Bonaparte*). Historical materialism can be summarised as the methodology that is based on historical (*diachronic*) and structural analysis (*synchronic*) using empirical sources as well, while it is ruled by the previously-mentioned dialectics. According to Godelier (1973, p.278-279), synchronic analysis sets out

> '*what elements of ... (a) system are and what their relations are at a given time (t) in the evolution of ... (the) system*' and diachronic adds '*how these elements and their relation have been formed during (dia) the time that this system has lasted*'.

For instance in economic analysis, studying the meaning and the importance of working time in capitalism belongs to *synchronic* (*structural*) analysis, while studying its evolution from feudalism, through capitalism, to socialism belongs to *diachronic* (*historical*) analysis. Although, this dissertation is not concerned with such massive periods of time, the study of working time trends in Britain before and after the outburst of the ongoing economic crisis is one example of synchronic and diachronic analysis.

The historical materialistic methodology is distinct from a positivistic notion of science, since it recognises structural causalities in each phenomena and does not examine them as a mere sequence of events. For instance, in neoclassical economics working time is detached by the laws of production and becomes merely a matter of individual preferences. Therefore, the increasing general tendency of working hours after 70s is attributed to (random) individual choice, and not to the dominant labour processes of that period, eg. Post-Fordism. Or a change in the working time pattern is regarded by neoclassical economics as a merely different pattern, and not as changes in structures of capitalism.

1.6 Structural analysis – Synchronic of working time and labour productivity

Contrary to the current neoclassical analysis, historical materialism gives particular emphasis on studies over structure as mentioned above. Claiming that there are no structures but only individuals or agents, post-modernism reinforced the assumption of methodological individualism in economic analysis. Therefore, 'social interactions' that Political Economy has originally proposed have been downgraded to 'interactions between individuals' (Arrow, 1994). More specifically, according to neoclassical economics, there are three central assumptions according to Weintraub (1992):

> *'i) individuals have rational preferences between outcomes that can be identified and associated with values ii) Individuals maximize utility and firms maximize profits iii) People act independently on the basis of full and relevant information'.*

In the case of unpaid overtime, most neoclassical theories claim that unpaid labour either does not exist or that is workers' own choice, subtracting the phenomenon completely from the conditions that generated it (short narratives, no structure etc). However, since this dissertation is based on the historical materialism adopts the below steps regarding the synchronic part of this methodology as described by Harvey (2012):

> '• *Analysis of structure* (eg. unpaid overtime as part of capitalistic production analysis and labour processes)
>
> • *Critical deconstruction* (eg. Deconstructing neoclassical theories on unpaid overtime)
>
> • *Examination to assess ideological underpinnings* (eg. The neoclassical theories regarding overtime imply that it should not be paid)
>
> • *'Logical' (re)construction of the history from the totalistic perspective* (eg. unpaid overtime as part of total unpaid hours, necessary requirement for capitalism to reproduce).

Therefore, historical materialism as expressed in the Critique of Political Economy analyses workers' wage as a result of the interpenetration of the *forces* and the *relations* of production over time.

Moreover, by rejecting *methodological individualism* it is implied that this dissertation also rejects the axiom that groups are a mere sum of individuals. Bringing individuals together is leading not to a mere increase of the numbers that the group is comprised from, but to a new quality and new features. Even 19th century anthropological developments had rejected this perception; Homo sapiens became a human with social substance due to a new conscious activity that no other creature did: the labour. Therefore, bringing humanoids together does not just increase the group of humanoids, but literally transforming them to a new kind, the kind of homo sapiens.

Especially through history's progress, in capitalism where the widespread socialisation of labour took place for first time, as large groups of workers came together in production, created new conditions in human interaction; workers as a newly formed class included social demands in their agenda, rather than individual desires. In cases, they even sacrifice their individual interests to achieve their collective goals; e.g. in strikes they may sacrifice their daily (or weekly, monthly etc) wage to prevent their colleagues' dismissals. Numerous are the examples of pro-social, altruistic behaviour and collective actions.

1.7 Historical analysis – Diachronic of working time and labour productivity

The previously presented *synchronic* analysis of tracing the inner link of phenomena is leading to the *diachronic* part of historical materialistic methodology. As it has already been mentioned, this diachronic analysis concentrates on the evolution of specific concepts within the structural whole. For instance, working time tendencies are regarded as an evolving category in the structural totality of modes of production. Moreover, diachronic analysis also focuses on the way certain elements develop their relations with other elements, rather than on the complex totality per se. In the same example of working time, it is not only its evolution through the totality (mode of production), but also with its remuneration as an outcome of balance of forces and its variation through different labour processes.

Generally, based on this methodology history is not regarded as an exogenous factor to economic analysis or sequential conjunctions, but as the 'conscious product of historical movement' (Marx, *Poverty of Philosophy*). This principle is important because the mainstream in economic analysis, the neoclassical economics do not consider history as endogenous factor in economic analysis. Different economic systems are not recognised; capitalism and feudalism do not have different laws. Even different stages within a system are not accepted; capitalism has passed from its competitive stage (machinofacture, manufacture and industrial period) to its monopolistic stage (imperialism). Accordingly, history is seen as a mere progression of time where individuals maximise their utility or their profits. Thus, crises are not regarded as the accumulation of quantities leading to new qualities. Usually the new qualities are either different stages in capitalism (competitive to monopolistic) or different labour processes within the same stage of capitalism (Fordism to post-Fordism). This is the reason that this dissertation examines unpaid labour over the years and the on-going crisis. Overtime and working time tendencies cannot be examined out of the historical context and empirical results should be interpreted accordingly. Therefore, labour processes are also part of the explanations provided in the following data analysis.

In this case, the historical period that unpaid overtime appears (since 70s) more persistently, it is characterised by many scholars of the Critique of Political Economy as an adverse period for the forces of labour. In other words, for different reasons, labour is found itself in an adverse period where a series of working rights are lost, including a proper payment for overtime hours, ending up being a temporarily historical 'symptom'. Consequently, the fundamental unit (labour remuneration) has been broken down revealing its essential nature (balance of forces between capital and labour), and thus the structure over time is the evaluation of this construct (synchronical to diachronical).

1.8 Empirical Sources on working time, unpaid overtime and labour productivity

Gathering empirical sources for unpaid overtime becomes quite difficult, since these data are quite restricted. Despite this restriction, this dissertation as it has already been mentioned does make a full use of any available empirical sources. Particularly, the Office of National Statistics and the Labour Force Survey are the main datasets that are combined for this research. As it has already been described above, existing data and observations are usually restricted both by the *available techniques and tools* but also from the *underlying ideology* of statistical services and the law-makers. In other words, detecting unpaid overtime is something neither legal nor illegal. The British law regarding working hours is too flexible to establish a normal working day. Thus the underlying ideology of '*flexicurity*'[3] regarding working time restricts the availability of this kind of data. Moreover, the techniques for detecting this 'ambiguous' phenomenon are not fully developed. For instance, there is no 'objective observatory' or a national census to record unpaid overtime, but only the Labour Force Survey covering a small fraction of the British

[3] Flexicurity, a combination of flexibility and security. The term was first introduced by the social democratic Prime Minister of Denmark Poul Nyrup Rasmussen in the 1990s

employees who subjectively respond for themselves making an estimation on the extra unpaid working hours they perform only according to the already blur legal framework. Consequently, the empirical sources are indeed taken into consideration without deifying them as the unique way of approaching science.

Therefore approaching 'with responsibility' and critically the existing resources, informing them structurally and historically is the main way that they are used in this dissertation. Although, the existing data are not enabling us of ‘constructing’ adequate categories and variables based on the Critique of the Political Economy (Marxian analysis) that are in accordance with the previously described philosophy, at least for an industrial level analysis, the dissertation is following Dunne’s (1991) suggestion regarding the use of data. More specifically:

> *‘(i) researchers can attempt to measure Marxian categories directly*
> *(ii) orthodox data could be adjusted to make it closer to the required Marxist categories*
> *(iii) we can use Marxist theory to attempt to explain the movement in the orthodox statistics*.’

Because of the difficulties that will be further described, this dissertation is using the third approach to the existing evidence. Thus, based on the fact that the context of this study is the UK economy, the statistical databases that are going to be used are the Office of National Statistics and the Labour Force Survey. The focal point of the dissertation is the UK industries based on the Standard Industrial Classification Code 2007 (SIC07) for the period from 2002 to 2012, containing 5 years from the outbursts of the ongoing economic crisis in 2007.

Chapter 2: Unpaid Overtime: Theories, Definitions, Measurement & the Industry

Table 2.1 – Literature Review Outline

CHAPTER 2: LITERATURE REVIEW	Unpaid Overtime: Theories, Definitions, Measurement & the Industry	Working Time, Unpaid Labour, Unpaid Overtime and Different Ways of measuring labour's contribution
Theories	*Working Time: Objective Needs or Subjective Preferences? The case of overtime*	• Working Time: Subjective Theory of Utility Value OR Objective Theory of Labour Value? • Commodification of Labour? The Theory of Surplus Value. • Working Time & Unpaid Overtime: Individual preferences or History and Labour Processes? • Workers' remuneration and working time: defined by production or distribution?
Definition of Unpaid Overtime	*Issues with defining unpaid overtime*	• European Working Time Directive • Flexicurity • British Legal Framework
Measurement	*Critical review of the different approaches of measuring the economic activities*	• Wage-based approaches: The opportunity costs approach The market replacement cost • Output based approach
Industrial Analysis	*Industrial analysis of Unpaid Overtime*	Advantages of an industrial level analysis Dealing with issues of industrial level analysis • Capital Controversies • Can an aggregate production function be assumed? • Technological change issues Productive–Unproductive Labour and Productive–Unproductive Industries

This chapter is analysing a wide range of issues related to unpaid overtime. Having provided the philosophy that this research is based on, a critical review of the assumptions and arguments that the existing literature on working time and unpaid overtime will be originally presented, followed by a description over the difficulties of defining unpaid overtime. To continue with, an analysis on an inter-industrial level will be also provided. By the end of the chapter, the various ways of measuring 'unpaid' economic activities will be presented too.

2.1 Working Time: Objective Needs or Subjective Preferences? The case of overtime

2.1.1 Working Time: Subjective Theory of Utility Value OR Objective Theory of Labour Value?

To begin with, the Classical political economy (reflected in the works of Smith and Ricardo) is based on a *labour theory of value*. Although, this is an initial attempt to explain the existence of commodities' value based on the amount of labour is used for its production, it remains an outstanding contribution in the science of economic analysis. The Theory of Value as provided by the Classical Political Economy apart from analysing how commodities acquire their value it also describes the way all independent economic units (firms, households) are united and synchronised in the sphere of production and exchange. This is an important achievement since for centuries philosophers and practitioners could not explain the basis on which commodities are exchanged. This is also an important contribution when analysing working time, since it does not consist of a mere 'input' in production, but what is actually defining products' 'objective' value.

Additionally, the Classical Political Economy has introduced rationality and hedonism as typical characteristics of economic beings, divorcing themselves from the mysticism and abstinence ruling the ethics and aesthetics of the 'late' feudalistic system. Therefore rationality describes workers' preferences over working and leisure time. In other words, working time tendencies are attributed to *income* or *substitution effects* for workers (working and leisure time have competitive relations).

To continue with, the Critique of Political Economy (Marx and Engels) took the science of economic analysis a step further, making a series of contributions: *value theory of abstract labour, historical property relations (class struggle), commodity fetishism, exploitation* and *surplus value, capital accumulation, crises, capital centralisation, material development* and *socialisation*. Although, this dissertation does not cover the whole range of these contributions, some of them are presented due to their implications regarding working time.

First, the *Value Theory of Abstract Labour* was proposed as criticism to the previous Value Theory of Labour, highlighting the fact that it is the *socially necessary working time for a commodity's production*, not the embodied labour that defines commodities' values (Marx, The Capital Vol I). When analysing economy at an industrial level and the value production, we need to decide on the theory of value. Although this is not the primary role of this dissertation, it is strongly related. By accepting a theory of value subjective, we end up with the un-critiqued treatment of the orthodox statistics. Rejecting that value is subjective, but rather an objective category, derived from labour (embodied or abstract) we end up following a separation of the different kinds of labour (by occupation, industry ect.). Contrary to the neoclassical analysis, where everything marketable adds value, according to the Classical Political Economy (CPE – Smith, Ricardo, Malthus) and its Critique, this would not be correct. In the CPE, Adam Smith (1776) starts paving the way for a Labour Theory of Value (LTV), by claiming that 'the whole produce of labour belongs to the labourer'. Smith also adopts the separation between value and use-value, with the former referring to the exchanging power of a commodity and the second to its usefulness[4]. Ricardo (1817) continues by introducing the concept of embodied labour, where commodities' values is derived from the concrete amount of labour that they already embody. However, a lot of methodological issues arise with the embodied labour, that Marx later corrected by critiquing the principles based on which the CPE was based on.

Marx, apart from adopting the distinction between commodities' value and use-value, is moving a bit further. Marx (1976) in Volume I, Chapter 1 and 2, provides the conditions for a use-value to become a commodity: a) the use-value to be a product of labour, b) to satisfy the need of producer and other people and c) to be given as an exchange for another good, not for free. For instance, water is a use-value, but it cannot become a commodity, because it is the product of nature, not of the labour. In capitalism, there is usually a water industry 9In the UK industry 36. Water Collection, Treatment and Supply). Although, a superficial reading of Marx would command that this is an industry that cannot be commodified, because the water is not the produce of labour, in fact all the related services and infrastructure can be commodified, therefore it appears that we pay for the water. Moreover, regarding the second condition for a use-value to become a commodity, the satisfaction of needs of both producer and consumer, it makes sense if we imagine a producer producing use-values, not useful to anyone else. The exchange could not be materialised. As for the last condition, the use-value should not be given for free, but exchanged for another commodity, this requires both a) Social Division of

[4] Smith (1776) analyses this further with the Diamond and Water Paradox, with the former having high exchange value, but low use-value and the latter the opposite.

Labour and b) Private ownership over the means of production. In other words, a Robinson Crusoe economy is without social division of labour (producer and consumer is the same), therefore anything produced does not consist of a commodity. Additionally, in stages of humanity where communal households was the main form of organising labour without private property over the means of production, there is gift or merely goods' exchange, not commodities' exchange (exchange with equal parts). In this dissertation, this would mean that if the economy that was analysed was a 'socialistic', 'collectivistic' one ect, we would not have an analysis of commodities, but an analysis of output. However, the UK economy is a typical capitalistic economy, with some of its industries owned by the government. Again, in a superficial reading, this would mean that if a service is public and not privately owned, the use-value is not commodified, therefore, it should not be calculated in the aggregate product of the capitalist economy. However, recognising that in capitalism, even a 'nationalised', 'privatised' ect. industry would still be part of the capitalistic mode of production and act as the collective capitalist, would command that industries like the NHS belong to the sphere of capitalistic production. However, household production does not have the same features. Although a household can be privately owned, it does not produce for exchange, but for self-consumption. therefore, industries 97. Activities of households as employers of domestic personnel and 98. Undifferentiated goods- and services-producing activities of private households for own use are not included in the industrial analysis.

Generally, the above conditions enable a use-value to become a commodity with exchange value. According to Marx, the ability of a good to be exchanged with another good (value) is taking place due to the fact that they both are products of human labour. The amount of human labour needed to produce the commodity equalised them. Contrary to Ricardo who focused on the amount of concrete labour already embodied in the commodity, Marx distinguished concrete from abstract labour. He described the former as the human labour as a particular activity that has a specific useful effect, while the latter as human labour in general as economically valuable worktime. For instance, concrete labour is the specific activity of fisherman or the teacher, with the different skills, different knowledge ect. The concrete kinds of labour are so different, that do not look like each other. However, what made the different kinds of labour, represented by their commodities, to be equalised is the abstract labour. This is any kind of labour is an expenditure of human energy or effort. It is the expenditure of human effort that enables human to exchange the fruits of their efforts (commodities). In a simplistic example, for Marx if a bottle needs 2 average working hours to be produced, based on the current technology its value will be £2, but for Ricardo, if one specific labourer needs 1 working hour to produce a bottle, its value will be £1, but if a worker from another factory needed 3 hours, the value would be £3. Therefore, from an Embodied LTV, Marx moves to an Abstract LTV.

Another important contribution that this analysis offers is related to the LTV, as now value expresses the Social and not the Individual conditions of production. In other words, now it is expressed by the Social Necessary Labour Time (SNLT). Socially necessary labour-time is the labour-time required to produce any use-value under the conditions of production normal for a given society and with the average degree of skill and intensity of labour prevalent in that society (Marx K. The Capital, Vol. I. p. 129). This part is very important as it enables this dissertation to overcome the issue of heterogeneity among industries, among occupations ect. The Abstract LTV with the SNLT enable an industrial analysis with all their heterogeneity in concrete terms and all their homogeneity n abstract terms. Therefore, the following industrial analysis requires less unrealistic assumptions than a neoclassical analysis would rush to adopt.

Consequently, the LTV properly establishes working time as the measurement of commodities' value. Generalising this to the whole national output, the aggregate value added is reflecting the aggregate working hours. Therefore, what the national statistics describe as Gross Value Added (GVA) per industry, should reflect the total working hours in the UK for the years that are studies. But even this task is not as easy as it is described below. This dissertation continues highlighting the importance of a debate on working time, like the tradition of Political Economy and its Critique does, since it became an autonomous science (Adam Smith, 2011, The Wealth of Nations). Work time has also been highlighted by the Weberian tradition, naming it as instrument of control and a measure of social progress (Adam, B., 2001). This dissertation examines working time and tendencies, since it is also important since for years the perception that working time can only be reduced has changed massively since the 1973 crisis. Therefore there is still a need in taking into account explanations for this trend and detect possible changes during the outburst of the current economic crisis.

Contrary to the Political Economy tradition and its Critique, the neoclassical school of thought, rejected the *objective* Labour Theory of Value and replaced it with *subjective* Theory of Utility Value according to Theocharakis (2005). Accordingly, in mainstream analysis commodities' value are defined from the subjective utility (given and unchangeable) that individuals derive from commodities. Therefore, working time is not the value generator, but another 'commodity' to be attributed with value too, and particularly with a subjective one. Consequently, working time reduction or working time extension was explained by the dominance of either income or substitution effects. Thus, the whole debate over working time is reversed with preferences defining working time tendencies, and not working tendencies and labour processes defining individuals' -adjusted- decisions.

Therefore, subjective utility ends up being an impossible category to be measured, since measuring billions of individuals' preferences over a commodity is not a feasible task. Thus, skipping the hard duty of measuring value, neoclassical economics started focusing on prices, rather than values, with the former being determined by supply and demand. Consequently, talking about the appearance (price) rather than the substance (value) of a phenomenon causes even more theoretical and eventually practical deficiencies. Apart from that, price analysis is useful for detecting marginal changes, but adds few contribution when analysing deeper factors.

Moreover, focusing on prices does not necessarily reflect the 'importance' of a commodity. For instance, the price of working time (wage) does not reflect its contribution to eg. output. There is amble theory and evidence that wages do not reflect contributions (see 2.1.3). Additionally, prices (and wages) have a particularly volatile nature, and this becomes quite evident for the period that this dissertation studies including the outburst of economic crisis, ie. 2002-2012. In other words, wages for a certain period of working time, and the lack of wages for most of overtime are extremely volatile magnitudes that could not provide valid information on 'contributions' or efficiency. Therefore, this dissertation following the Critique of Political Economy paradigm focuses on working time as the objective and measurable category for examining labour's contribution.

2.1.2 Commodification of Labour? The Theory of Surplus Value.

Following a synchronic (structural) and diachronic (historical) analysis means that each economic system should be examined differently. Therefore, analysing the capitalistic mode of production requires an analysis of the above described LTV implemented within the system's framework. Although, the CPE and its Critique have extensively described the Simple Commodities Production where one commodity (C) is transformed to Money (M) in order to be exchanged again for another commodity (C'), or as briefly described as C— M —C', only Marx extended this exchange in capitalism, as subjected to a qualitative transformation. More specifically, in the Capitalistic Commodities production people do not exchange to get satisfaction from the consumption of the exchanged commodities. Instead, profit (and not consumption) becomes the ultimate goal, where investing money in a business (M) for producing a commodity (C) is happening in order for the capitalist to get more money (M'), or briefly: M— C —M'.

The above reflects a change in the system where capitalists in order to occupy labour they need means of production (M). Contrary to the stingy knight of feudalistic system, who saves his gold to his chest and hides it, the capitalist uses money for business (M). After some time, the capitalist enters the market as a commodities' seller (C), selling commodities gives more money than he spent (M'). The difference between M' and M is called Surplus Value (S = M' – M)

This is important as surplus value is an economic category that is peculiar to capitalism. Like Adam Smith described that the whole produce belongs to the labourer, Marx cannot find any proof either that capitalists or the capital invested are productive forces. Therefore, for Marx too the whole produced is produced by the labourer. The difference in capitalism though is that apart from all the other use-values that are commodified, labour is subjected to this process too. However, Marx makes a substantial contribution by distinguishing labour from labour power. According to Marx, the former is the work actually performed, or what was described earlier the Abstract Labour expended throughout the process of production in order to produce values. The latter,): is the ability to work; all the physical and mental abilities of humans that are expended in the production process. Therefore, in capitalism, commodification of labour power happens for first time in history. In other words, the capitalist is buying and the worker is selling labour power. Labour Power is the commodity to be sold for a certain price (ie. wage).

This is not the same with other modes of production. For instance, in the slavery-based society it is the labourer himself bought and sold. The immediate implication of distinguishing labour with labour power is that work actually performed (labour) is always bigger than labour power. This means that only the power of workers is for sale and only for the duration of the working day, not the work that has actually performed. Therefore, saying that labour (and not labour power) is a commodity is a methodological mistake. Labour power is useful for its ability to create surplus value, and according to Marx this is the peculiarity of the commodity labour-power. However, like all the other commodities, its value is not the same with its use-value. Therefore, although labour power's usefulness is to create surplus, its value is the value (abstract labour does it need to be expended in order to 'produce' labour power) of the means of existence, that are necessary for worker's maintenance and reproduction (food, clothing, fuel, housing, etc). In other words, labour power's use-value is higher than its value, or the ability to create value bigger than its value is the peculiarity of this commodity.

To continue with, although neoclassical economics do recognise labour as a production factor, they do not distinguish it from labour power. Apart from this, neoclassical economics do include capital as another production factor. For this school of thought, capital is an object with which you can acquire another object. For example, even a bat at a caveman's hands is a capital, because he can acquire more objects. However, for Marx capital is a specific feature that can exist only in capitalism, where labour power has been commodified, and there is private ownership over the means of production. For Marx, capital is neither object, not money per se, but a specific *relation of production* between people. It was not existed for ever (not in feudalism, slavery ect.) and it will not exist in the future (ie. socialism). Capital is actually a value (abstract labour) that brings surplus value to its owner, through labour exploitation. Machines, raw material ect. are not capital (means of exploitation) if they are not owned by the capitalist who buys labour power. Therefore, capital is not universal and not every object that is used in the production process is capital.

Additionally, Marx (1867) distinguishes capital in its two different components: a) the variable capital that goes for workers' wages and b) the constant capital as the part that 'does not in the process of production, undergo any quantitative alteration of value' (Chapter 8 and 9 of Volume I). More specifically, he mentions that:

> '*Now we have seen how that portion of the constant capital which consists of the instruments of labour transfers to the production only a fraction of its value, while the remainder of this value continues to reside in those instruments. Since this remainder plays no part in the formation of value, we may at present leave it on one side*'

And he continues:

‘*...the value of the constant capital is transferred to, and merely re-appears in the product’*.

Therefore, as capital just transfers its value to the new commodity produced, without producing any new value added it goes again to what Adam Smith said, that the whole produce belongs to the labourer. Therefore, for Marx too all gross value added in the national economy reflects the total working hours. However, only part of the national product goes to the labourer, and the rest goes to the capitalist. Generally, all surplus value produced reflects all the unpaid working hours, as the surplus cannot be attributed to a non-productive force.

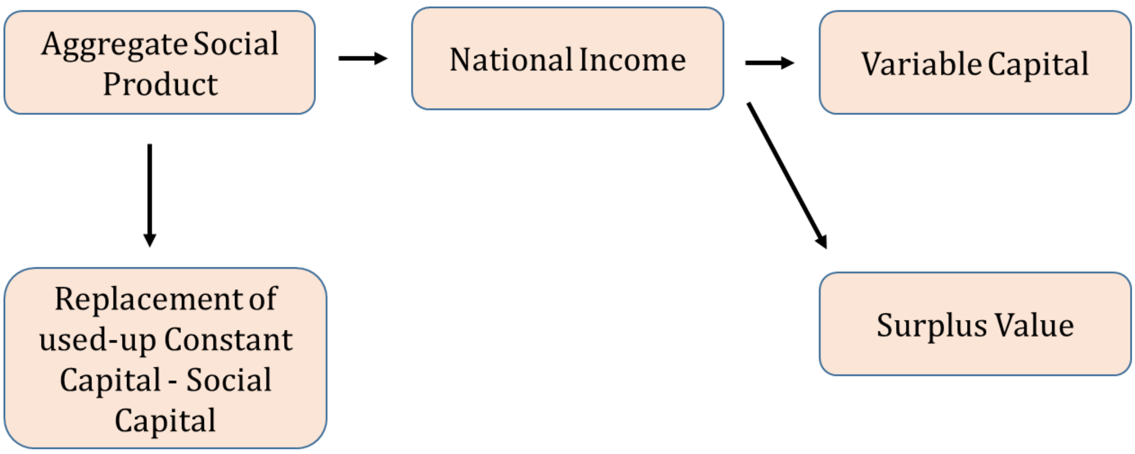

Figure 2.1 – The Marxist Decomposition of the National Product

In other words, profits from all sectors come from the workers of productive occupations of the productive industries. What statistics call as the Gross Operating Surplus (GOP), in fact according to Marx they talk about workers’ unpaid labour. Consequently, measuring total unpaid work in this dissertation would not be contributing to the debate, as it has already been attempted by a lot of scholars, with substantial success.

Since the national income of the economy is reflecting the total working hours, the profits reflect all Surplus Labour Time (SLT), all wages reflect the Necessary Labour Time (NLT) according to the Critique of Political Economy. Therefore, for a capitalist to make profit, they should try to extend the SLT against the NLT as much as possible. For instance, extending the SLT or extracting surplus value can be in a *relative* or *absolute* form. In the case of *relative* surplus value extraction the working day remains stable, but the wage per hour is reduced due to productivity increase, intensification increase, or due to working class' *immiseration*. In the case of *absolute* surplus value extraction there is a prolongation of the whole working day. Overtime, and especially its unpaid form is the case of absolute surplus value extraction, since the whole working day is prolonged with the wage remaining as it is.

Generally, the *Theory of Surplus Value* see that unpaid working hours in general are a requirement to the current mode of production to continue (Marx, The Capital, Vol 1, p.159). Working time is not important only because it acts as a source of value, but also because is surplus part acts as a source of surplus value. Also different parts of the working day reflect the struggle between the working class and the capitalists. This generates a series of contradictions that are examined below.

2.1.3 Working Time & Unpaid Overtime: Individual preferences or History and Labour Processes?

Having already discussed the methodological individualism assumptions where neoclassical economics are based on, and more specifically the assumption that 'social interactions are finally interactions between individuals' (Arrow, 1994), it is important to analyse its implications to working time and unpaid overtime. As it has been described previously, the balance between income and substitution effects is considered to be the main tool for working time limits. In other words, individual preferences form working time tendencies ultimately, while collective bargaining and industrial actions over working time determination are usually considered exogenous factors and not inner determinants of work time limits. They might act as disequilibrium forces, but somehow they will return to optimal. Apart from the theoretical and practical deficiencies that this 'method' has, it is also at a disadvantage when it is compared with other methodologies that do include history and social factors as inner determinants, like in the Critique of Political Economy does. At the end, preference theory 'is an empirically-based, predictive theory that tries to avoid and overcome the weaknesses of current theorising' according to Hakim (2000).

Moreover, there is ample research showing that working time and its remuneration are mainly determined by physical and historical factors. Therefore, prioritising individual preferences as the first key factor is not only scientifically deficient but also disorientating. For instance, there can hardly be any 'individualistic' interpretation of why working hours experienced a drop in 30s decade for Britain (see Figure 2.2), but mainly historical factors that determine such a change. For instance, the outburst of a crisis on capitalistic profits does have effects on working time patterns, since capitalists press for more work. Additionally, the drop in total working hours (See Chapter 3, Descriptive Statistics) after 2007 is not independent of the outburst of the ongoing crisis in 2007. Moreover, Philp & Wheatley (2011) following a structural analysis demonstrate how working time patterns are linked with the rate of surplus value, which is a variable determined regardless of preferences. Additionally, Philp et al. (2015) demonstrate the relation between working day extension as an immediate indicator of profitability, or working class's rate of exploitation in relation to the party in the government, adding also an institutionalist perception in the analysis.

Preference theory becomes even more inappropriate when analysing the phenomenon of unpaid overtime. Unpaid overtime or generally unpaid work is an anomaly for neoclassical analysis (Papagiannaki 2014). Therefore, to skip this obstacle the mainstream school of thought has elaborated new theories to cover this gap, but they cannot avoid being within the limits of methodological individualism that has already been discussed. For instance, there are theories claiming that unpaid overtime consists of a signalling device (*Signalling theory)* or a gift *(Gift Exchange theory*) between employees and employers. For instance, according to Akerlof's (1982) *Gift Exchange Model, '*employees working in excess of the minimum standard' responding to high wage levels offered by employers is the gift for this 'good' contract[5]. Similarly, according to the *Signalling theory*, employees perform unpaid hours in order to signal their employers that they are of 'good' quality and therefore should be kept at work, be given promotions etc.

However, these theories allow for inefficient use of resources, since workers' incentive to get higher wages, remain at job or just express their gratitude to their employers by using unpaid overtime results in inefficient situations. In other words, these theories in their attempt to explain phenomena that do not agree with basic neoclassical conclusions allow for inefficient use of resources, ie. excess working time in pursuit of a possibility for higher wages, remaining at job, career development etc. Additionally,

[5] This theory should not be confused with the gift economy per se that is mainly studied by anthropology, but an idea that neoclassical economists borrowed from anthropology, particularly Malinowski (1922).

signalling (by employees) and screening (by employers) raise some concerns regarding the accuracy of the method. In other words, employees or employers might use unpaid overtime as a signalling or screening device in order to show or identify employees' quality, but the uncertainty is not necessarily resolved. For instance, there can be possible outcomes according to Fine (2016), when using signalling or screening: i. market may clear but in a Pareto inefficient way due to the waste of resources ii. market may not clear at all, since the more employees are willing to offer unpaid overtime the more employers will demand it as a requirement and thus there will be a surplus of employees iii. there might be a complete absence of market, in case where providing unpaid overtime employers might not necessarily choose the high quality employees, but those that just offer unpaid overtime regardless of their quality. Thus, the abovementioned situation of asymmetric information allows non market factors, like collective responses to market imperfections (Fine 2016) as explanation. Therefore, trade unions might step into.

To continue with, another problem with these theories is that what *appears* as an individual gift or signal in *substance* is socioeconomic phenomena responsible for it. For example, employees' fear of unemployment, wage reductions or non-increments, career stagnation etc. (Papagiannaki 2014) are the 'superficially' individual expressions of 'substantially' economic factors, such as the '73 crisis triggering changes in labour processes (change from Fordism to post-Fordism and the subsequent working time extension). Additionally, the fact that it is mainly the last decades that these gifts or signals are sent in a massive degree to employers is a strong evidence that the issue surpasses individuality and becomes social and historical. Furthermore, employers' and employees' uneven positions disqualify them for equal *givers-takers* or *senders-receivers*. In other words, the fact that one owns means of production, while the other owns only their labour power, disables these two groups being regarded as equals for such exchanges. Subsequently, workers may be forced to offer unpaid overtime, but not to choose it.

On the other hand, there are theories which attribute the existence and persistence of unpaid overtime to production's structures (structural analysis). There are some mainstream approaches over the *post-fordist organisation* of production and the fact that unpaid overtime is a result of its *time greediness,* according to Van Echtelt, et al. (2007*)*. Bell et al. (2000) attribute the existence of unpaid overtime to *uncertainties over a task completion* or *leadership roles as causes of unpaid overtime,* however, these can also be referred as symptoms of the above-mentioned *time greediness* of the *post-fordist* *organisation of production*. Also, 'examining unpaid overtime in the context of changes in organisational mechanisms seems a much more appropriate way forward' according to Granovetter (1985; Uzzi, 1997). But still there is a need to understand what lies behind these changes and the form in which they appear. The main reasons behind rising unpaid overtime may lie more in the (re)structuring of labour which has been taking place a couple of decades ago in most industries of economy (Manufacturing, 'Services' or 'Productive' and 'Unproductive industries' etc).

Finally, theories which approach unpaid overtime historically, such as *labour processes theories* (See Braverman 1998) include analyses on the tightening of management control, developments in the wider organisation of monopoly capitalist societies, and changes in their occupational and class structures[6]. These approaches are based methodologically on the tradition of the Critique of Political Economy. As it has already been described above, the fact that surplus value extraction can take place either in a *relative* (working day remains stable) or in an *absolute* form (extension of the whole working day), means that working time limits are defined by the balance of forces between labour and capital.

As described previously, the Critique of CPE attributes the increasing phenomenon of unpaid overtime to the pursuit of capitalists to extract more *surplus value* (Mavroudeas and Ioannides (2011)) and considers the appearance of unpaid overtime as an historical phenomenon, whose roots lie mainly on the capitalistic restructuring which took place in 70s decade facilitating the extension of working time generally, and particularly its unpaid part. However, the battle of working time between employees and employers is characterised by interesting contradictions, such as the contradiction between collective interests of capital and the individual capitalists' interest over working time. According to Saad Filho (2002):

> '*While collective capital profits from a limitation of work time because shorter hours protect the source of surplus value, boost productivity, and help to preserve economic stability, individual capitalists may lose potential to extend surplus value'*

In other words, due to their intra- or inter-industrial competition, they are led to extend working hours, ending up lowering labour productivity. Consequently, a consistent socio-historical analysis over production organisation has to take LTV and LSV into account, as well as *labour processes theories* too (see Braverman (1998)).

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[6] For more details see Knights (1990) and Willmott (1990)

2.1.4 Workers' remuneration and working time: defined by the sphere of production or distribution?

For the Critique of Political Economy, capital and labour shares are not coming from the reward of their marginal productivity as neoclassical economics maintain, but from the power that capitalists have over the means of production enabling them to extract a surplus from labour for profit and reinvestment. In other words, it is the a priori distribution of wealth and income as well as property rights determine factor payments or prices (wages and interest rates) (Dobb 1973, Cohen and Harcourt 2003). According to the Critique of Political Economy, economy is composed by the sphere of production, consumption, distribution and exchange. All these economic activities-structures consist of a totality (Marx, 1861, *Grundrisse,* p. xxxvii). However, the problem of neoclassical theory is not that it does not examine these spheres neither separately nor as a totality dialectically united. On contrary, traditional economic analysis are completely ignoring some of these spheres.

To begin with, *the sphere of production* is the general base of economy, where new values are created. Production is the process where live forces (employees) and means of production (machinery, raw materials) are used to produce an output. Working time and wages are objects that cannot be examined outside the sphere of production. Particularly, they are linked with laws of production, the different modes of production, the division of labour, labour processes, efficiency and wages consist etc. However, not everything is defined by production. It is actually *the sphere of distribution* to define the particular set of laws which determine the way of wealth allocation. Distribution concerns the distribution of products which is firstly based on '(a) the distribution of the instruments of production and (b) the distribution of the members of the society among the different kinds of production take place, social distribution' (Marx, 1861, *Grundrisse,* p. xcvi). Particularly, social distribution assigns people whether to sell their labour power or to buy others' labour power. Moreover, the collective bodies that these classes form (workers' unions, entrepreneurs' lobbies etc) are also regarded as part of social distribution, where wage levels, working time, surplus value are objects of dispute. Therefore, according to the Critique of Political Economy wage determination is happening mainly in the sphere of distribution either in an a priory (by formal laws and institutions) way or in an ongoing class struggle, based on historical, technological and other variables related to production. Therefore, the existence of unpaid overtime is regarded as the outcome of a ‘zero sum game’ (one wins one loses) within the sphere of distribution, especially between the two classes, where capitalists out-win their workers.

However, distribution should not been confused with the sphere of exchange. The latter is defined as ‘the particular way that both the already distributed wealth and the already produced goods can change hands’ (Marx, 1861, *Grundrisse,* p. xcvi). More specifically, exchange is the economic activity where products, labour power and means of production are exchanged. For instance, the market is the main current way of exchange. However, there are other ways, such as the pillage, where not only in the past, but also in the present is the prevailing way of exchange in some cases; some African tribes, according to Bates (1987) still use this way in order to acquire products, labour power and means of production. Ex-socialist countries had central planning defining distribution and exchange. Another form of exchange is the gift economy such as in Malinowski (1922) observed, while was studying tribes from Malaysia. Gift exchange theory, as it has been presented above, has been used in analysing the phenomenon of unpaid overtime. Despite its theoretical deficiencies, this theory consists of an example of a non-market form of exchange, within a market economy. In other words, market is one and the currently dominant way of exchange.

Accordingly, consumption is defined as the individual/singular completion of this process. Consumption can be comprehended as the consumption of products, labour power and means of production. Like the previous categories it cannot be examined separately, since it is connected with production, distribution and exchange as well. Even the individual consumption of products can be seen as ‘production of our own bodies’ (Marx, 1861, *Grundrisse,* p. xxxix). Consumption of commodities produced in some can take place in other industries eg. Insurance and pension is a typical example of industry consuming commodities of others. Generally, there are industry’s whose main role is production (mainly manufacturing industries), others’ is distribution (eg Insurance), others’ is exchange (eg Retail trade) and consumption (here all of the ‘unproductive industries can be found). However, there are not completely ‘clear’ border lines, since some industries can overlap with each other or an industry can have activities of the other sphere. However, one of the focuses of the dissertation is (based on certain assumptions) the distinction between the industries in the sphere of production, distribution, exchange and consumption.

Contrary to the Critique of Political Economy, neoclassical analysis is following a more technical and much less social-historical methodology, based on a series of unrealistic assumptions. One of the basic principles concerning labour economics within the neoclassical school is the theory of competitive markets as a requirement for the marginal product of labour to equal the real wage (See Hamermesh 1986, p. 429). In other words, according to this mainstream economic analysis, wage determination takes place in the sphere of production only. Particularly, William Stanley Jevons's Theory of Political Economy (1871), Carl Menger's Principles of Economics (1871), and Léon Walras's Elements of Pure Economics (1874–1877) claimed that under perfect completion, full employment and a single sector economy, employees' wage represents their marginal product. In other words, this implies that employees cannot receive less than they contributed, meaning that there cannot be any kind of unpaid labour.

However, reality does not agree with the assumption of perfect competition. First and foremost, the concept of competition with neoclassical economics is related with the number of firms, according to Weeks (2011). However, the concept of competition appears to be more complicated. According to Fine (2016 p.66), there are issues like price determination, quantity, collusion, entry and exit, discrimination, mergers and acquisitions, economies of scale and scope, strategizing, path dependence, property rights and transaction costs, where competition is expressed massively violated. Therefore, although there are neoclassical works taking these variables into account the concept of competition is still restricted and expressed mainly with a quantitative factor, the number of firms. Consequently, the whole concept of competition is expressed with 'price-taking to entry into and exit from' (Fine, 2016, p.67). In the case of labour markets, this would mean that employees (suppliers) are wage-takers. However, in neoclassical research on wages the existence of control variables (gender, race etc) almost always used are indicating an admittance of market imperfections. Consequently, labour market is not competitive as assumptions require, even if there are infinite (a lot of) employees.

Having the competitive markets assumption violated, even neoclassical analysis admits that this lack of is intense enough competition cannot prevent any possibility of exploitation. For instance, some neoclassical economists recognise that there is *exploitation* i.e. a factor of production receiving less than its marginal product; exploitation can only occur in imperfect capitalism due to imperfect competition. With the neoclassical notion of productivity wages there is little to no exploitation in the economy (See Zafirowski 2003). In other words, when there is monopoly in the product market, a monopsony in the labour market, and cartelisation then and only then exploitation of workers occurs[7]. Therefore, wages in monopsony labour markets are not related to labour productivity. In other words, with market imperfections as the default situation, wages are not determined in the sphere of production.

Moreover, the assumption on full employment is also essential for constructing the model in which the production factors receiving their marginal product. However, due to above-explained imperfect labour markets, unemployment occurs by default as well, in capitalist economies. Apart from reality that rejects the full employment assumption, the existing neoclassical theories on imperfect labour markets are also rejecting this assumption.

To explain this better, together with the implication that wage is not the marginal product of labour, we are going to demonstrate Fine's proof (2016) on the independent of wages from the production process in two cases: the case of developing and developed countries. This proof is within the context of imperfect labour markets, as in reality.

In order to prove that wage is not affected by productivity, Fine (2016) analysis two possible scenarios: developed and developing economies depending on the wage level of effective labour supply. According to Clower (1965) effective supply is 'the amount of labour a worker would like to provide at the given wage and at given commodity prices, subject to any quantity constraints in all but the labour market'. Effective labour supply: is conditioned by the length of working hours. If the workers are asked to work for a longer period in a day or a week it leads to inefficiency among workers due to fatigue. Effective labour supply is reduced to exceedingly long working hours and fatigue.

To begin with, developing economies are usually characterised with surpluses of labour mainly to unskilled labour dominating these particular labour markets. Therefore, the maximisation problem for a firm will be like the following:

$$\text{Max} \qquad \Pi = pF(a(w)L) - wL \qquad (2.1)$$

[7] According to Fishback (1998), exploitation under the neoclassical meaning is expressed: $E = MPL - W > 0$ (1), Where E is labour or monopsony exploitation, MPL is the marginal product of labour and W is the wage that workers receive.

Where $a(w)$ refers to labour productivity as a function of the wage itself, and $a(w)L$ refers to effective labour supply, and it operates in imperfectly competitive goods market, like labour, p is the product price and F the production function. Thus, employer maximises their profits deciding on what wage to pay and how much labour to employ:

$$\frac{d\Pi}{dw} = pa'(w)LF'(a(w)L) - L \qquad (2.2)$$

$$\frac{d\Pi}{dL} = pa(w)F'(a(w)L) - w \qquad (2.3)$$

Dividing both equations, profits are maximised, when, marginal efficiency wage equals average efficiency wage (Fine 2016):

$$a'(w) = a(w)/w \; (2.4) \quad \text{OR} \quad w = \frac{a(w)}{a\prime(w)} \qquad (2.5)$$

Therefore, wage is determined independently of the production function in developing economies. In other words, although one could expect that *w = F'(L),* marginal product of labour, however, based only on the assumption of imperfect labour market (reality) and that labour productivity can be expressed as a function of the wage, wage does not appear to be determined in production. Another issue that certifies this, is the fact that in the developing countries that are described, employers choose not to drop wages more in order to clear the market, although they can. This can act as an additional evidence that labour does depend on sufficiently high living standards, ie. social, historical conditions, rather than production. Additionally, dropping real wages is a phenomenon taking place mainly in developed economies. Unpaid overtime is also a phenomenon taking place in developed countries, but there is no much evidence for the developing ones.

Regarding the developed economies, theories about wage determination in developed economies with imperfect labour markets, are still not sufficient to explain wage levels. Still based on Ben Fine's analysis on the assumptions of imperfect labour markets, in these economies there is no surplus of labour as in the case of developing countries, but there is asymmetric information; employers tend to know the average productivity of workers, not their individual one. Particularly, in developed countries where asymmetric information occurs employers tend to use different wage levels as screening device to identify the highly productive employees. Therefore in order to attract them, employers set a salary a bit higher than the one corresponding to average productivity, because in a lower salary none of the high quality employees would apply due to the good options they have. Therefore, employers set the wage higher than the average productivity, to secure that most of the applicants will be of average productivity or more (definitely not less). Thus, excess supply of labour for that wage appears. Similarly, if employers set a lower wage, they would mainly attract lower quality employees, and the decline in quality would not compensated by the lower wages. In other words, although employers can drop the wages, they do not do it because profitability is higher with higher wages. Consequently both in developing and developed economies, two things occur rejecting the mainstream theories' assumptions: i. employers do not choose to drop wages to clear the market and ii. market structure emerges, with employed & unemployed. Therefore, wages do not reflect labour's marginal product. Additionally, the screening/signalling device has been used for unpaid overtime too. Unpaid overtime is a device that employees are using for demonstrating their quality in order to receive bonuses, to avoid been made redundant etc. Even in this case, we have such a loss of 'productive' working hours that do not reflect employees' remuneration.

Apart from the fact that the sphere of production is not determining wages, by using the neoclassical analysis own tools we can further disprove their models' conclusions. Moreover, the very fact that labour is not like any other soulless input to be sold and bought disables the neoclassical model even more. Labour is subjected to its own social laws, and this acts as another factor that highlights the sociology and the significance of economic relations underlying the issue (see 2.12). Oranges do not create unions on how they are going to be sold, but employees do. More specifically, they have a saying on the conditions they sell their 'services'. Therefore, wage determination cannot be seen as something determined in the sphere of production; workers can and they actually do form trade unions bargaining over their remuneration, working time limits, overtime premia etc. Consequently, the sphere of distribution seems the appropriate place to study this determination.

Apart from this, labour markets are different, not because the agents who sells is different, but because of the nature of what is sold and bought (Marx, Capital Vol I). Despite the mainstream economics that maintain that labour is a commodity for sale, the Critique of Political Economy has highlighted the fact that this commodity for sale is labour power, not labour. In other words, what has been disproved above by using neoclassical tools, it is also confirming what the Critique of Political Economy claims too: despite that wages are related to production, they are not determined in production.

Additionally, the historical narrowness that mainstream economics is undergoing is expressed also by seeing work as disutility. Work is regarded as disutility in two ways: because i. leisure time is sacrificed (opportunity cost) and ii. work is wearisome anyway[8]. But disutility of labour is not universal, but just contemporary and temporary, because work can become enjoyable like in the case of child upbringing. However, it is still the historical context and the alienation encompassed in production (see Marx, Capital Vol 1) that makes this approach quite popular. Therefore, according to Fine (2016)

> *'what is taken to be the disutility aspect of work serves as a proxy for the social and historical context of wage work itself, as well as the rationale for explaining labour markets might work inefficiently*'.

The disutility assumption is important when analysing wage as a compensation for this disutility. Moreover, a potential rejection between work as disutility would have as implication the complete disconnection of wage and work. In other words, if work stops being seen as disutility, but as an enjoyable process, mainstream economists would propose no wage for rewarding to employees. Human capital theory is an example of mainstream analysis, which does not consider work as disutility, but it is not completely detached from neoclassical methodology.

Additionally, the problem with neoclassical analysis becomes even bigger when they have to justify the existence of unpaid work. Therefore, different approaches within the neoclassical tradition deny the existence of unpaid overtime, even when data are undeniable. For instance, the *Deferred Compensation theory* [Pannenberg, (2005)], *Human Capital Theory (*Booth et al., 2003*), Unpaid Overtime as a Pareto Optimality* (Bell et al., 2000) claim that employees are rewarded somehow even with unpaid' overtime. However instead of wages, there are different ways, such as future benefits or personal pleasure. In other words, nothing remains without a relevant reward of equal value. Although the latter can also be challenged.

To begin with, the theory which argues that unpaid overtime consists of a Pareto Optimal change, according to Bell et al. (2000) maintains that unpaid overtime is the Pareto Optimal outcome if employees and employers are left to bargain freely without any state's or unions' interventions which define higher overtime premia. In other words, without the externally imposed overtime premia by unions and other collectivities,

[8] Adam Smith (2010) regarded work as an inherent pain.

employees and employers would reach a wage level and working time limits that are Pareto Optimal. The fact that unions and governments prevent this spontaneous clearing of the market creates an inefficiency. However, this inefficiency is solved informally by the agents offering the amount of working time and the clearing wage leading to the appearance of unpaid overtime. Despite that this approach sees state or unions as *externalities* (Papagiannaki 2014) which disturb the optimal outcome of production it is an admittance of mainstream economics that wage levels and working time limits are not determined by production. Therefore, wages do not actually represent the marginal product of labour. On the contrary, it is the sphere of distribution (bargaining among agents) that determines these levels. Therefore, the argument that 'the choice between earnings and leisure is not, in modern conditions, left entirely, or even mainly, to the preference of the individual, but is standardised by collective decisions, legal or customary' (Robinson, 1947) is valid.

Additionally, although the concept of unpaid overtime as a Pareto Optimality after bargaining between agents allows for some kind of socially determined wage level, it still hides the fact that the bargaining between agents does not come from their equal positions, especially because the agents who are damaged are not employers but employees. As it has already been mentioned, one group owns means of production, while the other owns only their labour power. Subsequently, workers may be forced to offer unpaid overtime, but not to choose it (see details in Papagiannaki 2014). Moreover, in cases where there is no bargaining or legal working time limit employers still do not choose to drop wages completely to clear the market. This implies that there are certain living standards as described above confirming that wage levels are not determined by the sphere of production. Therefore, although bargaining or class struggle is a core concept of understanding how wages, working time and overtime behave, it cannot say much if historical context and technological achievements applied in daily life are not taken into account. Consequently, wage determination has a physical and historical component.

Among the theories which claim that there is no unpaid overtime, or at least it is somehow remunerated, is the *Deferred Compensation Theory* as expressed by Pannenberg M., (2005) claim that unpaid overtime is actually paid in the future after companies increased profits. However, it have been disproved theoretically (Papagiannaki 2014) and empirically (Campbell & Green 2002, Anger 2008), since the increase in workers' future earnings is disproportional to employers' profits. Therefore, Deferred Compensation Theory, is also deficient of explaining unpaid overtime.

As for *Human Capital Theory*, that has already been mentioned, it claims that unpaid overtime is somehow paid. Based on the principle that work does not consist of a disutility, human capital theory maintains that work is an enjoyable activity and therefore gains can be derived by those who offer it, ie. employees. More specifically in the case of unpaid overtime, what appears as working in excess without payment is actually paid differently, and more specifically with enjoyment. Particularly, it is claimed that human capital acquisition -'investment' where more skills are gained- is taking place during the overtime; working long hours (especially for the new entrants) acts as a way to learn the job better etc. Contrary to the traditional approach, production is considered as a process involving work itself and not simple purchase of inputs.

Apart from this, in the case of unpaid overtime, an employee can acquire human capital but after having worked and contributed to output and profits of the firm, unjustfying why the 'normal' working hours are paid while overtime not. This human capital acquisition apart from being an asset for employees is also an asset used in production with the firm earning profits by it. Therefore, there is no explanation while both employees and employers' enjoy the outcomes of this human capital acquisition, only one receives payments. Additionally, research has observed by that a small human capital investment appears to have huge returns (Fine 2016) that cannot be explained. Unexplained factors (by neoclassical economics) lead to higher returns. Therefore, this leads some researchers to assume some kind of externality or imperfection. However, the human capital theory assumes perfectly competitive labour markets; human capital variables in empirical research might just be capturing the deviation from these assumptions. As it has been highlighted above the existence of control variables (gender, race etc) are indicative of market imperfections. Consequently, labour market is not competitive as assumptions require and therefore human capital theory cannot explain much.

For all the above mentioned reasons, this dissertation is based on the principle that the wage represents the value of labour power, not labour. To state it better, wage represents the value of the average commodities working class needs to survive and reproduce, not the value of their contribution. Therefore, it represents only one part of their working day. In Political Economy this is the law of Surplus Value (Marx, The

Capital, Vol 1, p. 124), where employers' profits are extracted by employees' unpaid working hours, and this takes place in the sphere of production. Therefore, level of wages is determined by i) historical/social factors including the class struggle between capitalists and workers and ii) physical factors (Mavroudeas and Ioannides, 2011). Thus, under the spectre of political economy, unpaid overtime is just a way that capitalists use to extend the unpaid part of an employees' working day, as it has been mentioned above. Although this dissertation is not focusing on collective bargaining and the sphere of distribution per se, it is useful to take it into account, because it sets the boundaries of what is researched. Wage is not to be researched. Union's contribution to paid/unpaid hours is not to be researched either, but aspects of social analysis might be taken into account. Moreover, it will be taken into account in the different stages when analysing labour's contribution to industries output, since some industries tend to be highly unionised and this has an effect on working hours as well.

Additionally, as we have described above, wages have a particularly volatile nature, especially during crises and periods of change, like the period 2002-2012 that this dissertation focuses on. In other words, wages for a certain period of working time, or the lack of wages for most of overtime are extremely volatile magnitudes that could not provide valid information on 'contributions' or efficiency. Consequently, due to all this issues that wages have, this dissertation following the Critique of Political Economy paradigm focuses on the sphere of production and therefore working time is considered as the objective and measurable category for examining labour's contribution. In other words, this thesis is rejecting wages as a proxy for labour as input in production.

2.1.5 Economic crises and working time patterns

Another topic central to the Critique of Political Economy is the appearance of period crises in capitalism. For Marx (as it is described in Volume III) crises in capitalism are inevitable and essential for the reproduction of the capitalistic system itself.

The base of crisis in capitalism is the social form of production against the individual adoption of profit. However, the form in which the crisis is expressed appears as the Tendency of Profit Rate to Fall. However, for the neoclassical analysis, crises are not inevitable and caused by accidental reasons. Of course, this dissertation does not attempt to examine the causes of crisis, but to see how industries respond. Taking into account that the period that is studies includes the 2007 'Global Financial Crisis', leading to a recession for the UK until 2009, it is interesting to see how capitalists in each industry respond. The main instrument that they have to get over it as soon as possible, is mainly the minimisation of cost of production. In the Critique of CPE this can take place through the following main strategies. Firstly, by intensifying labour exploitation (intensification) and reducing workers wage (Immiseration). This is called capital saving. The other alternative is to equip businesses by renewing fixed capital and by introducing better production techniques. This is called labour saving. It is interesting to see how the different industries in the UK can adopt different strategies.

As it is discussed later, industries with high capital composition might be more flexible to adjust their capital utilisation compared to the others. While industries with lower capital composition might rely more on intensifying labour exploitation.

2.2 Issues with overtime and defining unpaid overtime

2.2.1 Working time: trends, regulation and deregulation

Before analysing the phenomenon of unpaid overtime a definition of overtime should firstly be put forward. Overtime is mainly a 'legal' notion, rather than an economic one. It is defined as the amount of time beyond the contractual hours, and the concept of overtime was born. In several historical periods in the past workers had to work more than their contracts. Generally, during the first centuries of capitalism there was little or no legal protection for workers; they were working for 16 hours per day, a lot of children were working from a very early age, women had no maternal rights etc. Therefore, as it is obvious, there was no notion of overtime. Overtime was introduced as a notion after the first factory acts of the 19th century (See Table 2.2), when legal limits of the working day established due to working time extension, and paid overtime was one of the outcomes of the regulation of work time.

Table 2.2 – Working time regulations in UK and EU - The history of European working time laws 1784-2015

Date	Event
1784	Ten-hour day proposed at Manchester Quarter Sessions (England)
1802	First Factory Act (Health and Morals of Apprentices)
1815	Foundation in England of the 'Ten Hours Movement'.
1818	Robert Owen presented a petition to the five leading European powers meeting at the congress of Aix-la-Chapelle. The document asked for the establishment of working hours restrictions throughout Europe in order to stop unfair competition. His submission was rejected as 'lunatic'.
1819, 1825	British Factory Acts (not enforced)
1831, 1833	British Factory Act : Under 21s not allowed to work at night in cotton mills. Under 18s not allowed to work longer than 12 hours (9 hours on Saturday). Robert Owen begins to experiment with a co-operative system based on labour working time tokens.
1843	Ten-hour Day Act (normal working day)
1844	British Factory Act: maximum working day of 12 hours for adults and 6.5 hours for children.
1847	Ten Hour Act
1850	British Factory Act: Limits for women and children introduced. Employment permissible between 6.00 am and 6.00 pm (later in winter) on weekdays and until 2.00 pm on Saturdays.
1874	British Factory Act: Reduction of half an hour each day for textile workers.
1897	'Eight-hour day' strike by engineers
1975	EC Council Recommendation on the 40-hour maximum working week and 4 weeks paid holiday. (75/457/EEC)
1985	Common EC statutory limits for heavy goods vehicle and public service vehicle drivers
1993 (Nov 23rd)	EC Directive on working time (93/104/EC). 48-hour week limitation (averaged), but with voluntary opt out by employees in some member states.
1994 (Jun 22nd)	EC Directive on the protection of young people at work (94/33/EC). 40-hour week limitation on 16/17 year old adolescents who are not in full time education.
1996 (Jun 3rd)	EC Directive on parental leave requirements
1997	EC Directive on part-time work
1998	Revised EC Regulation on working and rest time (transport)
1999	EC Directive on seafarers' hours of work
2000	EC Directive on working time in civil aviation
2000	SIMAP ruling by the European Court of Justice. All hours spent in residence and on call must count as working time.
2001	BECTU ruling by the European Court of Justice. This confirmed as unlawful any qualifying period before a new employee could build up entitlements for statutory paid annual leave.
2002	EC directive on mobile road transport activities
2002	Extension of EC working time restrictions (offshore workers and doctors in training)
2003	New consolidated Working Time Directive (2003/88/EC).
2003	Jaeger ruling by the European Court of Justice. If an employee is required to be present at the workplace, or otherwise at the disposal of their employer for a period between two shifts then the rest period must be classified as working time.
2015	European Court of Justice Decision concerning the working time of mobile workers with no fixed workplace.

Source: The Federation of International Employers 2015

The working time regulations shows the restrictions that are introduced over the last 200 years; The above table with After the establishment of the legal limits of the working day (determined by the already mentioned i) physical and ii) historical limits), there was a general tendency of working time to be reduced (See figures 2.2 and 2.3).

However, only recently (last 30-40 years) working time started increasing again in developed capitalistic countries after a long period of time when it was reducing. Schor (1991, 1999) was the first who observed the increasing working time tendencies in a research for American economy after years of reduction. In particular, overtime, as one form of working time extension, was increasing too, both its paid and unpaid form. Particularly, Americans have been detected to work 158 hours more per year. This is equivalent to an extra month of work each year- based on data from 1969 -1989 (Schor 1999 p.2). In addition to that, Golden and Figart (2000) found that in the US working hours per year have increased 4% since 1980 (p.16). Moreover, Bell et al. (2000) based on data from both UK and Germany analysed the phenomenon of both paid and unpaid overtime. They concluded that overtime working is more prevalent in UK than in Germany (paid/unpaid), and that in both countries, paid overtime is more common among manual workers, while unpaid overtime is more prevalent amongst managers and professionals. Anger (2005) provides evidence from Germany showing that paid overtime hours are declining with unpaid having the opposite tendency. Moreover, different research revealed the existence of unpaid overtime for the countries mentioned above (Campbell and Green (2002), Booth et al. (2003), Pannenberg (2005), Anger (2005), plus Sweden (Meyer & Wallette (2005)), Switzerland (Engellandt & Riphahn (2005)), Netherlands (Van Echtelt et al. (2007)) and Australia (Drago et al. (2009)).

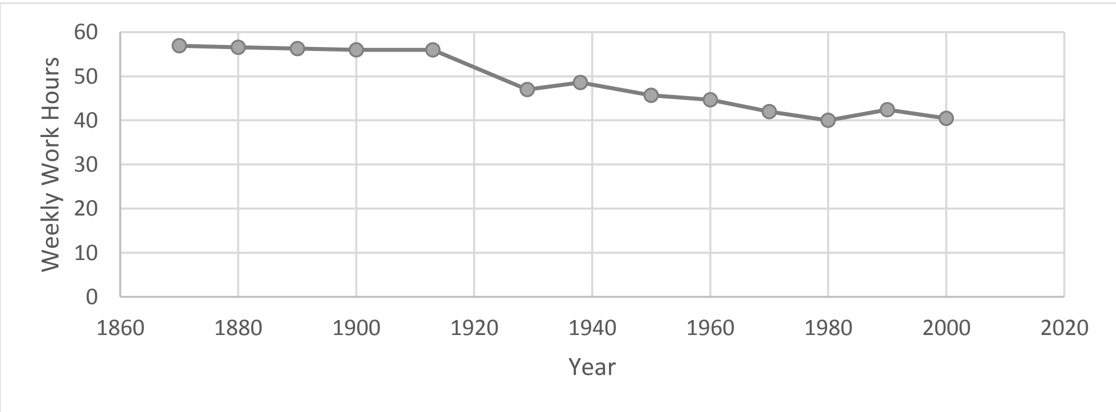

Figure 2.2 – Full time weekly work hours per person – UK 1870-2000

Source: Huberman, M. and Minns, C., 2007

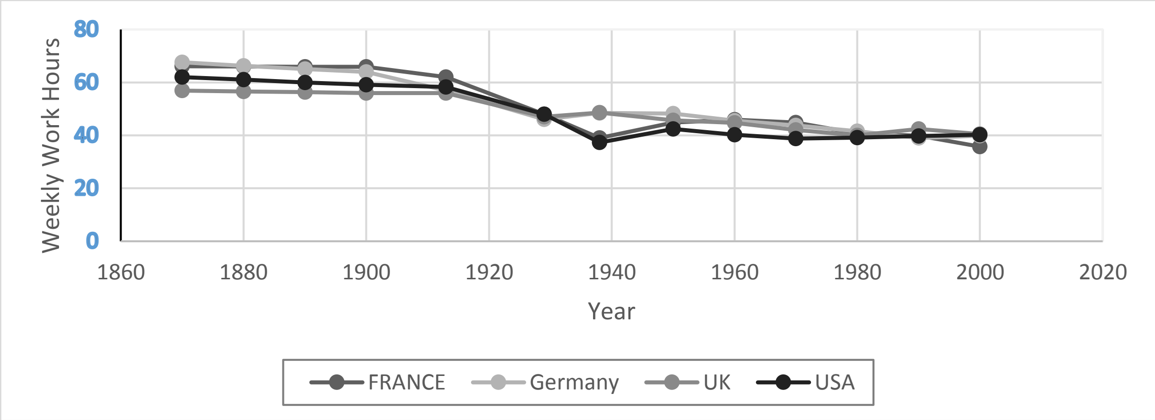

Figure 2.3 – Full time weekly work hours per person – France, Germany, UK, USA – 1870-2000

Source: Huberman, M. and Minns, C., 2007

Generally, after observing these tendencies scholars could only assume that working time can only be reduced.

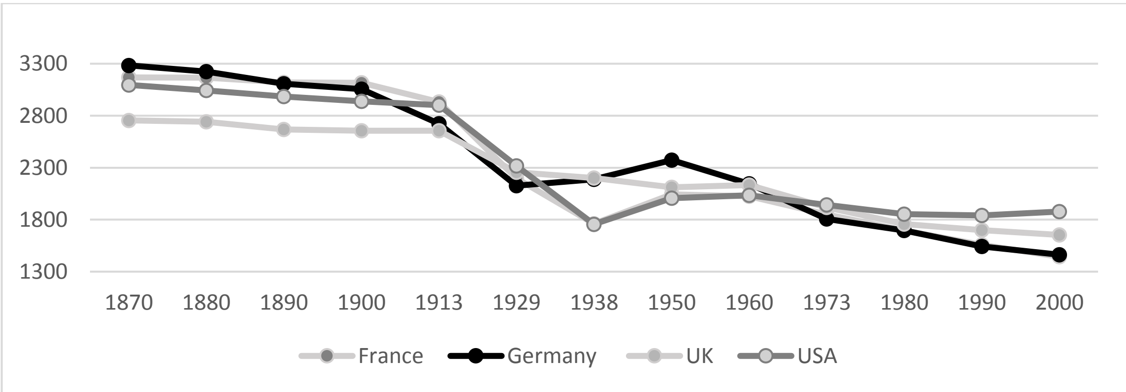

Figure 2.4 – Annual Worldwide full time work hours – 1870-2000

Source: Huberman, M. and Minns, C., 2007.

The last evidence is not surprising especially if labour market deregulation during 80s and 90s is taken into account. For instance, nowadays in the UK there is a huge variation of labour contracts; declining full-time and increasing part-time and zero-hours is the main pattern for the country (See figures below). Therefore, an undefined length of the working day or defined but violated is quite common.

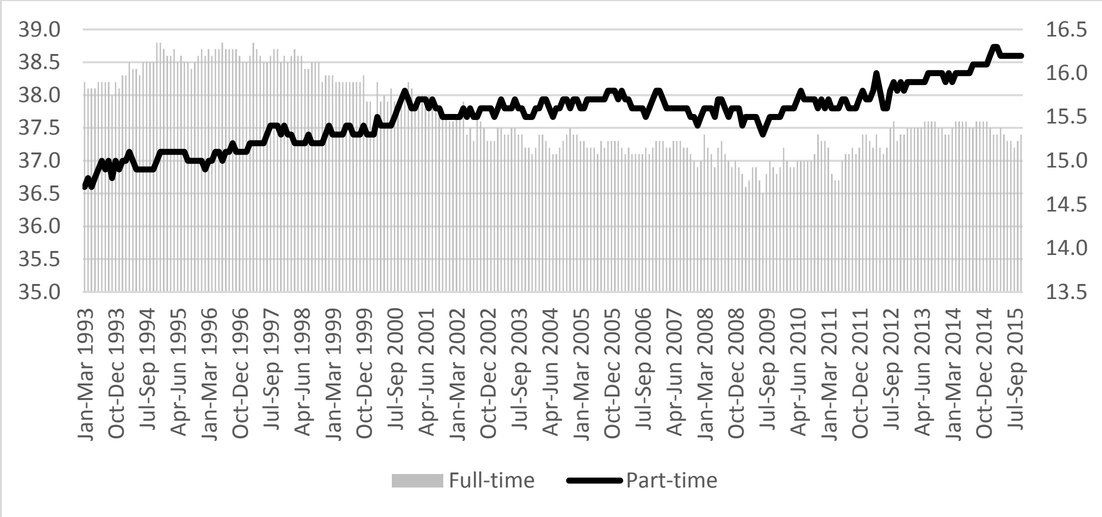

Figure 2.5 – Weekly Part- time and Full-time hours in the UK (Full-time in the left vertical axis and Part-time in the right)

Source: Office for National Statistics, UK sector accounts, (2016)

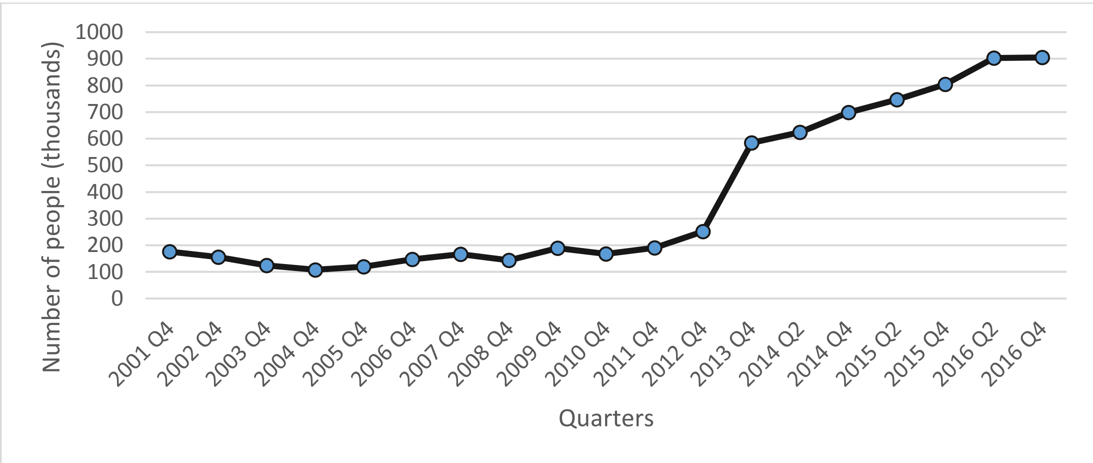

Figure 2.6 – Number (thousands) of people in employment reporting they are on a zero-hours contract, October to December 2000 to October to December 2017 in the UK

Source: Office for National Statistics, Employment and Labour Market series, (2017)

Apart from the different theories that the abovementioned scholars proposed, their findings are quite interesting as well. Most of these scholars analyse the phenomenon of unpaid overtime in a microeconomic way, with respect to variables such as the level of education, experience, sex, marital status, union membership, immigration, age, existence of debt, self-employed/private/public sector etc. The main conclusions derived from these empirical tests are related with the 'business cycle', with economy's industries and sector, unionisation, labour contracts, tenure, age, gender.

To begin with, there is some research on linking overtime generally with the phase of economy. More specifically, Hetrick (2000, p.30) claims that the economic expansion of the 1990s employers in manufacturing industries were more likely than in previous recoveries to increase overtime hours among existing employees than to hire new workers. This evidence is in accordance with theory, and more specifically with the Critique of Political Economy regarding capitalistic accumulation and crises. It maintains that especially during capitalist expansion an absolute extension of working time is common. This dissertation is also taking the outburst of the ongoing crisis into account when analysing unpaid overtime.

Although, existing literature has mainly observed that employees in services even before crisis manufacturing experienced record levels of overtime, according to Golden and Figart (2000). This result is not unsound if the nature of work in each industry is taken into account (*physical component*). Workers in manufacturing apart from having more manual work that those in services, depend also on the machinery schedule rather than their own pace. Therefore, working time limits may not vary a lot. This is an important aspect of unpaid overtime with respect to industry that will be examined further later on (see 2.4). Although, manufacturing industries seem to be characterised by lower overtime than in services, overtime hours in manufacturing had reached a record level at least by late 90s (Golden and Figart, 2000, pp 16), signifying some kind of general tendency regardless of industry back then confirming also the abovementioned cyclicality of the phenomenon. This thesis apart from taking cyclicality into consideration, it also follows different analyses in different groups of industries too.

Moreover, unionisation is another aspect where existing literature is linking it with unpaid overtime. Bell and Hart (1999) claim that unionisation has a disputable impact; in some cases serves to reduce working time and increase overtime, but in some other cases it reduces overtime hours. Although this sounds contradictory, it does make sense when variety of agendas among unions is taken into account. For instance, in cases where unions achieve a victory over a formal working time reduction, it would not be impossible if informally working time is extended (overtime). Similarly, unions that accept a formally higher working day might face reduced overtime. Or unions that have a stricter and clearer agenda on normal working day and its extension might reduce both the formal working day and its formal/informal extension (overtime). Moreover, Bell et al.(2000) on a more general research observed that unionised workers or workers in more unionised countries do not work unpaid overtime or work less unpaid hours in comparison with those that are not unionised. These results are in accordance with the Critique of Political Economy and the role of class struggle (or 'bargaining') between employees and employers. Therefore, even empirically there is evidence on the fact that working time and its remuneration are not determined in the sphere of production, but in the sphere of distribution. Although unionisation variables are not included in the core of this dissertation's analysis, they might be taken into account when interpreting results.

Based on the above reasoning, employees with smaller 'bargaining' power due to tenure or kind of contracts might perform more unpaid overtime. Particularly, unpaid overtime has been observed to be higher among temporary workers by 60% than among permanent employees (Engellandt and Riphahn, 2005). In other words, employees with smaller presence in the workplace and without any reassurance of permanency do not have the strong alliances with those that have been longer and their job position is more secured. Therefore, the former are more vulnerable than the latter, succumbing easier to employer's pressure. This result is also in accordance to Anger (2008) who observed that workers with short tenure work unpaid overtime for Germany, and Bell et al. (2000) who find that their unpaid overtime tends to be equal with paid for UK. However, the majority of existing literature is based only on testing unpaid overtime by using mainly full-time workers, and as it has been discussed above, this is not giving enough information on the extension of the phenomenon due to the labour market deregulation and the existence of underemployment (part-time jobs, zero-hour contracts).

Moreover, white collar workers or workers with higher education demonstrate a kind of persistence in working unpaid long hours (Pannenberg 2005, Anger 2008). This can be also linked with a similar research which detects that unskilled workers exhibit lower overtime, than skilled workers (Bauer and Zimmermann, 1999). Although this might appear as a confirmation of human capital theory, in fact it must probably be linked with the physical component mentioned above, with tiredness that blue collar workers or the low skilled are subjected to. That is to say that blue the latter tend to do more manual tasks than the former. Therefore, extending working time for even some dozen of minutes would have a severe physical impact, disabling them from being equally productive the next day. Moreover, white collar workers or highly skilled do not need to perform repetitive tedious tasks that blue-collar or unskilled might have to. Therefore, working time limits have to be strict for one category and more flexible for the other.

Additionally, existing literature detects that male employees' work more long hours than the female ones (Bell et al.2000). This is not unjustifiable if we take into consideration that female employees have already squeezed schedules, allowing little space for performing unpaid overtime, since they already undertake the majority of domestic labour and child-upbringing (another kind of unpaid labour). However, this dissertation is not going to focus on the behavioural and individual level of unpaid overtime.

Consequently, after having a basic idea on the microeconomics of overtime and unpaid overtime, and after having the literature agreeing on the existence and persistence of unpaid overtime in certain groups of employees and certain sectors, at least until before the outburst of the ongoing economic crisis, there is a need of highlighting the importance of overtime not as a simple quantitative extension of working time, but as a different quality of labour power, usually of lower quality representing employees' fatigue.

2.2.2 Quality of productivity of overtime hours

Generally, there are different approaches in a complete disagreement regarding the concept of overtime, focusing on the definition of overtime in general, on the limits of overtime, or on productivity. Although existing literature on overtime and its effects might disagree, there is usually a general silent admittance even from the mainstream economics that overtime is not a working hour of the same quality like the previous working hours. In other words, one can consider anything beyond a normal 8 hour working day as overtime, another might think that this is subjectively defined. Generally, most agree on the 'wear and tear of labour' (Political Economy) or the reduced marginal utility' (neoclassical approach) with the extension of working day. Therefore, there is a need in identifying these aspects that overtime consists of a different quality.

According to the Critique of Political Economy, although the working-day is a fluctuating quantity - it can only vary within certain limits. There are minimum and maximum limits. The minimum limit is determined by the value of labour power. In other words, in the capitalist production working day should ensure that is not shorter than the part of the day which the labourer must necessarily work for his own maintenance, the *necessary working time*. This part is represented by wage. Thus, working day should represent the wage plus the *additional working time*, expressed by *surplus value*. Surplus value is derived from the additional working time whose contribution to output is adopted by their employers, and this is the very source of any kind of profit. That is to say that in capitalism, where capitalists try to maximise their profits, there should not be a working day smaller than the necessary working time. Therefore, the necessary working time (time for making up for employees' salary) is the minimum limit of working day.

Similarly, the working-day has a maximum defined by physical and historical (social, technological, ethical etc) limitations. Regarding the physical limits, 24 hours could act as the absolute maximum, where a worker can 'expend only a definite quantity of his vital force'[9]. Within this 24 hours they must rest, sleep and satisfy other physical needs, to feed, wash, and clothe themselves. Apart from these, there are contemporary physical limitations. For instance, endless is the bibliography that links extra working hours with severe health issues (Kivimäki et al, 2015, Virtanen et al. 2012, Shields 1999). In a summative report on overtime, it is mentioned that 'in 16 of 22 studies addressing general health effects, overtime was associated with poorer perceived general health, increased injury rates, more illnesses, or increased mortality. One meta-analysis of long work hours suggested a possible weak relationship with preterm birth. Overtime was associated with unhealthy weight gain in two studies, increased alcohol use in two of three studies, increased smoking in one of two studies, and poorer neuropsychological test performance in one study', according to Caruso et al. (2004). Therefore the physical limits are not just provided due to the fact that a worker needs to do other things as well, but also because of the need to replenish the occurring wear and tear. Generally, employers want their employees to be able to work the next day with similar productivity as today. This also explains the fact that working day cannot be extended in an absolute degree.

Therefore, overtime cannot be detached from productivity studies either. The abovementioned physical factors cannot be uncorrelated with productivity loss. Particularly, there is substantial evidence regarding the inefficiencies that arise from the use of overtime. For instance, it is demonstrated later that although overtime contributes in UK industries output, there is evidence for diminishing productivity in some industries too. According to Brunies and Emir (2001):

> '*The most cited factor affecting productivity during scheduled overtime is physical and mental fatigue. Other factors which may contribute to a*

[9] See Karl Marx. Capital Volume I, Chapter 10: The Working-Day

> *productivity loss include: i. absenteeism, accidents, ii. reduced supervision effectiveness iii. shortage of materials, consumables or tools due to accelerated pace iv. tardy processing of engineering questions and requests for clarifications due to greater demand within a given period*'.

However, there are studies on working time and productivity showing some peculiar patterns. According to Ellwood (2010) who presented a study in the International Association of Time Use Research in 2010 had shown that

> *'when people work long hours, there is a greater tendency to come in early and do their work before the start of the official work day (...) Employees are able to achieve greater concentration, before and after regular hours (...) During overtime, the percentage of time spent on high priority work increases only slightly, while time spent on secondary or support activities is replaced by non-value added activities'.*

In other words, morning overtime is changing the way that academia examines overtime traditionally, linking it with the wear and tear of labour. Therefore in cases it should appear having higher productivity than normal hours. Apart from the physical limits are linked with an overtime analysis (either it happens in the morning, or especially later in the day) there are also socio-historical issues arising with the working day extension. Karl Marx (*Capital Volume I*, Chapter Six: The Buying and Selling of Labour-Power) highlights the moral point of analysing overtime. Generally, employees need time

> *'for satisfying his intellectual and social wants, the extent and number of which are conditioned by the general state of social advancement'*[10]

Even in terms of mainstream economics, the extension of working day is a problematically explained phenomenon. For instance, in cases of involuntary overtime the disturbance of employees' balance between work and leisure is one moral issue that arises. In other words, the sacrifice that employees make from their leisure time, precious time away from friends and family cannot be really compensated even with highly paid overtime. Even in cases of 'voluntary' overtime, moral issues arise when existing employees perform tasks that could be undertaken by unemployed. In other words, instead of occupying longer some employees, more employees should be occupied for less hours. Therefore, together with the moral aspect studying overtime can have a lot of macroeconomic implications.

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[10] Karl Marx. Capital Volume I, Chapter 10: The Working-Day

However, what consists overtime varies together with working time. For years the notion of overtime was not existing. As it has already been presented, only after the establishment of working time acts in 19th century, the notion of overtime is introduced for first time. Therefore overtime can safely be considered as working beyond the contract. Additionally, the way that overtime is remunerated seems to relate with the socio-economical, historical and political conditions or prevailing perceptions in each country and each period. The notion of wear and tear of labour was one of the most defining regarding overtime. Gradually in the 20th century, overtime used to be paid more than the normal working day due to that. For years, the European working legislation in different countries, used to treat overtime differently from the normal working hours. However, the 21st century British labour market seem not to be affected by these notions anymore.

Another aspect of overtime analysis is a quantitative one. Overtime cannot be independent from the length of 'normal' working time. With an extended working day of 15 hours, it is highly unlikely to have overtime work, but with the establishment of an 8 hour working day the concept of overtime is more prevalent. Therefore there is no 'absolute' way of defining overtime. It has to be relative to the rest of normal working day. The moral point of view and previous analyses would command that in the 21st century anything beyond 8 hours should be examined as overtime, especially if 8 hour day was established for first time in 19th century. However, the deregulation of working relations, individualised contracts, the lack of collective labour agreements and the extension of working day, especially in the UK, prevent this dissertation from considering an 8 hour as the 'normal' situation. Therefore, overtime will be examined in a quite blur spectrum based on the subjective responses of employees participating in the British Labour Force Survey.

Consequently, despite the difficulties in defining overtime, it does consist of a different quality when analysing working hours. Therefore it is going to be examined in separately and in comparison with the usual working hours.

2.2.3 Unpaid overtime

Although the term 'unpaid' is relatively clear regarding its meaning, there are different aspects that need analysis. The previously mentioned schools of thought have completely different views regarding what is considered paid and what unpaid, apart from the different perceptions regarding overtime as it has already been extensively presented. The neoclassical perception that *nothing is unpaid*, comes to contrast with the Marxist approach that *every working day of dependent labour is partially unpaid*. Although, for the Critique of Political Economy, unpaid labour is a quite clear concept, measured by economy's profits, in economic analysis there are different approaches. To begin with, most capitalistic economies are using different kinds of labour in different spheres of economy. Glazer (1984) in a work focusing on female participation in economy, has proposed that an inclusion of labour should consist of '*i. domestic labour in the household, ii. paid labour, iii. voluntary unpaid labour and iv. involuntary unpaid labour*'.

However, before analysing labour and its remuneration, there is a need of examined labour allocation in different sectors of economy. In other words, the difference among the various kinds of unpaid labour lies on various factors, such as the sphere or sector of economy that working hours can be spent; either in parts of production which is *capitalistically organised* (employers-employees-means of production for profits as the direct purpose), while others are organised within a household or a community (without having profitability as a direct purpose). Based on this first basic distinction, domestic labour that is not subjected to any immediate control of any employer, but is used for labour power reproduction (not biological workers' reproduction) does not consist a capitalistically organised form of labour, therefore this dissertation does not study it. It is important to highlight here that in underdeveloped countries domestic production is the main core of national economies. Therefore, household is the unit of production with its members being both employees and employers. These households do maximise profits and belong to a raw or immature capitalistically organised economy. However, this dissertation focuses on the UK, and the number of households like this is possibly extremely low or at least unrecorded.

Moreover charity work could also be examined within the sphere of not capitalistically organised work, since charity organisations' main purpose is not supposed to be profit maximisation. However, there are serious arguments against this fragile 'assumption' that for the sake of easiness this dissertation will not examine. Voluntary/charity sector is not analysed separately, but parts of it might be included as part of the following analysis. For instance, industry *94. Activities of Memberships' organisation* is capturing one aspect of the volunteering sector.

Another, distinguishing feature is whether the capitalistically organised labour is in form of *dependent* or *independent* labour. For instance self-employed are considered independent (despite all the ties that disable them from being completely free). Self-employment though is not characterised by certain contractual hours due to the high flexibility that goes with it. Generally, they cannot be included in the research due to extreme vagueness regarding their working time.

Another feature is whether dependent labour in capitalistically organised sector is *not remunerated with wage in an institutionalised way*. If not, then formally it may consist of apprentice, or 'voluntary' work for gaining working experience in the profession etc. This is different to the abovementioned work in charity organisations that can take place in leisure time and can exist together with another job as well. It is also different from work in trade unions, religious organisations, emergency situations' charities (eg earthquakes, floods, etc). Although all these kinds of voluntary work can overlap, volunteering for building up a career should be treated differently from volunteering in order to eg. save earthquake victims. Despite that contemporary statistics contain restricted or no information at all. Due to restricted information regarding volunteering, this dissertation does not include it, although it can be captured in an intermediate way.

Another feature to examine is whether dependent labour in capitalistically organised sector is not remunerated with wage, due to *contracts violations*. This is not a formal/institutional way off not providing salary. This is the case of unpaid overtime that this dissertation studies. Focusing only on the conventional meaning of the term, there are different ways that overtime is remunerated: a. completely unpaid, b. paid equally to the normal working hours, c. paid more than the normal working hours and d. paid less than the normal working hours. Moreover, despite the fact that the research comes from the standpoint that an extra working hour *technically, ethically* and *logically* should be remunerated more than a usual hour, the overtime hours that are paid even in a smaller percentage than the normal hours are going to be analysed as paid overtime. The choice of using such a widely accepted conventional definition of the term 'paid overtime', is not related with some kind of 'research neutrality', but in order to highlight the differences between paid and unpaid overtime in their contribution to output, even in this extremely vague way.

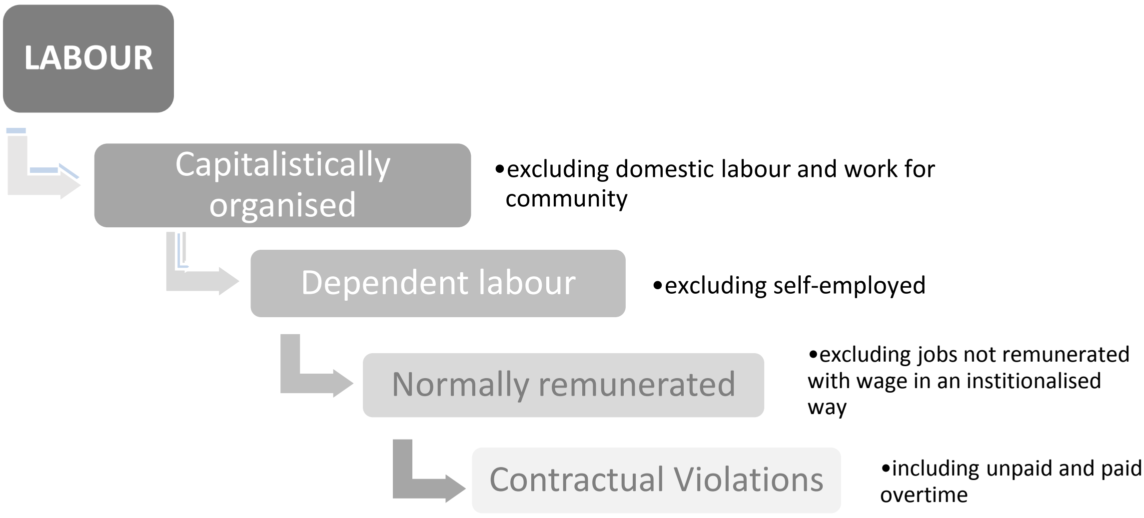

Figure 2.7 – Labour Allocation - Focus of Dissertation

Although the increasing and varying tendencies of all this kinds of 'paid' and 'unpaid' labour create a need for a unifying totalistic analysis this dissertation does not aspire to complete this task now. Despite that time use surveys and some empirical works have conducted an aggregated analysis of these kinds of unpaid labour (Philp & Wheatley 2011), a relevant study needs to be reinforced with further details in the role of working time in total production regardless of its current allocation to the different sectors, spheres of economy. An extensive a analysis of the different kinds of unpaid labour (with its conventional meaning) within the different industries of the economy would also be an interesting research task for future analysis.

Although the 'unpaid' terminologies do not consist some kind of Marxist definitions, they are used because of their usefulness. As it has been presented before, according to Dunne (1991) there are three options of examining empirical resources within the framework of the Critique of Political Economy:

> '*i. researchers can attempt to measure Marxian categories directly, ii. orthodox data could be adjusted to make it closer to the required Marxist categories and iii. we can use Marxist theory to attempt to explain the movement in the orthodox statistics*'.

This dissertation is using the third option.

Apart from issues regarding overtime and unpaid labour, there are also British peculiarities making the task of identifying overtime even more difficult. First and foremost, the last three decades working relations have been deregulated, especially after the prevalence of Reaganomics or Thatcherism in labour markets globally this deregulation is not only of a British phenomenon. However, Britain was a pioneer in this area disabling an analysis of working time with its traditional form.

The first issue with the UK arises with its exemption for the European Working Time Directive (Council Directive 2003/88/EC) that sets upper limits in the working day. Even before the BREXIT vote in June 2016, the UK had a series of exemptions that made its comparison with other European counterparts difficult enough. The Directive sets a maximum of 48-hour week, including overtime. This is depicted in the duration of the British working day compared to other European countries according to Philp et al. (2005). Apart from having a longer working day on average, Britain has some extreme working week phenomena. For instance, in the Labour Force Survey there is an extreme case of an anonymous employee who works 80 hours per week in their main job, and only 20 hours are the basic contractual ones. The rest 60 hours appear to be unpaid overtime. Although this is not the case for millions of British employees, this outlier demonstrates that situations of extreme unpaid overtime are allowed and can take horrifying dimensions.

2.2.4 UK labour market peculiarity and EU labour policy's vagueness

On the other hand, although there are individual contracts where employees are eligible for being subjected to the EU Working Time Directive, this individual choice has to take place during the job application or the interview. It can be easily comprehended that this is not the most encouraging timing for most candidates to ask for a relatively reduced working day, since their employers pre-occupy their future employees with the fear of not getting the job. Thus, although they are asked, candidates usually remain opted out from the Directive. This 'decision' has the relevant effect on not only on the extension of their individual working day but also on their overtime period, which under these circumstances remains undefined based on their individual contracts.

Even in cases where employees are finally opting for working within the framework of EU Working Time Directive (Council Directive 2003/88/EC) are subjected to the above-mentioned requirement of the 48 hours week. More specifically,

> '*EU countries to guarantee the following rights for all workers: a limit to weekly working hours, which must not exceed 48 hours on average, including any overtime…*'

In other words, the maximum that EU sets appears to be higher than the western states started imposing a century ago. The 48 hours is still far from what was originally claimed in the 1886 working strike in Chicago regarding the 8 hours working day (ie. 40 hours per week), a claim which had been established as a right to a series of western countries at the beginning until the last decades of the 20th century. Consequently, a real working day extension is expected to have its effect on the length of overtime as well. In other words, the need for overtime is expected to be reduced if the normal working hours are increased. Generally, having a 48 hours working week already leaves smaller place for overtime.

Moreover, the abovementioned requirement for 48 hours as a maximum is just a limit. This means that one labour contract may demand the maximum European legal, which is 9.6 hours per day (48 hours per week), while another may demand 7 hours per day (35 hours per week). In the first case, legal overtime is not permitted, but in the second case there is a 13 hour of legal overtime. That is to say that, although employees in those two different jobs work 48 hours per week, in statistical services, the first job is detected with 0 overtime, while the second with 13 hours. Consequently, these personalised contracts and the lack of collective agreements covering employees is sectors/industries etc lead to a lack of precise definition of overtime in a uniform way.

Additionally, providing an objective definition for overtime becomes even more difficult when considering every kind of labour contract, apart from the full-time ones. The extension of '*flexicurity*' (flexibility and security) ruling EU labour markets is also demonstrated in Britain. For instance, 1 out of 4 employees works part-time. This is a very high ratio in the British workforce, making almost impossible to exclude them from their contribution to the industries output (See Figure 2.5). Apart from that, part-time employees have been observed do perform overtime as well, which is unpaid in a lot of cases. Moreover, this 'flexicurity' is demonstrated with the existence of temporary labour that consists a 5-6% for the period we study 2002-2012 (See Appendix 1). Additionally, although the percentage 'zero-hours contracts' (See Figure 2.6) for the period between 2002-2012 that is studied is 0.6%-0.8% (while in 2016 was 2.9%) is quite small, it highlights the difficulties in setting objective and uniform measures for overtime generally. For instance, the previously mentioned extreme case of an employee who works 80 hours per week, has obviously, a non-full time contract (20 hours per week).

One could also argue that all work on zero-hours contracts is overtime and should be paid as such. Higher wage could act as a compensation for lack of employment security. Consequently, the inclusion of flexible labour contracts of dependent in this dissertation makes the objective and uniform definition of overtime even more difficult.

Since the notion of overtime is not existing in a national or even industrial level in labour contacts, to skip these issues, this dissertation is not providing any objective definition for overtime. Instead, it accepts the subjective estimations of individuals who participate in the Labour Force Survey. These estimations act as the only measure of overtime in this dissertation given participants' responses that are completely based on their individual contracts. Regarding the way that Labour Force Survey (ONS, 2012, p.122) defines overtime is quite clear. Any extra working hour beyond the 'usual' working hours is considered as overtime. It actually contains data about the Total usual hours including overtime, Total usual hours excluding overtime, Usual Paid Overtime and Usual unpaid overtime.

Apart from these, records of unpaid overtime started being kept rather recently making a detailed historical approach more difficult. More specifically, In the Labour Force Survey data on overtime are kept after 1992. However, this dissertation is using data from 2002 because of the lack of availability of other variables that are taken into account.

2.3 Critical review of the different approaches of measuring the economic activities

Regardless of one's views on the wage system, the debate of labour remuneration and working time is important for those who implement or fight for implementing proper wage policies (governments, parties, firms, trade unions etc), those who challenge the wage system in favour of an employee-participation scheme within the capitalistic firm, or those that seek a complete overthrowing of the labour exploitation and therefore wage system, or they are just in favour of policies where people's remuneration will be regardless of their contributions to production, but according to their needs. Despite this permanent need for a debate regarding labour remuneration and the wage system generally, there is also a need for measuring working time contributions to production before proceeding to any axiological statements, regarding labour payment.

Practitioners and theorists came up with difficulties when they had to measure 'productive' activities that are not remunerated. Domestic labour is the first activity that triggered the debate on measurement issues, with which working time is 'invested' and certain output is produced. Another kind of 'unpaid' labour is volunteering in its general meaning. Measuring the value of volunteering in national economies is something that has been recently proposed by the United Nations General Assembly (GA Res 56/38) passed a resolution calling on governments to establish the economic value for volunteering. Subsequently, the International Labour Organisation (ILO) has recently proposed a methodology to guide countries in generating the data for volunteer work (ILO 2011) where the *full replacement cost approach* is followed. Generally measuring non-market activities (according to neoclassical economics) or activities belonging in the sphere of consumption or distribution (according to the Critique of Political Economy) – like domestic labour and volunteering - is a practical question that practitioners asked with scholars proposing a various theoretical responses.

The responses vary according to the theoretical framework and the economic activity that is examined. Those that are already 'marketable' having a certain price are quite easy to 'value' according to neoclassical analysis. For instance, a volunteer cleaner's work can easily be estimated by assigning them a professional cleaner's wage. But, there are not immediate ways of valuing the non-market activities, like domestic labour. There is no equivalent price for being eg. professional housewife in the market and therefore difficulties arise. Therefore, assigning a relevant wage does not seem to be appropriate.

All the existing approaches of measuring this kind of activities can be summarised in two basic categories: i. *wage based approaches* and ii. *output based approaches*. The former attempt to attribute a relevant wage for the unpaid activity, while the latter try to evaluate it based on activities' outcomes. Few are the works which measure unpaid economic activity with 'output-based' valuations of working time and most of them are analysing mainly domestic labour. Taking into account that unpaid overtime is part of the capitalistically organised labour but an 'unpaid' kind, this dissertation attempts to find its contribution with an output-based approach. The easy task would be to apply the existing hourly wage of the already 'paid' hours to unpaid ones (wage-based approach), but the difficult task would be to measure their contributions (output-based approaches). Practitioners, like Trade Union Congress (TUC 2017) so far have used wage-based approaches[11]. TUC calculates the value of unpaid overtime in Britain by attributing an hourly wage of any other typical working hour for te unpaid hours too. However, for first time in a theoretical and practical level, this dissertation attempts to approach the value of unpaid overtime with an output-based approach.

2.3.1 Wage-based valuation of activities

Before moving to an output based approach of analysing unpaid overtime's contribution, the theoretical framework of wage based approached are presented first. The wage based approaches for the non-market activities attempt to evaluate these activities by attributing them a relevant wage. This wage would be determined either according to the amount of wage that employees/volunteers 'sacrifice' (by not performing their paid job instead) or according to the wage that another professional would receive for these specific activities. This implies that the wage-based approaches are divided in two different sub-categories: i) the *opportunity cost approach* and ii) the *replacement approach*.

The opportunity costs approach

The '*opportunity cost approach'*, as its name betrays, evaluates activities according to the sacrifice that the individual worker has made for not doing other activities. According to this approach, 'individuals who perform unpaid labour give up other activities' that could do instead, 'along with all associated monetary and non-monetary benefits' (Hamdad 2003, p.7). This approach has been used mainly in measuring the value of domestic labour assuming that the household gives up working hours which would have been paid by the hourly income they already have as professionals (Luxton 1997). This approach is having strong links to neoclassical economics, where the notion of opportunity cost penetrates the whole analysis of consumers' and producers' behaviour (marginal utility and marginal rates of substitution).

In their effort to attribute value to the amount of unpaid overtime when overtime payment is not compulsory, statistical services, policy makers and other institutions using the *opportunity cost approach*, have attempted to estimate a possible overtime

[11] According to Trade Union Congress (2017) '(m)ore than 5.3 million people put in an average of 7.7 hours a week in unpaid overtime during 2016. This is equivalent to an average of £6,301 they have each missed out in their pay packets.' This is a typical calculation of overtime's value with a wage-based approach.

remuneration based on the individual contracts. Particularly, the online calculator[12] proposed by Trade Union Congress (TUC) suggests that an extra overtime hour should be remunerated like a normal hour of employees' individual contract[13]. TUC makes estimations over the years. Particularly, for 2015 during the campaign for W*ork Your Proper Hours Day,* TUC (2015, *Workers contribute £32bn to UK economy from unpaid overtime*) estimates that 'UK workers gave their bosses nearly £32bn worth of unpaid overtime last year – an average of £6,050 each if these hours had been paid'. For 2013, TUC (2014, *Jobs recovery and rising work pressures have led to record levels of unpaid hours*) it was calculated that it is '5.4 million employees in the UK that work unpaid overtime of weekly value £640 million or annual value of £33 billions'.

The market replacement cost approach

According to the '*replacement cost approach'*, non-market activities' value is calculated by the amount of resources which are necessary in order to replace this value. In other words, employees' unpaid labour can be valued at the earnings level of other people who (would) work in similar activities in the labour market sector. Since this is usually used in measuring domestic labour (eg ONS, *Find the value of your unpaid work*) it actually implies that household members-workers can be replaced by other employees. This is based on the *Margaret Reid's third party principle*, (as Beneria 1999, p.295 mentions) according to which any household activity that can be conducted by a third person can be subjected to the replacement cost approach. For instance, taking shower is a household activity that nobody can do it for you, but showering one's children is a kind of task that a third person can do (for money). This approach requires though an economic equivalent activity (Wood 1997). In other words, cooking is an example of household activity that has an equivalent in the market, ie. cooks in restaurants. The *replacement cost approach* has recently been implemented in measuring the value generated by volunteering too. The UN and the ILO (2011) are proposing this approach to national governments for

[12]TUC, Work Smart, Overtime Calculator, https://worksmart.org.uk/tools/overtime-calculator

[13] For instance, if an employee's annual salary is £30,000 and he is meant to work 35 hours a week, but in fact he works 40 hours a week, this means that his hourly pay is £16.48 and he should be earning £82 (£16.48 x 5 extra hours) in overtime every week. Over a year this adds up to £3,955 (assuming four weeks' holiday). Or if their overtime was paid at time and half, it would be £5,932. Adding their unpaid overtime together, that employee works the equivalent of 46 unpaid days a year. Thus, this way of calculating is on individual contracts with individual pay and individual working hours per week. Based on this method TUC has made estimations on the whole economy.

evaluating unpaid volunteering activities. Based on the previously mentioned example, a volunteer cleaner should be valued with the professional cleaner's wage.

According to Hamdad (2003) who focuses on domestic labour, there is a way of calculating the value of housekeeping tasks. More specifically, the amount of money saved by household (by not occupying a third person) represents the value added to the household's income which is the cost of purchasing the same services in the market, or hiring someone else to perform the tasks. Implementing this in the case of unpaid overtime, it would be the case of hiring an extra employee to perform this task. This approach is also divided into two sub-categories of (1) *replacement cost specialist* which imputes the unpaid work on the basis of hourly earnings of people employed in matched occupations (eg. specialist cook, specialist cleaner) and (2) *housekeeper cost method* which employs the wage rates of a general housekeeper in this respect (Hamdad 2003). In case of unpaid overtime that is an unpaid activity the replacement cost approach could be more appropriate. The amount of money saved by firms that use unpaid overtime instead of occupying the same employee in a paid way or other employees, represents the replacement cost.

Although the TUC proposes the *opportunity cost approach* of calculating unpaid overtime, as it was mentioned before, the conclusions they reach have replacement cost implications. In other words, in most reports TUC 'translates' overtime's value calculated with the opportunity cost approach into potential jobs that would have been created if this overtime was covered by other employees, and particularly the currently unemployed. The outcomes of TUC's approach are frequently used in order to highlight the percentage of unemployment that could be reduced by occupying new employees (eg. Peacock, 2011).

Issues with wage-based valuation of activities

As it has already been mentioned extensively the wage system has a lot of deficiencies for being a proper measure of labour contributions; mainly because the income share between capital and labour is a matter of i) the physical or ii) the socio-historical component (see 2.1.3). Therefore, the fact that wages do not consist of the marginal product of labour in the production process[14], wage levels can be rarely linked with labour

[14] As it has been mentioned before, one of the basic principles concerning labour economics and wages in the neoclassical theory of competitive markets, the marginal product of labour equals the real wage,

productivity across history (see Figure 2.8), and that wage level does not fulfil any criterion of stability – especially after the outburst of current economic crisis where real wages experienced a drop- in order to act as a means of comparison or a means of measurement are the generally basic problems for rejecting the wage-based valuation of unpaid overtime. Moreover, the UK peculiarities mentioned above are also acting as deterrent from adopting wage-based valuation of overtime; the exemption from the already 'vague' EU Working Time Directive, the fact that overtime payment practically is not compulsory in the UK and the fact that are no national or industrial overtime premia.

An additional issue with the wage-based approaches is that they are profession-specific. This means that any potential valuation of output will be based on the concrete commodity that the concrete skills of the concrete employees use. This is also problematic because the use-values produced by concrete labour are becoming the instruments that equalise the commodity of labour power in this case. In other words, this is related to a Ricardian perception of valuing commodities, where concrete and not abstract labour is the equalising force. The issues that arise with the concrete theory of value have been already described earlier.

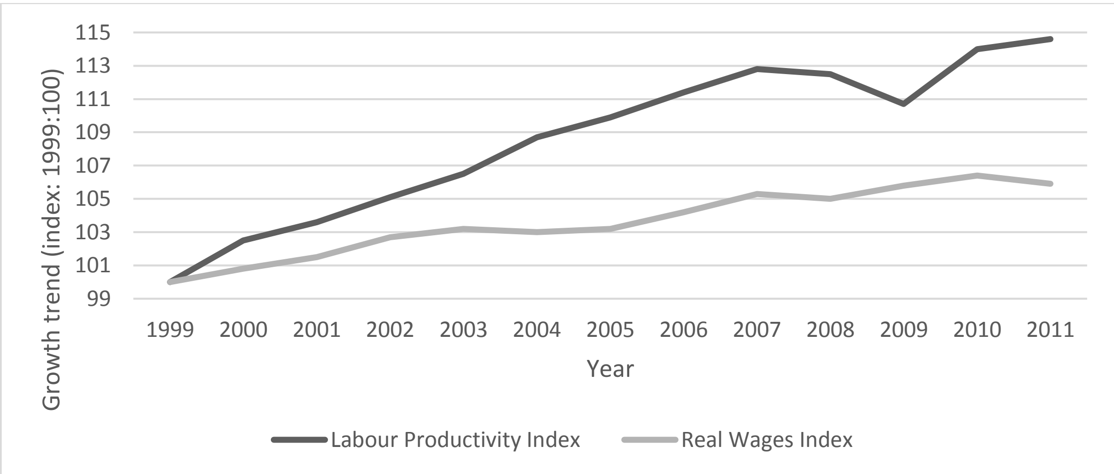

Figure 2.8 – Trends in growth in average wages and labour productivity in developed economies (index: 1999 = 100)

Source: International Labour Organisation (2013)

Apart from these issues, there are also approach-specific problems. Regarding the opportunity cost method, offering' an extra unpaid overtime hour appears to have an

(William Stanley Jevons's Theory of Political Economy (1871), Carl Menger's Principles of Economics (1871), and Léon Walras's Elements of Pure Economics, 1874–1877) opportunity cost equal to offering a 'normal' hour. In other words, practitioners and mainstream researchers do not attribute unpaid overtime with an opportunity cost equal to a paid overtime hour, but to a paid normal hour. This ignores the wear and tear of labour when performing long hours. As it has been analysed before, working longer hours would require the extra compensation in money or holiday time that this would need. Treating overtime hours as of the same worth with 'normal' working hours would also ignore the whole 20th century legislation (still existing or past, depending on countries) on remunerating overtime hours with extra payment. Therefore, the potential value that researchers and practitioners attribute to unpaid overtime with this method is still much smaller than the payment that unpaid overtime used to receive in 20th century in European (at least) countries.

Moreover, the opportunity cost method has a problematic application in domestic labour. Particularly, it implies that different individuals, with different professions and salaries, performing the same household task can be evaluated in different rates; a highly salaried employees' work in household would have higher value than a lower one, according to Hamdad (2003). For instance, the value a doctor's house cleaning would be higher than a cleaner's one, since the former's wage is higher than the latter's. Regarding unpaid overtime, a possible overtime payment is based on opportunity cost approaches would be calculated by individual contracts. Contrary to domestic labour valuation giving an opportunity cost valuation of unpaid overtime is easier. In the same example, the value a doctor's diagnosing after 18:00 (overtime) would not be completely incomparable with the same doctor diagnosing at 14:00. Or a doctor diagnosing at after 18.00 could be comparable with another doctor diagnosing at 18:00. But in the second case, these two doctors have different wages and same skills. However, there are is still their wage that in a lot of cases can be substantially different. This would mean that two different doctors with the same duties, tenure, education, productivity etc., but with different hourly wage would have also different valuation of overtime, because of their different opportunity costs. Therefore, valuing one's working time based on salary sacrifice is becoming extremely subjective.

Regarding the *replacement cost approach*, there are less problematic issues. This approach actually commands to assign a wage value to another individual/employee's work for performing the tasks that are currently performed by the unpaid labourer. This is a principle also proposed for domestic labour. It actually implies that a housewives' contribution with their unpaid labour can be calculated by imputing the wage of a professional; if she cleans for 2 hours, this would be the equivalent for a 2 hour wage of professional cleaner's. Although, *Margaret Reid's* (1934) *third party principle* does not have a consistent applicability in domestic labour [15], because there are a lot of complications regarding tasks that are not commodified, in workplace the third party criterion would not have inconsistencies in its application. Contrary to household, in workplace, everyone is substitutable by an employee with similar qualifications and skills; a mother loving/caring for her children can only be substituted for caring, not for loving (it is not commodified), but in workplace an employee can be substituted by another employee with similar skills. Especially, if the former has to perform overtime, the latter could substitute him/her after 5pm when overtime starts. Therefore, applying the criterion in workplace is rather methodologically easy and consistent.

Apart from the substitutability of labour, there are other issues occurring. Similarly, an employee's unpaid overtime hours can be 'replaced' either by their own unpaid hour compensation premium or by occupying additional employees within the normal contractual hours. In the first case, the replacement cost of an employees' long hour would be would be an overtime payment, not a normal hour payment, since overtime represents the wear and tear of labour. In this case the attributed value of this extra amount of labour would appear high, since overtime work should be compensated more. But in the second case, where instead of extending one employees' hours longer, the firm is occupying additional employees within 'normal' contractual hours, the attributed value of unpaid overtime would be equal to a normally compensated hour. Therefore, this would be lower than assigning an overtime payment like in the first case. Consequently, if in an industrial or national level we follow the first replacement cost approach (all unpaid overtime equal to paid overtime of the same employee) would be high, but if we follow the second (all unpaid overtime equal to paid normal hours of other employees) it would be low. Therefore, the valuation of unpaid overtime wold be strictly depend on the political and ideological views of the analysist or policy-maker.

In any case though, wage-based approaches end up with the previously presented problems that wage causes; when using the wage levels (a distribution sphere variable) as proxy for labour contributions (a production sphere variable) we end up with both

[15] According to Wood (1997, p.50), 'the existence of economic activity unique to the household, since it does not, or does not yet, have a commodity equivalent cannot be considered economic'.

inconsistencies and a big ideological bias by assuming what is produced is paid. Subsequently, there is a need occurring of using the physical (not necessarily tangible) output that labour produces.

2.3.2 Output-based valuation of unpaid labour

Measuring output with respect to labour time 'invested' is not a very popular approach, especially in mainstream accounts. The literature of output-based approaches has been used mainly for evaluating domestic labour. ONS uses this method in the case of housekeeping[16]. Various scholars have proposed an output-based valuation for domestic labour. One of the most structured and completed works, introduced by Goldschmidt-Clermont (1993), proposes a certain structure of measuring the outcomes of domestic labour. The measurement is possible if domestic labour is analysed in four components: i. *physicality of units produced* ii. *valuation of products with market prices* iii. outp*ut-related valuation of time* and iv. *valuation's relevance with economic purposes*. Although these elements are originally made to be implemented in domestic labour can be also applicable to the case of unpaid overtime. Actually, this is attempted to be the main contribution of this thesis, to highlight that as labour time in domestic labour is evaluated according to the output produced, in the same way the labour time can be evaluated in the capitalistically organised sector of the economy.

The difference however is that this dissertation does not adopt an unjudgemental adoption of the household production as a part of the capitalistically productive industries, as the use-values produced within the limits of the household are not for selling and therefore, are disqualified for commodities' production. Another issue that is revealed with the above methods is that the orthodox statistics turn to the output-based approach when there is no marketable-equivalent, like in the case of domestic labour.

[16]According to Fender V., (2012, p.2), '*the output method values what the household produces, for example the number of children cared for or the number of meals prepared. This is important because it is often easier to value outputs than inputs, particularly when there is a market equivalent to the service being produced. Output measurement is also more consistent with the way the rest of the National Accounts are constructed and reflects household productivity. It may be possible to construct a historical series using this approach, even in the absence of time-use data. Outputs can be estimated through surveys that specifically request this type of information. An estimate of gross unpaid production is obtainable by multiplying the volume of output by an appropriate market value or price. This in itself is problematic due to the difficulties in applying a market price or wage rate to outputs without any information on the variation in quality between households. The methodology is essentially the same for all of the principal functions except voluntary work.*'

Before implementing this approach to the case of unpaid overtime the applicability of the above components have to be checked. To begin with the first component of *physicality of units produced* is fulfilled in the case of unpaid overtime. Considering working time as an input in the production there are also certain outputs. More specifically industries' output is the outcome of production procedure that is examined by this dissertation. Consequently, the first component is fulfilled covering both tangible and non-tangible products. Even in the Marxist approach, this component is important as if the use-value is not useful to anyone, it does not have the potential of being transformed into a commodity. However, since the dissertation is not about domestic labour, but about the already commodified labour capitalistically organised, this first condition holds by default.

The *valuation of products with market prices* is the second condition to be fulfilled. Indeed, all the goods and services that are produced appear in the national accounts. The Office of National Statistics (ONS) is already providing the monetary value of industries' output. More specifically, Gross Value Added (GVA) per industry is the output measured with market prices. Here too, according to Marx although the main focus would be the valuation based on the necessary working time for each commodity, the valuation with market price is still useful. Generally, under simple commodity production, commodities are sold at prices which correspond to their value, but under the capitalistic commodity production commodities are sold prices which correspond to their prices of production. The fact that the commodities are not sold in their value, might seem that the Law of Value is not valid, but as Marx explains in Volume III, this price of production is merely a modified form of value. Additionally, this dissertation does not aim to refine GVA from its market distortions, expressing the product with market price is still contributing in the analysis.

The third element for an output-based approach is the *output related valuation of time*, which is actually the main purpose of the dissertation. As it has been stated multiple times so far, measuring the contribution of working time, and particularly of unpaid overtime, towards industries' GVA is the primary goal of the dissertation.

Although national statistics offer productivity indicators, they do not provide a decomposed indicator for overtime hours and especially unpaid overtime. Therefore, this value has to be derived. The last condition for implementing an output based approach is related to a *valuation's relevance with economic purpose*. The economic purpose is to reveal i) the contribution of overtime hours and ii) the impact of this relationship on the national output. This has strong implications a) from a philosophical point of view for the wage system as a whole, and even the lack of this wage-system for these particular hours of the working day, b) for a conceptual point of view for the importance of theoretical frameworks and models that are currently used in economic analysis, and c) from a methodological point of view for the different kinds of measuring the national economic activity, and labour productivity.

2.4 Inter-industrial analysis of Unpaid Overtime

In this thesis, Office of National Statistics (ONS) and Labour Force Survey (LFS) are combined for analysing unpaid overtime as an input in production. The structure of these two databases does not allow for a firm level analysis. The ONS is structured in a macroeconomic level containing information on national economy and the LFS is based on individuals. The only common element that links these two different datasets is the industry code (Standard Industrial Classification). In other words, the more detailed that ONS statistics could be decomposed was by industry, and the bigger that individuals could be aggregated was again the industry. Therefore level of analysis in this dissertation is the industry. According to the UK there are 80 main industry codes (See Appendices 2 and 3), where Primary, Secondary and Tertiary sector are further decomposed (eg. Forestry, Mining, Food Manufacturing, Computer Programming etc). However, in combining the two datasets, various modifications should take place, ending up with 61 industries for analysis. Each industry is defined by the commodities they produce and the services they sell. They are comprised by numerous firms, production units and services quarters. Industries tend to use different technology and have different capital composition among each other and have a completely different way of functioning in general. There are several concerns for focusing on an industry rather than a firm level, especially regarding technology homogeneity, measuring different kinds of capital, forming an aggregate production function for all etc. However, statistics and DEA have been used with specific treatment regarding these non-homogenous units. Generally, there are series of advantages and limitations following and industrial analysis.

2.4.1 Advantages of an industry level analysis

To begin with an industry is composed of numerous firms producing similar products, using the respective inputs, having their own cost, returns-to-scale etc. Although there are serious implications of aggregating different productive units - such as the assumption that an aggregate production function is the summary of the individual ones, or such as that the aggregate production function does not represent anything, except from an 'ideal' firm (see Chapter 5, Production Functions) – an industry indisputably bares some specific characteristics that a firm does not necessarily do. Without being able to opt for a firm specific analysis, 'compromising' with an industry level one has some certain advantages and disadvantages.

An industry is a complete entity, as it is comprised by all these firms competing for the market share of the specific commodities. This intra-industrial competition however has different features from the inter-industrial competition. This is important to highlight as the neoclassical school of thought does not distinguish these two different kinds of competition. In Marxian analysis distinguishing those two enables the study pf the different phenomena that take place. The intra-industrial competition establishes one uniform price. The 'Law of One Price' (Marx, 1959, p. 865) is described as below:

> '*Competition can only make producers within the same sphere of production sell their commodities at the same price'*.

This uniform market price combined with the different firm costs lead to different rates of profit for each firm leading them to face profits or losses. The neoclassical school of thought would refer to this point as the market structure of the industry with the leader and the follower. Contemporary contributions in mainstream analysis also incorporate this element. According to Mishra (2007) there is a series of advantages in an industry level analysis even in mainstream economics terms. '*A firm might be a price-taker in the factor market, but an industry might be a price-maker*'. Therefore the whole process of price making-taking is endogenised, allowing no externality. Although this dissertation is not concerned with prices (wages) and profits, the Gross Value Added (GVA) and Net Capital Stock (NCS) per industry consists of prices, not current, but expressed in chain volume measures. Thus, being a price-maker (industry) has less problems than be a price-taker (firm), facilitating us overcoming the difficulties that a price-taker has to face. For instance, an industrial bargaining outcome (workers' federation in the industry vs industrialists' lobbing) over working time and overtime remuneration, might find a firm incapable of adjusting to the new bargaining outcome and the firm might be inefficient or even close down. Increasing the number of inefficient units (in a firm level) would lead to further heterogeneity, eg HSBC (in banking sector) and Costa Café (in Food and Accommodation industry). However, the fact that in this dissertation the whole banking sector is compared to the whole food and accommodation sector internalizes the intra-industry competition. Therefore, what is an externality for a firm, it is an internality for the industry, even according to mainstream analysis.

With the Marxist analysis of intra-industrial competition, assuming homogeneity among firms is not necessarily, as heterogeneity (with different vintages of physical capital, different costs and different rates of profit) is the default situation. The neoclassical analysis is usually restricted in analysing firms or generally, what appears to be more homogenous entities. Therefore, they usually avoid an interindustry analysis of competition. One of the main reason is that the mainstream economics do not see homogeneity in commodities is that they regard them as goods subjectively valued, and this cannot be aggregated. Even within the tradition of Political Economy, particularly the New-Ricardian one, heterogeneity is an issue. Although Robinson (1947*, Essays in the Theory of Employment*) during the debate of Cambridge capital controversies raised a series of concerns regarding the mainstream ways of aggregating capital, among her detailed and grounded critique she highlights an advantage that an aggregate industrial analysis may have. Additionally, she argues that following an industrial analysis the know-how of production is widely diffused and differences in skill of management per firm becomes unimportant (1953, *The Production Function and the Theory of Capital*).

However, for the Critique of Political Economy, the different commodities in the national economy can be aggregated as values generated by abstract labour. Therefore, the inter-industrial analysis skips this extra level of micro-complexity enabling aggregation in the terms of working time, at least for labour. Regarding the different production costs that give rise to the different rates of profit and therefore the outcome-structure of the industry, there will be a default both intra- and inter- industry heterogeneity that by focusing on the latter is enabling us skipping an extra level of complexity.

According to Tsoulfidis and Tsaliki (1998):

'*the interindustry equalisation of profit rates implies that industries with higher capital requirements per unit of output (or labour) are expected to display profit margins on sales higher than industries with low requirements for unit per output (or labour)'*.

This implies that the former ones are expected to be the surviving ones for the 11 year period that we study, and particularly after the 2007-09 crisis. Again in Tsoulfidis and Tsaliki (1998):

'industries with higher capital requirements tend to respond to variations in demand more with variations in capacity utilisation and less by price changes. As a result these industries are expected to display relatively more stable prices, profit margins (on sales) and profit rates for every percentage change in demand'.

In this dissertation this would mean that these industries' changes in weights and contributions would reflect less a change it the capital and GVA price, and more a physical process. Additionally, Tsoulfidis and Tsaliki (1998) continue stating that '*these phenomena of competition (high profit margins, sticky prices and reserve capacity)*' of the high capital industries *'…are often interpreted as evidence of the presence of monopoly power, however these are precisely the expected, and therefore, normal results of the equalisation of profit rates between industries*'. In this dissertation, monopoly power in the market structure of the industry implies that, on the one hand, there might be a weaker bargaining power for employees and their trade unions, but on the other hand, lack of competitors, and therefore not a strong urge for the capitalist to extend employees' working day.

Additionally, using the Data Envelopment Analysis (DEA), enables the clearing of the data from inefficiencies. This means that even if an industry is at a phase of adjustment without fully utilising their resources, DEA provides a picture of how would this industry look if it was performing on the efficient frontier, compared always to another industry. DEA also provides industry-specific weights enabling also a more detailed analysis.

Subsequently, it is interesting to see if unpaid overtime is more prevalent in some industries, rather than in others. For instance, it is expected to be more prevalent in productive industries, such as Education or Health, rather than in Mining and Quarrying. Or industries that belong to the sphere of exchange, such as Finance and Commerce are also expected to have more unpaid overtime compared to Manufacturing. On the other hand, unpaid overtime is also expected to be more prevalent in industries where there is low composition of capital compared to industries of the sphere of production that the composition of capital is higher. For instance, it would be expected that employees in Textiles would work more unpaid overtime, compared to employees in Automobile industry. Additionally, industries where *manual* work is prevalent are less possible to be detected with unpaid overtime because both of their physical limits, compared to industries where mental work is more prevalent. Moreover, industries which still preserve the 'chain' form of production rather than a post-fordist way may also perform less unpaid overtime. For instance, employees in the finance sector are expected to work more unpaid overtime because of the flexibility of labour's organisation and the physical capacities, which are not exhausted so easily. However, this detailed industrial analysis is provided mainly by Data Envelopment Analysis (DEA), not statistics.

Apart from identifying the industries in which unpaid overtime is more prevalent, it is their very contribution to industries' output that ultimately counts in this dissertation. In other words, unpaid overtime might be more prevalent as a kind of labour in one industry, but have smaller contribution to output, and vice-versa. This would be an interesting finding that could verify one approach over the other regarding working time. For instance, in cases where less overtime is used but the contribution to output is high, a lower working day (short overtime) would be highly productive for capitalists, or in cases where more overtime is used but its contribution to output is smaller, Marxists and Weberians could be confirmed.

Regarding the use of DEA in an industrial level, there are issues to take into account. In DEA we can only know the contribution of industries that produce in at the efficient frontier level. DEA as a method compares all units among them finding those that use their inputs in an efficient level. Therefore, the input weights that are derived and their contribution to GVA will depend on the frontier defined by labour and capital working in different ways. The same labour and the same capital can be used in different ways. As we are going to see, on an aggregate level (industry), re-switching technologies is a possible scenario. Therefore, an industry can be a black box. However, the Critique of Classical Political Economy in combination with DEA that has also been used for more or less homogenous unities, could also be implemented in the case of analysing unpaid overtime in an industrial level.

2.4.2 Dealing with issues of industry level analysis

Capital Controversies

Apart from some advantages, there are some issues occurring by analysing all these industries in one go. There are issues with aggregating both labour and capital, with the latter being more challenging than the former. Therefore, the below paragraphs present the issues that arise and the way that this dissertation handles them.

To begin with, the different kinds of labour (skilled, unskilled, manual, mental etc) have a difficulty to aggregate. This is one of the main issues that the Critique of Political Economy addresses and has solved with the introduction of abstract labour. Therefore without making any breakthrough, abstract labour measured by working time contributions can act as the homogenous labour, enabling different intra-industry aggregation and inter-industry comparison over labour.

Although aggregating labour is quite common it either based on a wage level or on a working hours one, aggregating capital is even more difficult to handle. This is a question that occupied mainly the New-Ricardian view. According to Harcourt (1969)

> *'the first puzzle is to find a unit in which capital may be measured as a number, i.e., an index, which is independent of relative prices and distribution, so that it may be inserted in a production function where along with labour, also suitably measured, it may explain the level of national output'.*

However, as Harcourt (1969) describes, according to Robinson 'the basic reason is that it is impossible to conceive of a quantity of capital in general, the value of which is independent of the rates of interest (or, interchangeably, profit, given the present assumptions) and wages'. In fact he summarises that Joan Robinson therefore proposed to measure capital in terms of labour time; Working time 'sets of equipment with known productive capacities (when combined with given amounts of labour) were to be valued in terms of the labour time required to produce them compounded at various given rates of interest'.

Thus the same sets of equipment would have different values for each rate of profit and different sets would have different values at the same rate of interest. However, as it was mentioned before, at least for the high capital industries, the change over the years wold reflect mostly capacity utilisation and more physical changes instead of changes in prices and rates of profit.

Moreover, Robinson's proposal would be methodologically consistent for this dissertation with the difference that it is not the concrete labour that is aggregated but the abstract dead labour that capital represents. However, there are difficulties in national statistics preventing a potential 'calculation' of capital's valuation based on working time that is necessary to be produced. Therefore, capital is going to be expressed in price terms and not in purely physical ones.

Additionally, valuing capital based on working time is not a task that this dissertation aspires to solve. Therefore, while working time is used for describing labour contribution, it cannot be used (at this stage at least) for describing capital. Consequently, orthodox statistics are used in measuring capital's value transfer, with all the problematic 'market prices' that distort a purely technical analysis, at least for the non capital intensive industries.

The practice of orthodox statistics in measuring capital contains indicators, such as gross capital stock (GCS), net capital (NCS), capital consumption (CS) and gross fixed capital formation (GFCF). For instance, according to the ONS (2016), 'gross capital stocks tell us how much the economy's assets would cost to buy again as new, or their replacement cost'. In other words, it is evident that it is not counted based on how many average working hours this capital needs to be produced (*working time approach of measuring capital*), but on their market price. Market prices can hide the real 'abstract labour value' (Socially Necessary Working Time for a commodity to be produced – Marx, Capital Vol I), as it can contain supply shocks, monopolistic pricing and other factors that remove its price away from its real value (Fine, 1975).

Similarly, for ONS (2016) The 'Net capital stocks (NCS) show the market value of fixed assets' and 'they account for the depreciation in assets, so both the level and the rate of increase in the net capital stock will be lower compared with gross capital stock'. In other words, by using NCS, the 'problem' of market price is not resolved, but at least it is tackled by taking depreciation into account. It is not surprising that British statistical service does not use a Marxist statistic, but orthodox neoclassical ones, but still this creates an issue of aggregation. Additionally, based on the above description of capital, the most suitable variable derived from the mainstream statistics would be capital consumption. Since capital is used in the production process is a mere transfer of its value through the vintages, Capital Consumption from the Office for National Statistics (ONS) would appear to be the most suitable. However, in ONS, Capital Consumption is estimated based on an assumption of Gross capital's depreciation, and this ratio is standard for every industry. Therefore, capitals consumption would not vary over the years. Gross Fixed Capital Formation (GFCF) would be the next best variable to use, however, since it can take negative values it is not suitable for the following DEA and econometric analysis. Consequently, this thesis opts for the use of NCS as the most suitable statistic for capital. For more details see Chapter 3.

Apart from quantitative measure of capital composition hides qualitative features. Industries are not expected to have homogenous characteristics regarding capital composition either. Labour and capital can be combined differently within industries. There are labour intensive and capital intensive industries. For instance, textiles manufacturing is expected to be more labour intense, while Automobile industry is more capital intense. In the Marxist terms composition of capital is the proportion of active and passive components of capital. In other words, variable capital that is represented by labour is the active part, while constant capital, represented by the fixed and circulating is the passive one. Although we cannot completely account for the qualitative features of capital composition, a capital/labour ratio is provided for taking these different issues into account.

Generally in the Critique of Political Economy, there are three different indices that can describe the labour-capital ratio: *technical*, *value* and *organic composition of capital*. According to Marx (1894, The Capital, vol. III, p. 109)

> *'Two proportions enter into consideration under this heading (...) The first proportion rests on a technical basis, and must be regarded as given at a certain stage of development of the productive forces. A definite quantity of labour-power represented by a definite number of labourers is required to produce a definite quantity of products in, say, one day, and – what is self-evident – thereby to consume productively, i.e., to set in motion, a definite quantity of means of production, machinery, raw materials, etc (...) The difference between the technical composition (TCC) and the value composition (VCC) is manifested in each branch of industry in that the value-relation of the two portions of capital may vary while the technical composition is constant, and the value-relation may remain the same while the technical composition varies. ... The value-composition of capital, inasmuch as it is determined by, and reflects, its technical composition, is called the organic composition of capital (OCC)'*[17].

Although, the dissertation is focusing mainly on the technical part, it faces a

[17] Marx, 1894, The Capital, vol. III, p. 109

difficulty in expressing the labour-capital ratio in pure technical terms because of the way statistics are recorded. Despite that labour power input is expressed purely in technical way, capital and gross value added are inserted as market values that incorporate physical units as well. Therefore, the different labour-capital ratios could disable an analysis that focuses purely on technical or value terms. On the contrary, the dissertation is using a 'hybrid' of *technical* and *market value* composition of capital working time and the market value of physical capital input.

Apart from that, aggregating has been widely debated in the Cambridge controversies' discussion (Robinson (1947, 1953) and Sraffa (1975) against Solow (1956) and Samuelson (1987)) from the point of 're-switching' of technologies is quite possible. In other words, the same inputs can be combined differently giving different output. This would cause issues with the convexity assumption that DEA requires. Robinson (1947, 1953) and Sraffa (1975) argued that there is no monotonic relationship between the nature of the techniques of production used and the rate of profit; there can be a situation in which a technique is cost-minimizing at low and high rates of profits, while another technique of the same production is cost-minimizing at intermediate rates. However, the fact that this dissertation follows an industry, and not a firm level analysis, it may facilitate the assumption of monotonic production function, since at industry level re-switching techniques can be marginal.

Regarding industries' heterogeneity, the thesis concedes the obscurity by converting labour and capital to GVA differs by industry (and even within industry by operating unit). However, our aim is not to assess the industries on efficiency in a comparative manner and fair as in regulation where access to the same technology in principle within the black box matters for setting input targets. The boldest assumption that this dissertation makes is that ultimately each industry only uses capital and labour at a high level of aggregation to deliver GVA we want to see. Therefore the main questions attempted to be answered are:

a) Which industries deliver more GVA for given labour and capital?
b) At the efficient frontier what is the contribution of each type of labour to GVA

Can an aggregate production function be assumed?

According to the most representative authors of neoclassical economics, the variables of a 'good' aggregate production function should be decomposed. Following what Solow (1974) stated in (a) regarding this decomposition it should hold that:

> *'When someone claims that aggregate production functions work, he means (a) that they give a good fit to input-output data without the intervention of data deriving from factor shares; and (b) that the function so fitted has partial derivatives that closely mimic observed factor prices.' , (and)..(c) ...technical change is always represented by a smooth function of time (or something else) and part of the test is whether the residuals are well-behaved'.*

Solow who introduced the use of aggregate production function proposed that it can act as a summary of the individual ones. However, for all the previously mentioned reasons, aggregation can be disputed that represents an 'ideal' firm.

Additionally, although the production function dependent on both capital and labour, F(K,L) is considered to be an absolutely fine expression in neoclassical economics, the CPE has considered only labour as the only productive force, F(L). Although, in the following DEA and econometric analysis capital is included, it is not going to be interpreted as capital's contribution, but as value transferring process.

Another point worth-mentioning is that, as stated before, the sphere of production is different from the sphere of distribution. However, in neoclassical economics, the simple production function F(K,L) is used to assess sources of i) growth in output and ii) distributional outcomes (profit, wage by marginal products of capital and labour). Although, we focus extensively in output's growth and its main components, at this stage, distributional outcomes are totally ignored at this dissertation. In fact, the labour variable is expressed only in working hours and the capital as the Net Capital Stock (NCS). Both express sizes that are 'invested' rather than sizes that are 'consumed' in production.

As Laibman and Nell (1977) well summarise,

> '*the controversy [see above Capital Controversies] has shown that, (...) it is not possible to consistently relate capital goods (in the theory of production) and capital funds (in the distribution of income to property ownership) within a comprehensive supply and demand framework that rules out social relations other than market relations grounded only in exogenously given technology and preferences*'.

Another issue with the aggregate production function is related to the assumption of one-sector economy is not representative of the economy with more sectors. As Fine (2016) argues 'we cannot have knowledge of distribution only because we know the technology' demonstrating that the introduction of another sector leads to different results regarding distribution outcomes (wages, profits etc). In other words, the distribution between labour and capital, i.e. wages and rates of profit, differ substantially when the one sector economy assumption is violated. The previously presented proof on wages in developed and developing countries is an example of that. Aggregating production function has problems mainly in variables that are socially distributed.

However, once again, in this dissertation, wage and profits are not assessed at all, and the input-output function is not acting as a production function with distribution implications, liberating the current analysis from such restrictive and unrealistic assumption. In other words, production function here is perceived as a narrowly technical function without implications in the sphere of distribution. Consequently, this dissertation behaves more of an engineer takes assumed prices and first selects inputs and then determines quantity, rather than of an economist who would be concerned with the varying prices upon production combinations.

Production Function: Is a Cobb-Douglas appropriate?

There are different mathematical expressions of aggregate production function that could be used: Constant Elasticity of Substitution (CES), Cobb-Douglas, Leontief, the Linear production function and the Transcendental Logarithmic (Translog). The CES is the function that encompasses the Cobb- Douglas, the Leontief and the Linear production functions as its special cases[18], while the Transcendental Logarithmic (Translog) production function is a generalization of the Cobb–Douglas production function[19]. However, a question arises, which one is the most appropriate for analysing aggregated economy.

To begin with, the CES, there are some difficulties that arise when more than two inputs are used in production. 'For three inputs there would be three elasticities and for more inputs there would be many more'[20]. This is a major issue in this dissertation,

[18] If Elasticity of substitution:
=1, Cobb Douglas
$=\infty$, Linear production function
$\rightarrow +0$, Leontief or perfect complements production function
[19] As Berndt and Christensen (1973) have demonstrated.
[20] A Brief History of Production Functions, SK Mishra, North-Eastern Hill University, Shillong (India), 9. October 2007

measuring the contribution of four different variables: capital, basic working hours, paid and unpaid overtime. However, Uzawa (1962) and McFadden (1963) proved that it is impossible to obtain a functional form for a production function that has an arbitrary set of constant elasticities of substitution if the number of inputs (factors of production) is greater than two (impossibility theorems of Uzawa and McFadden). Uzawa (1962) demosnstrated that

> '*the only possible n-factor production functions (n>2) with constant partial elasticities of substitution require either that all elasticities between pairs of factors be identical, or if any differ, these all must equal each other and all remaining elasticities must be unity'*.

This immediately makes the CES function impossible in this dissertation.

As for the fixed proportions production function (*Leontief* production function) there are issues occurring as well. The Leontief implies the factors of production will be used in technologically pre-determined proportions, since there is no substitutability between factors. On the contrary factors act as perfect supplements. This is obviously true in principle, as no capital can operate without labour. Therefore, they can only be analysed as complements, not substitutes. However, what this dissertation is interested in is the way that they are combined. A useful concept is as we already discussed the Marxist category of the organic composition of capital. This provides not only usefull information on the firm, industry, country, ect. but also to relate one industry with the other providing the very factor that capitalist crisis are expressed; the falling profitability that is already discussed is partially the outcome of an increasing organic composition of capital (g=c/v). However, in mainstream analysis this is expressed by the MRSs. Although marginal analysis is the selling point of the neoclassical school of thought, it is not alien to a Marxian analysis though. Particularly, this dissertation uses marginal analysis between labour and capital as expressed by Marx in Volume III, Chapter 15:

> *'There would be absolute over-production of capital as soon as additional capital for purposes of capitalist production = 0. The purpose of capitalist production, however, is self-expansion of capital, i.e., appropriation of surplus-labour, production of surplus-value, of profit. As soon as capital would, therefore, have grown in such a ratio to the labouring population that neither the absolute working-time supplied by this population, nor the relative surplus working-time, could be expanded any further (this last would not be feasible at any rate in the case when the demand for labour were so strong that there were a tendency for wages to rise); at a point, therefore, when the increased capital produced just as much, or even less, surplus-value than it did before its increase, there would be absolute over-production of capital; i.e., the increased capital C + ΔC would produce no more, or even less, profit than capital C before its expansion by ΔC. In both cases there would be a steep and sudden fall in the general rate of profit, but this*

time due to a change in the composition of capital not caused by the development of the productive forces, but rather by a rise in the money-value of the variable capital (because of increased wages) and the corresponding reduction in the proportion of surplus-labour to necessary labour.'[21]

Provenly, capital has been used over the years to substitute labour to reduce production cost. Consequently, Leontief is not an appropriate kind for this dissertation. Especially, if we take into account the Marginal Rates of Substitution (MRS) between capital and labour, Leontief would not allow such analysis. Additionally, this thesis is analysing 3 labour variables (basic hours, paid overtime and unpaid overtime), which are perfect substitutes to each other. Consequently, the use of Leontief production function is not suitable for this dissertation.

As for a Cobb-Douglas production function, it is based on certain assumptions regarding an input-output transformation. Homogeneity is the first property of the function, wage and rate of profit act as partial derivatives of labour and capital, while time acts as a neutral variable. Apart from homogeneity that has already been discussed previously, the latter two properties are needs further analysis.

It has been widely argued that Cobb-Douglas is not necessarily an economic production function but an algebraic form for any input-output data (Shaikh 1974). This means that Cobb-Douglas should not be used for interpreting variables determined in the sphere of distribution (wage and profits). This section is important because according to the Critique of Political Economy, production is not regarded as a mere transformation of inputs to outputs, but as a mode of production with specific production relations among the different classes. However, since this dissertation focuses only on the technical part of production, adopting the Cobb-Douglas specification should not cause major methodological deficiencies, since it is not assume to define production factors.

In addition, Cobb-Douglas has been highly critiqued for representing an approximation of the National Income Identity, leading to a misinterpretation of the 'good fit' in the empirical models (Shaikh, 1974). However, the response to this argument is coming from a neoclassical analysis, focusing mainly on the technically critiqued of Shaikh's arguments not addressing the fundamental arguments of the latter. More specifically, Felipe and Holz (2001) argue that all aggregated production functions are different approximations of the National Income Identity. Additionally, they highlighted that

[21] Marx (1959) Vol III, p.360

'the contribution of spuriousness to a high R^2 is minor once they properly account for a fact that input and output data used in production function estimations are linked through the income accounts, ie Output equals wages plus profits in value terms'.

However, this dissertation skips the association of factor contributions to their payments, concluding that Cobb-Douglas is robust to relatively large variations in factor shares.

As it has already been described, the figures in ONS' spreadsheets that are used for this empirical analysis are based on output GVA and are not balanced to the income and expenditure measurements of GVA. According to ONS (2015, *Gross Value Added*).

'These estimates of Gross Value Added (GVA) are compiled using the production approach (GVA(P)), whereby GVA is calculated for a given reference period as the total value of all goods and services produced (output), less goods and services used up or transformed in the production process, such as raw materials and other inputs (intermediate consumption)'.

This is a new experimental method that the ONS uses[22] . In a similar logic, capital seems to be expressed better with the Net Capital Stock rather than with capital consumption, as described in Chapter 3. Net Capital Stock (NCS) is arrived at by Acquisitions of new/existing fixed assets less Disposals of fixed assets plus certain additions to the value of non-produced assets[23].

Apart from the use of Cobb-Douglas, this dissertation is also considering the use of Translog production function in order to tackle issues of non-linearity in inputs' contribution and to exclude the doubt of omitted variables. Although the number of parameters increases dramatically as the number of considered production factors increases, this would create further collinearity issues. This thesis uses translog to detect

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[22] According to ONS (2015, *Gross Value Added*) 'The GVA(P) measure is principally designed to provide 'real' estimates of GVA growth, with the effect of inflation *removed, via chained volume measures (CVM). The CVM are presented as indices referenced to equal 100 in 2012 (...) Unconstrained estimates are still available in separate tables, as these estimates present a more accurate picture of the relative performance of different industries within a given region (since they are not affected by the coherence adjustments applied to certain industries in order to balance the SUT nationally). Users should note, however, that owing to the use of output deflators these unconstrained estimates show real growth in output rather than real growth in GVA. It is therefore not appropriate to compare these unconstrained estimates across different regions or with the UK as a whole. ONS is developing SUT in previous years' prices, which should provide industry-level deflators that can be applied directly, removing the need to constrain the regional estimates to ensure consistency with the UK figures. It is expected that this development will be completed by 2017, resulting in a single regional real GVA dataset from December 2017*.'

[23] The latter is the act of selling an asset usually a long term asset that has been depreciated over its useful life like production equipment.

the different non-linear ways that production inputs are linked with each other.

After having reduced the links of the variables that are used with the National Income Identity and after taking into account non-linear forms of production, Cobb-Douglas can be used as a basis of comparison as the most typical case of aggregate production function that requires the least assumptions. Despite Cobb-Douglas' strong link with the neoclassical theory, there are some ways that can make it a useful tool for heterodox schools of thought. It is a simple kind of input-output function that allows the use of more than two variables, it does not assume perfect complementarity between variables and does keeps collinearity levels to the minimum compared to translog. However, translog is used complementary to Cobb-Douglas for detecting if with non-linear interaction of inputs-output and within inputs we still have omitted variables.

Although Cobb-Douglas requires constant returns to scale in order for factor shares are to be equal to their marginal productivity, in this dissertation the lack of this assumption disables such an equation. However, in the statistical part of analysis the assumption of systematic returns of scale throughout the 60 industries and for 11 years is inevitable. As it has already been highlighted production can have different returns for each initial set of inputs and their increase in proportion. In addition, the dissertation does not assume perfect competition. Therefore, another pre-requisite assumption for inputs' marginal product to equal their factor prices is not valid.

2.4.3 Productive–Unproductive Labour and Productive–Unproductive Industries

Neoclassical economics tend to analyse all kinds of labour like equally contributing in the output of economy, while the Political Economy (Adam Smith) and its Critique (Marx) make a separation between the 'P*roductive*' and '*Unproductive*' labour. There is a lot of literature dealing with the labour's decomposition into occupations and/or industries predominantly productive activities and those predominantly with unproductive. In the UK, focusing on occupations and the Standard Occupational Code (SOC) would probably give more precise results, but focusing on the Standard Industrial Classification (SIC) would provide a variety of results. In this dissertation, as mentioned before, we focus on the industry level.

Although, the definitions vary according to scholars, in this dissertation, Mohun's (1996) approach is adopted. According to Mohun (2002, p.205-6)), productive labour and productive industries are those that

> *'add new use-value or alters the existing one, and the process of production produces surplus-value, but not consume it'.*

Thus, industries like Finance and Commercial industries according to this definition are unproductive industries because they use surplus-value produced in previous stages, like Manufacturing. Roughly, both industries' output and profits with respect to labour and capital have different qualitative characteristics in the different industries.

For instance, most economists are aware that agriculture depends on natural processes. In agriculture, according to Hegel (1991, p.203)., 'the main part is played by nature, and human industry is subordinate to it'. According to Sayers (2007) for Hegel and Marx agriculture is 'formative'.

> '*Although it uses natural processes in doing so, its results are not the products of such processes alone, as Benton at times appears to suggest; rather they are use-values that embody human labor'.*

Although the agriculture industries will be part of industries' mapping between productive and unproductive labour, belonging to the former category. Agriculture industries will be also included within an aggregate and more blur analysis, but they are not going to be included in the 'traditional' mapping between agriculture, manufacturing and services due to practical reasons; few observations to stand on their own.

Similarly, Sayers (2007) analyses manufacturing or previously defined as 'craft work' as

> '*less reliant on natural processes and less dependent on natural contingencies. It involves the creation of a material product by the direct activity of the worker. It is thus a directly formative activity…Craft work is the basis upon which industry develops. Under the impact of capitalism, first the division of labor and then the character of the labor process itself are transformed…With the introduction of machinery, the labor process itself is altered. The relation of subject and object is changed. This is what Marx calls the "real subsumption" of labor under capital (1976, 1023–1025, 1034– 1028). In craft production, the worker controls the tool. In industrial production, the tool is taken out of the worker's hands and operated by the machine. The craft element is progressively eliminated from the labor process (Marx, 1973, 705). The industrial factory and the production line are created'.*

Apart from the role of labour in production, in most manufacturing industries there is productive labour and generally surplus value extraction. Therefore, manufacturing industries will be included in the productive category of the mapping between productive-unproductive and on their own in the traditional mapping between agriculture, manufacturing and services.

Additionally, in developed capitalist economies new forms of work that seem to have no relation at all to the creation of material (not necessarily tangible) products or the satisfaction of material needs. These include commercial, administrative and other kinds of service work. As it has already been mentioned, these kinds of activities consume the surplus value produced in the sphere of production. Thus they consist unproductive labour. Therefore, in the following chapter(s) industries like finance, public administration, wholesale trade etc. will be mapped in the unproductive category of the mapping between productive-unproductive. Moreover, some of the industries that belong traditionally to the wide category of services, like computer programming will be mapped in the productive category. However, regarding the neoclassical traditional approach, all services will be mapped together regardless of the fact if they produce surplus value.

Moreover, even within the same industry (e.g. manufacturing) there is also productive and unproductive labour according to Marxist analysis. For instance, a labourer is a kind of occupation that produces new use-values and their process of production produces surplus value, while a secretary within the same firm consumes this surplus value produced by labourer. However, since this research focuses on an industrial analysis, we are going to assume that each industry has homogenous regarding the labour it uses.

Consequently, apart from this aggregated economy analysis, industries' are also mapped in specific groups; one grouping is with the traditional division between manufacturing and services, and the other grouping is between productive-unproductive industries derived from the paradigm of the Critique of Political Economy in order to detect the industry-specific features regarding working time, unpaid overtime etc. This grouping takes place since 'participation in production does not mean participation in the creation of value' (Pochkin 1971, p.71), and therefore different patterns are generally expected in the contribution towards industries' output. Therefore, DEA and regression analysis are used in this different mapping.

Productive labour, in its meaning for capitalist production, is wage-labour which, exchanged against the variable part of capital (the part of the capital that is spent on wages), reproduces not only this part of the capital (or the value of its own labour-power), but in addition produces surplus-value for the capitalist. It is only thereby that commodity or money is transformed into capital, is produced as capital. Only that wage-labour is productive which produces capital. (Marx, Capital, Vol IV, p. 152).

Marx borrowing a definition from Adam Smith defines as productive labour this 'labour which is directly exchanged with capital' (Marx, Capital, Vol IV, p. 157), while 'unproductive labour is not exchanged with capital, but directly with revenue, that is, with wages or profit (including of course the various categories of those who share as co-partners in the capitalist's profit, such as interest and rent) (Marx, Capital, Vol IV, p. 157).

However, there is a need to clarify that these definitions are therefore not derived from the material characteristics of labour (neither from the nature of its product nor from the particular character of the labour as concrete labour), but from the definite social from, the social relations of production, within which the labour is realised (Marx, Capital, Vol IV, p. 157).

More specifically, according to the Critique of Political Economy, Marx categorises three types of labour as being unproductive. Although the first category of unproductive labour includes the labour of (re)producing labour-power, when he explains himself mentions that productive labour would therefore be such labour as produces commodities or directly produces, trains, develops, maintains or reproduces labour-power itself. Therefore, anything that does not produces commodities or directly produces, trains, develops, maintains or reproduces labour-power itself would be allocated to the unproductive. In other words, apart from manufacturing where new commodities are produced, industries like health and education can also be included in this category, especially when are used for surplus value production. Despite the prominent Marxist economist David Harvie's emphasis on not including the latter, like Adam Smith excludes the latter from his category of productive labour, this dissertation following Marx's further explanation includes analyses both manufacturing only and manufacturing with industries like Health and Education in the productive ones.

The second category of unproductive labour that Marx identifies is the labour of superintendence of others' labour, as distinct to the labour of organisation of others' labour (Marx, The Capital, Vol IV, p. 505). In other words, inspectors, supervisors, administrative etc. are regarded as unproductive. Although in an industrial level it is almost impossible to purify these kinds of labour, since they exist in every productive industry, this dissertation is analysing the whole industry as either productive or unproductive. Additionally, based on this definition industries like Public Administration are included in the unproductive category.

Thus the third category of unproductive labour is that involved in the circulation of commodities. In other words, Retail and Wholesale trade are the typical examples of this kind of industries. The main reason for this group is that 'the content of his labour creates neither value nor products' (Capital, Vol IV, p. 290). In this category industries like Finance, Marketing and Advertising, Insurance and Auxiliary to Financing are also included for the same reasons.

In both cases, productive-unproductive labour, wages are still determined by distribution and the class-struggle over wages, rather than the production itself. Therefore, the distinction between productive-unproductive is not taking place with respect to employees' remuneration but because different patterns of working day extension (including overtime) are expected, and measuring their contribution could also reveal different behaviours among industries.

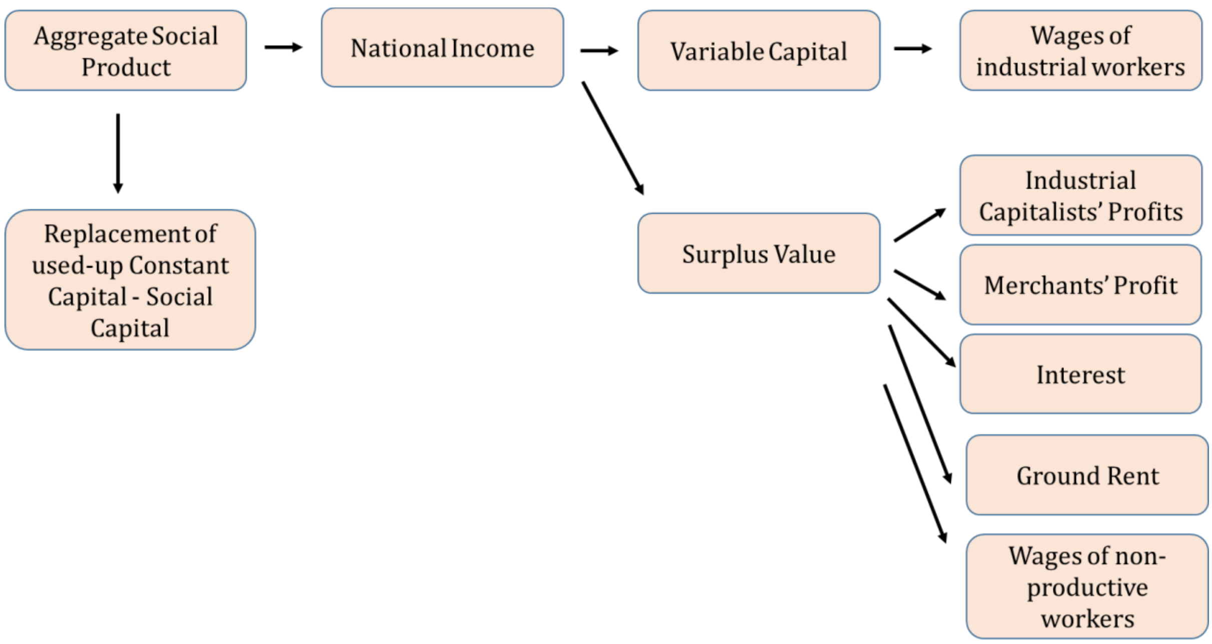

Figure 2.9 – The Detailed Marxist Decomposition of the National Product

The categorisation into productive-unproductive industries is important when it comes to aggregate the national product. The mainstream analysis aggregate any economic activity as equally contributing to the national output, however according to

CPE and its Critique some industries produce and others consume the product. The ONS statistics have an issue to face as there is no uniform way to calculate GVA per industry. Therefore, ONS's mainstream statistics use a 'hybrid' method of calculating it, by combining production approach, GVA(P), and income approach, GVA(I). More specifically, these mainstream statistics rely on income data and data on intermediate consumption to construct a measure of value added of industries (For more details see Chapter 3) that according to the Critique of CPE do not add value, but instead consume. Generally, according to the Marxist analysis what is produced by the workers in the productive industries is allocated in every sphere of the economy, supplying the capitalists with income (appearing as Gross Operating Surplus) and the salaries if employees of the unproductive industries (See Figure 2.9). Generally, the orthodox statistics exactly because they are ideologically biased in favour of the subjective theory of utility value, attribute value to everything with utility value, even if they do not fulfil the requirements for commodity production.

To sum up, working time becomes the common measure of abstract labour's contribution, regardless of the neoclassical and new-Ricardian debate over the lack of homogeneity. Since capital cannot be measured in working hours with current statistics, its market price will be taken into account, without avoiding the fluctuations of rates of interest, except from the capital heavy industries that possible changes will reflect capacity utilisation, and not market changes. Although there is an an aggregate production function, what appears as capital's 'product' in fact it is translated as a value-transfer. Additionally, the focus on inter-industry completion (instead of intra- one) is enabling an analysis with less assumptions. Generally, the question to answer is how much does overtime (as a form of absolute surplus value extraction) is contributing to the output of the UK economy for the years 2002-2012?

Chapter 3: The Data: filtering, organising and extrapolation of individual to industry level

Table 3.1 – Outline of Data

CHAPTER 3: THE DATA	Filtering, organising and extrapolation to industry level	Working Time, Unpaid Labour, Unpaid Overtime and Different Ways of measuring labour's contribution
Existing Databases	*Data about the kinds of unpaid labour in the UK*	• *Labour Force Survey (LFS)* • *Office of National Statistics (ONS)*
Labour Force Survey (LFS)	*Labour Force Survey: Filtering, Cleaning and Conversion of data from individual level to industries' level*	• *Filtering and cleaning data* • *Generating variables and converting individual to industrial level* • *Mapping Standard Industrial Classification (SIC) codes 1992 with SIC 2003 and SIC 2007, transforming weekly to annual data and Survey to Population*
Office of National Statistics (ONS)	*ONS data for industries' output and capital per industry*	• *Gross Value Added (GVA) in Office of National Statistics (ONS)* • *Net Capital Stock (NCS) in Office of National Statistics (ONS)*
Descriptive Statistics	*Descriptive statistics of the production variables*	• *General Descriptives* • *Correlation* • *Outliers* • *Annual tendencies of data*

3.1 Data about the kinds of unpaid labour in the UK

There are several large surveys whose data can be used in order to conduct a complete analysis about time which is spent in every kind of unpaid labour: the Labour Force Survey (LFS), the Quarterly Labour Force Survey (QLFS), the British Household Panel Survey (BHPS), the UK Household Longitudinal Study (UKHLS) and the Citizenship Survey (CS). Except from them, the Business Structure Database (BSD) offering statistics about industries' revenues, the Office of National Statistics (ONS) offers statistics for the GDP, the Gross Capital Stock, the Net Capital Stock, the Capital Consumption, and the State Expenditure.

According to ONS's manual (2015, p.2) on LFS

> *'output from the LFS is quarterly since 1992. Each quarter's sample is made up of five waves. The sample is made up of approximately 40,000 responding UK*

households and 100,000 individuals per quarter. Respondents are interviewed for five successive waves at three-monthly intervals and 20% of the sample is replaced every quarter. The LFS is intended to be representative of the entire population of the UK. LFS quarterly data sets are provided to Government Departments and are available to approved researchers via ONS's Virtual Microdata Laboratory (VML) and the UK Data Archive, Essex University.'

There are also other surveys that could be used for similar purposes, such as the British Household Panel Survey (BHPS) covering 5,500 households, and its predecessor United Kingdom Household and Labour Survey (UKHLS) covering 40,000 households or 100,000 individuals containing information about the amount of time which is spent in domestic labour as well. Additionally, the Citizenship Survey (CS) covering 10,000 adults in England and Wales and 5,000 adults from minority ethnic groups containing data about the amount of volunteering hours annually, and especially the proportion of employer's volunteering. The Business Structure Database (BSD) covering over 2 million enterprises, out of an estimated total of 4.3 million of the UK total is also a very useful source of information, however with restricted access to students and researchers. The focus of this dissertation in the workplace, LFS is used as the main source of information.

Additionally, we use Office of National Statistics (ONS) also in order to derive the output produced in each industry (GDP per industry), as well as data about Gross Capital Stock, Net Capital Stock and Capital Consumption per industry.

As it has already been mentioned the focal point of this dissertation is on the industry level. LFS and ONS can be linked only through an industrial level. Particularly, there are categorical industries for which the data availability range is between 1997 and 2012. The ONS datasets usually divide the UK economy to 61 industries (Appendix 2 and 3), while the surveys' datasets use the Standard Industrial Classification (SIC). However, this is also an issue to be addressed, since some industry codes are represented in one dataset, but not in the other. Therefore arrangements need to be made. Generally, the only way to link individual-based surveys on overtime payment with the other production variables, such as capital and output is to conduct an industry analysis. The Labour Force Survey contains data on individuals occupied in each industrial classification and region of Britain. On the other hand, the most detailed that ONS can become is to get GVA/capital by industry or region. Therefore, between these two an industrial analysis is chosen because it contains more information.

Apart from that, the combination of two different datasets is a challenging issue. Particularly, ONS data contain facts and figures for the whole UK economy, while the abovementioned surveys only for some thousands of individuals or household. Consequently, there are some assumptions to be made in order to bring together all these databases. For instance, aggregating working hours, paid and unpaid based on data form LFS it is representative for the whole population is a necessary assumption for extrapolating the LFS data into national level. This process is also facilitated by ONS that makes their own estimations regarding the total working hours. This process will be further explained later in the thesis. However, extrapolating data to a national level is also a task that ONS is already doing with most surveys, including the calculation of total working hours per industry. The difference with this dissertation's extrapolation in an industrial is that ONS is conducting it in a regional level. Consequently, there will be some differences.

3.2 Labour Force Survey: Filtering, Cleaning and Conversion of data from individual level to industries' level

3.2.1 Filtering and cleaning data

The availability of overtime information on a quarterly basis starts in the year 1997, but due to inconsistencies with the SIC codes and the data regarding weekly payment of working hours, including overtime this dissertation focuses on an 11 year period, from 2002 to 2012[24]. LFS contains a lot of information on working variables and conditions using information that is gathered at household level and containing information on individuals out of labour force. It was necessary therefore to filter the data by dropping those out of labour force, and keeping those in. There were several ways to drop those that do not actually work. The first and most apparent way is to drop the occupation status variable that is not matched with those of employees (LFS variable: inecac05). By filtering this variable, we end up having only employees with dependent labour contracts only[25]. Furthermore, self-employed have been dropped from the research, since the main

[24] LFS contains also data with odd values. For instance, there were cases where employees had negative weekly payment, eg values like -15, that are not within the range of acceptable responses. But LFS is still including these individuals as valid respondents. These odd responses can be attributed mainly to human error, and therefore, individuals like this were also excluded from the research of this thesis.

[25] However, there were several observations in the survey, where individuals appeared to be employees with 0 working hours. Not to be confused, this is not related with the so called zero-hour contracts, but with the fact that those 'employees' are working 0 hours in a week on a usual basis. Moreover, there were employees with completely undefined work hours. Although they could consist of zero-hours employees, there was completely no information on their usual working week or at least the last working week they

focus of this dissertation is employees with dependent employment, as it is presented in Chapter 2. Generally measuring difficulties regarding their working time and overtime patterns disqualifies them from being included in this analysis. Additionally, as it has already been mentioned, both full time and part time workers are included, mainly due to the high percentage of part-time employment.

Regarding the individuals who participate in the Labour Force Survey, there is a regional weight that they are assigned with. According to the ONS Information Paper, (2015, p.2)

> '*The LFS uses calibration weighting. The weights are formed using a population weighting procedure which involves weighting data to sub-regional population estimates and then adjusting for the estimated age and sex composition by region (income weighted separately. Estimation to population totals and projections based on the Census*.'

However, these individual weights are not used since individuals were added up by region, thus what we are interested in is an industry weight, and not a regional one. To test this summation there is a comparison made between the percentage of employees per industry derived in this approach and the percentage that ONS has already estimated.

Another think that needs to be taken into account when creating an industrial extrapolation is that it focuses only on employees. The regional weights are created to include the unemployed, those out of the labour force etc., because LFS is a household based survey containing information on every member of the household. Therefore, this industry derived participation percentage is different in a lot of aspects from ONS's, but not completely irrelevant. For more details see Table 3.2.

Step 1: Generating variables

Not every variable in the LFS is in the form that we want to use it. More specifically, overtime and unpaid overtime might be provided, but there are few individuals providing this information. The LFS contains information about the Total Working Weekly Hours including overtime (TTUSHR) and the Basic Working Weekly Hours excluding overtime (BUSHR). Therefore, overtime hours were derived by subtracting these variables Basic Hours from the Total ones:

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were ever occupied. These undefined individuals were also disqualified and dropped from the dataset. For more details see Appendix 4.

$$overT = TTUSHR - BUSHR \quad (3.1)$$

However, overtime is combined by both paid and unpaid hours. Additionally, the database does not include the precise rate in which overtime is paid eg. £8 per overtime hour. In fact, there are 4 different groups (OVRTME1) in which overtime payment can be mapped: i. If the variable OVRTME1was valued by 1, overtime hours were equally paid to the basic hours ii. If the OVRTME1 variable was valued by 2, overtime hours were paid more than the basic hours iii. If the OVRTME1 was valued with 3 were paid less, and if it was valued with 4 the respondent did not know the overtime compensation. However, the majority of the respondents with positive overtime hours were valued with -9, which means that overtime payment was not applicable. In other words, overtime payment is not remunerated at all. As it has been explained before, this dissertation defines the non-applicability of overtime payment in positive overtime hours as unpaid overtime. Therefore, five (5) new variables were generated:

$$unover=overT \text{ if } OVRTME1 == -9 \quad (3.2)$$ [26]
$$paidover1=overT \text{ if } OVRTME1 == 1 \quad (3.3)$$
$$paidover2=overT \text{ if } OVRTME1 == 2 \quad (3.4)$$
$$paidover3=overT \text{ if } OVRTME1 ==3 \quad (3.5)$$
$$paidover4=overT \text{ if } OVRTME1 ==4 \quad (3.6)$$ [27]

Step 2: Collapsing individual variables to industrial level and generating an average employee per industry

After generating these new variables, their values are collapsed based on industry. However, this aggregation represents only a usual working week of all employees in the same industry in the respective quarter, and also the usual working week of an average employee. They are collapsed both as a sum and as a mean, keeping also record of the frequency of observations per industry.

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[26] In the LFS OVRTME1=-9 means that payment is not applicable. Therefore, it is assumed that there is no payment.
[27] Therefore, from LFS there are three (3) variables used and five (5) newly derived:
Total Working Weekly Hours including overtime (TTUSHR)
Basic Working Weekly Hours excluding overtime (BUSHRS)
Weekly Overtime Hours (overT)
Unpaid Overtime Hours (unover) - DERIVED
Paid Equally to Basic Hours (paidover1) - DERIVED
Paid More than Basic Hours (paidover2) - DERIVED
Paid Less than Basic Hours (paidover3) - DERIVED
Don't know (paidover4) - DERIVED

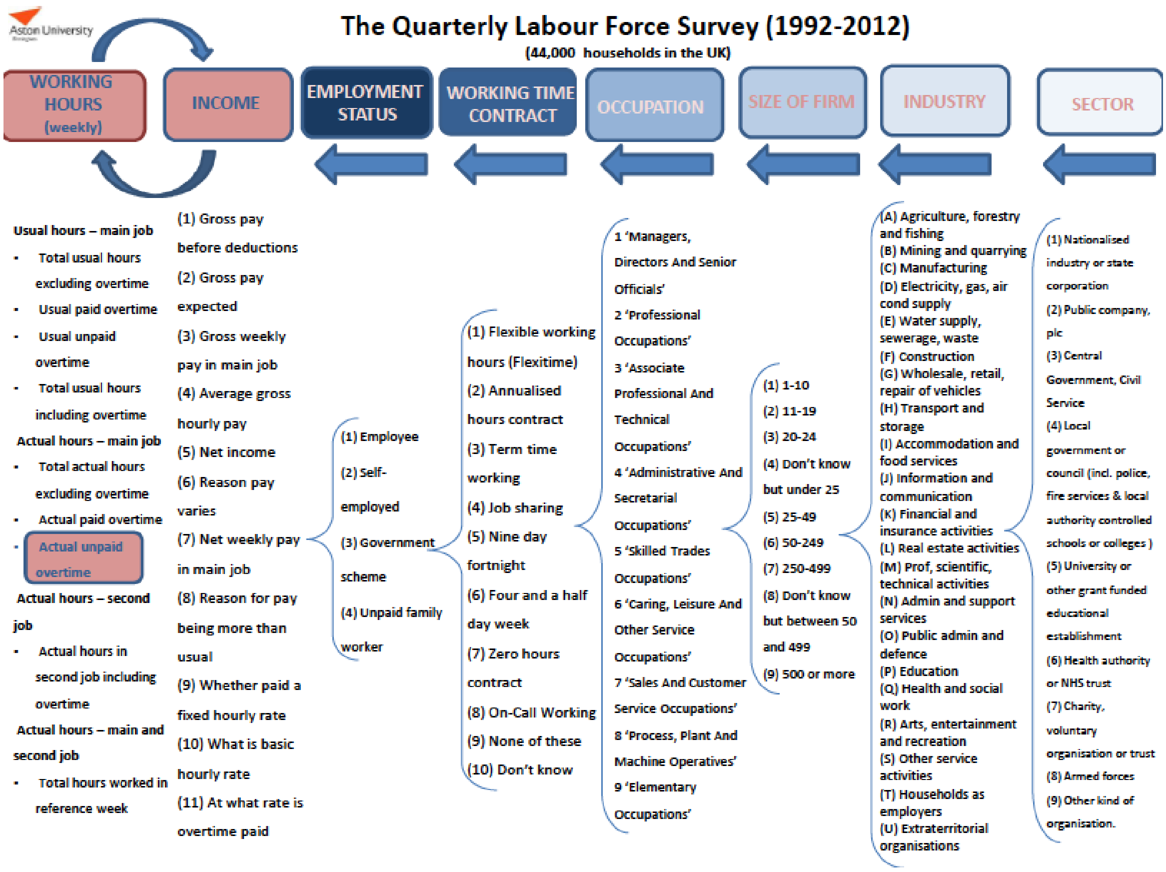

Figure 3.1 – The Structure of Labour Force Survey

Source: Retrieved from the Quarterly Labour Force Survey, 1992 – 2012

Step 3: Merging different waves of the same quarter

Additionally, there are five (5) waves of the Labour Force Survey that cover the very same quarter of a certain year. Each quarter is actually surveyed 5 times. However, only 2 out of 5 contain information about the net weekly and gross weekly payment (1st and 5th wave). Although, these variables are not used in this dissertation, they are kept as filtering variables that allow us to see if employees are actually paid or not (see above). Because, as it has been mentioned before, there are cases with negative payment that have been dropped. Therefore using weekly payment as a variable for filtering the responses in working time and overtime has been proved to be useful. Moreover, 20% of every sample (with 5 waves) is substituted by new participants in the survey. Therefore, the sample of a quarter that contains all the necessary information in the 1st wave is 80% substituted by another sample of the same quarter whose information is in the 5th wave.

In other words, the two (2) samples over the same quarter that are used in this dissertation contain information on majorly different individuals. Therefore, the values of the chosen variables are merged by being *added up*. Thus, an increased number of observations is achieved per quarter, leading to more accurate results.

Step 4: Mapping Standard Industrial Classification (SIC) codes 1992 with SIC 2003 and SIC 2007

Each industry in the UK has a specific industry code. These codes diachronically change depending on industries' changes, births or deaths. The industry codes in the UK were different in 1992-2003 compared to 2003-2007, and they changed again for 2007 onwards. Despite these changes, the Standard Industrial Classification (SIC) 1992 was used until 2008 and mapped simultaneously with SIC 2003. According to SIC 1992 there are 62 industry codes with 461 subgroups, while the SIC 2007 that is used after 2009, contains 99 industry codes. Consequently, we need to bring together these different codes creating a new mapping of the industries, since the data that this dissertation focuses on start in 2002 and end in 2012. In particular, the 461 sub-industries of SIC 1992 and SIC 2003 were mapped to industry codes of SIC 2007 measured up to 99 (See Appendix 2and 3). Therefore, consistency in codes is achieved among the different years that are studied.

However, this step has some challenges due to the fact that some industries are not defined as explicitly or have 'died' or have been merged with another industry from a completely different industry division. Below the most challenging industries are presented regarding their old mapping and the new industry code. This step is necessary because some industries of the LFS before 2009 cannot be mapped properly due to the fact that they overlap. For instance, according to SIC2007 the industry *33. Repair and installation of machinery and equipment* in our analysis is collapsed with industry *30.Manufacture of other transport equipment*[28] because parts of the repair were included before in manufacturing of equipment. Moreover industry *39.Remediation activities and other waste management services* is merged with industry *38.Waste collection, treatment and disposal activities; materials recovery*, since before 2009 they were in the same

[28] There are three industries merged in this:
31. Manufacture of Furniture
32. Other manufacturing
33. Repair, Installation

division, and the LFS had no data for code 39 separately. Additionally, industries *41.Construction of buildings* and *42.Civil engineering* are merged with industry *43.Specialised construction activities* for the same reasons.

Moreover, some industries are dropped since there are no data in the ONS statistics that the dissertation seeks to map LFS with. For instance, industries *97.Activities of households as employers of domestic personnel*, *98.Undifferentiated goods- and services-producing activities of private households for own use* and *99.Extraterritorial organisations and bodies* are dropped. Furthermore, there are no data in ONS for industry *7.Mining of metal ores*, therefore it is dropped. Also, industry -8.Not else classified industries are dropped since there are no available data from the ONS regarding GVA and NCS.

Step 5: Transforming weekly to annual data and Survey to Population

Although the data are collected on a quarterly basis, the questionnaires are structured to get responses for the usual employees' workweek. Therefore, despite having aggregated the different waves for each quarter, and each quarter has been merged with other quarters in a year, the information we have is still on an average of an annual workweek of the average employee per industry. Although someone could argue that we cannot make such an assumption in our sample that contains part-time and zero-hour employees, the answer would be that we might be eligible because up to 2012 zero-hours contract is a tiny part of employees, and part-time employees already have lowered the working week, captured by the average working hours of the industry. Consequently after acquiring these *weekly average variables* for the whole year, they need to be extrapolated to an annual level. By assuming that every employee works 252 days and by assuming a 5 days workweek, this implies that employees' weekly working hours will be multiplied by 252/5=50.4[29] :

$$TTUSHRT\_annual = TTUSHRT\_year \text{ x } 50.4 \qquad (3.7)$$
$$BUSHRS\_annual = BUSHHRS\_year \text{ x } 50.4 \qquad (3.8)$$
$$overT\_annual = overT\_year \text{ x } 50.4 \qquad (3.9)$$
$$unoverT\_annual = unoverT\_year \text{ x } 50.4 \qquad (3.10)$$
$$paidover1T\_annual = paidover1T\_year \text{ x } 50.4 \qquad (3.11)$$
$$paidover2T\_annual = paidover2T\_year \text{ x } 50.4 \qquad (3.12)$$
$$paidover3T\_annual = paidover3T\_year \text{ x } 50.4 \qquad (3.13)$$
$$paidover4T\_annual = paidover4T\_year \text{ x } 50.4 \qquad (3.14)$$

[29] 5 days / week x 52 weeks = 260 days. Including 8 bank holidays, the number of working days is often dropped to 260 minus 8 bank holidays = 252

Step 6: Extrapolation from the LFS sample to the Population

Following this method, the annual working hours of LFS participants are derived, which means that this value still does not represent the whole population working in the specific industry. Therefore, the LFS data need to be extrapolated to population sizes. As it has been mentioned before, the ONS has already made such an extrapolation in a series of datasets. However, this extrapolation concerns only the total working hours without calculating unpaid overtime and its particular forms and the extrapolation is based on regions. Although, these individual weights are not used in this dissertation since individuals here are added up by industry, and not by region, Table 3.2 shows the difference in participation in industries derived by the ONS and by the thesis.

More specifically, the participation rate of industries in labour force is derived accordingly:

Total Working Hours in industry in a year = Total Working Hours per employee in a year (LFS) x Real jobs (ONS) **(3.15)**

Basic Working Hours in industry in a year = Basic Working Hours per employee in a year (LFS) x Real jobs (ONS) **(3.16)**

Overtime Hours in industry in a year = Overtime Hours per employee in a year (LFS) x Real jobs (ONS) **(3.17)**

Unpaid Overtime Hours in industry in a year = Unpaid Overtime Hours per employee in a year (LFS) x Real jobs (ONS) **(3.18)**

Paid1 Overtime Hours in industry in a year = Paid1 Overtime Hours per employee in a year (LFS) x Real jobs (ONS) **(3.19)**

Paid2 Overtime Hours in industry in a year = Paid2 Overtime Hours per employee in a year (LFS) x Real jobs (ONS) **(3.20)**

Paid3 Overtime Hours in industry in a year = Paid3 Overtime Hours per employee in a year (LFS) x Real jobs (ONS) **(3.21)**

Paid4 Overtime Hours in industry in a year = Paid4 Overtime Hours per employee in a year (LFS) x Real jobs (ONS) **(3.22)**

The variable of Real Jobs is taken by ONS's estimations. In other words, instead of adopting ONS's estimation for working hours derives its own total, basic, paid overtime and unpaid, by using ONS estimations of Real jobs only. Using the Real jobs instead of the total working hours that ONS calculates, needs less assumptions.

Due to this fact, dissertation's industry's labour participation in most cases is close to the one suggested by ONS, however it differs slightly in some industries (See Table 3.2 for the year 2012). More specifically the largest deviation of percentages is around 1.5 to 1.8 %. The differences can be attributed to: i) regional weights per individual contain people out of labour force and the unemployed, while industrial rates contain only employees, ii) ONS captures all jobs but the sample of LFS that is used is capturing only the main jobs, not the second ones, because second jobs do not have information on unpaid overtime and are mainly self-employed positions. Moreover, another factor that contributes to divergence is that there are industries like Fishing and Aquaculture which are not represented at all in ONS' weighting but only with the method that this research follows.

Table 3.2 – Labour Participation per industry: Difference between the calculations of the ONS and the dissertation's, for the year 2012

SIC07 - 2012	Dissertation weight	ONS weight	Comparison	SIC07 - 2012	Dissertation weight	ONS weight	Comparison
1	0.59	0.48		**50**	0.20	0.05	
2	0.07	0.03		**51**	0.28	0.31	
3	0.03			**52**	1.09	1.27	
5	0.03	0.03		**53**	1.12	0.88	
6	0.08	0.04		**55**	1.08	1.16	
7	-	-		**56**	3.01	3.85	
8	0.08	0.06		**58**	0.62	0.63	
9	0.22	0.05	X	**59**	0.22	0.22	
10	1.22	1.37		**60**	0.19	0.17	
11	0.18	0.16		**61**	0.71	0.87	
12	0.03	0.02		**62**	2.01	1.74	
13	0.18	0.17		**63**	0.10	0.26	
14	0.07	0.07		**64**	2.14	2.33	
15	0.09	0.04		**65**	0.92	0.59	
16	0.20	0.21		**66**	1.18	1.46	
17	0.24	0.24		**68**	0.98	1.22	
18	0.41	0.40		**69**	1.36	1.97	
19	0.14	0.04		**70**	0.98	1.15	
20	0.46	0.40		**71**	1.83	1.52	
21	0.49	0.26	X	**72**	0.46	0.50	
22	0.50	0.63		**73**	0.39	0.45	
23	0.35	0.32		**74**	0.41	0.34	
24	0.42	0.35		**75**	0.17	0.20	
25	0.79	1.08		**77**	0.36	0.48	
26	0.84	0.55		**78**	0.52	2.01	X
27	0.41	0.41		**79**	0.31	0.31	
28	0.98	0.86		**80**	0.61	0.39	
29	0.59	0.62		**81**	1.39	1.62	
30	0.85	0.66		**82**	0.62	0.96	
31	0.22	0.23		**84**	7.37	5.51	X
32	0.38	0.26		**85**	15.39	15.60	
33	0.53	0.32		**86**	7.79	9.33	X
35	0.92	0.71		**87**	3.13	2.51	
36	0.30	0.16	X	**88**	4.01	2.52	X
37	0.03	0.05		**90**	0.16	0.17	
38	0.51	0.34		**91**	0.51	0.23	
39	0.07			**92**	0.27	0.43	
41	1.77	1.07		**93**	1.18	1.09	
42	0.98	0.64		**94**	1.00	0.78	
43	2.05	1.73		**95**	0.22	0.11	
45	1.36	1.69		**96**	0.64	0.72	
46	2.47	3.91	X	**97**	0.12	0.21	
47	8.46	9.38		**98**	0.07		
49	2.05	1.84		**99**	0.12		
				no class		0.02	

3.3 ONS data for industries' output and capital per industry

Labour Force Survey was filtered and organised in such a way to fit with the way that data on industries' output and capital are structured in the Office of National Statistics (ONS) according to the Standard Industrial Classification (SIC 2007). ONS provides data on output by industry in the form of Gross Value Added (GVA), and data on capital in the form of Gross Capital Stock (GCS), Capital Consumption, Net Capital Stock (NCS) and Gross Fixed Capital Formation (GFCF). These are provided either in the form of Chained Volume Measures (CVM) or Current Prices (CP). CVM and CP are explained later. Both are expressed in currency terms (£) and represent some kind of market value as presented later. Therefore, both GVA and NCS need a different treatment.

3.3.1 Gross Value Added (GVA) Data from the Office of National Statistics (ONS)

To begin with, GVA is defined usually as Output minus Inputs and it is mainly proxied by the Index of Production (IoP) that ONS derives. Gross value added is obtained by deducting intermediate consumption from gross output. Thus gross value added is equal to net output. And this is the variable that the thesis is mainly interested in. Net Value Added (NVA) is not used because it is obtained by deducting consumption of fixed capital (or depreciation charges) from gross value added. We are not interested in deducting consumption of fixed capital, since by using NCS (instead of GCS), capital consumption is already deducted. Therefore, we need at least one variable capturing it. Net value added therefore equals gross wages, pre-tax profits net of depreciation, and indirect taxes less subsidies. More specifically, according to ONS (Output and Productivity, 2017):

> *'The monthly United Kingdom (UK) Index of Production (IoP) provides a timely indicator of growth in the output of production industries at constant prices. The IoP is a key economic indicator and one of the earliest short-term measures of economic activity and shares exactly the same industry coverage as the corresponding quarterly series within UK Gross Domestic Product (GDP)'.*

The IoP is constructed by ONS based on data from different Surveys. Therefore, it is not only this dissertation that attempts combining different datasets, with different structure, but also ONS that uses these surveys on a monthly basis.

According to ONS (UK Sector Accounts, 2017), regarding the component of IoP,

> *'the majority of data used to compile the manufacturing sector, and thus the Index of Production, is collected via the Monthly Business Survey (MBS). The data collected is sales turnover excluding Value Added Tax (VAT). This data is then deflated using Producer Price Indices (PPI) (...)'.*

MBS uses the Inter-Departmental Business Register (IDBR) as the sampling frame for that represents small and large businesses according to the production and services sectors' population structures. According to ONS (A Guide to the Index of

Production, 2016):

> *'The MBS sample of approximately 32,000 businesses is drawn from a total number of 1.45 million businesses within the UK (production) and Great Britain (services) industries'*[30].

For ONS (A Guide to the Index of Production, 2016), it is difficult in practice and burdensome to ask respondents to supply data on inputs. 'Therefore the majority of industries in IoP measure output as a proxy for GVA. In general, the ratio between total output and total input remains fairly constant, thus measuring output is a valid proxy of GVA'. One exception is electricity data where data on both inputs and outputs are available and can GVA index be produced. This highlights the difficulties that arise from the existing types of measuring the economic output in each industry. In other words, the lack of homogeneity among industries starts even from recording economic outcomes. The above is also linked with the issues regarding measuring capital. The fact that ONS does not have information on inputs in order to calculate 'properly' capital and the GVA is an indicator of the issues that traditional statistics face.

Despite these, the dissertation does not attempt to propose any alternative way of keeping records of inputs and outputs of the national economy. Therefore, we rely on the existing data. Regarding GVA, existing data are provided bot in the form of Current Prices (CP) and in the form of Chain Volume Measures (CVM). According to ONS (UK Index of Production QMI, 2017) '(t)he chain volume measures of IoP are annually re-weighted chained indices referenced to current price values. A Laspeyres index is a fixed base index whose index numbers are weighted arithmetic means of price (or other) relatives, using value (or equivalent)'. Based on ONS's *Frequently asked questions* on GDP, the difference between CP and CVM 'lies on the fact that CP are the prices of the time period GVA being estimated and it is the actual price charged or paid for the goods

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[30] More specifically ONS (2015, Blue Book 2015) reports that '(d)ata for the manufacturing sector derived are also from: i) Department of Energy and Climate Change (DECC) for fuel industries, ii) Iron and Steel Statistics Bureau (ISSB) for steel industries, iii) The mining and quarrying sector is mainly comprised of data from DECC, including volume of oil & gas extraction and coal extraction, iv) The majority of data used to produce the energy sector index is also from DECC and includes energy and gas supply output'.
Additionally ONS (A Guide to the Index of Production, 2016) regarding the turnover data, they 'are collected from a sample of approximately 6,000 production businesses across the UK and 26,000 service providers across Great Britain. The sample, which represents the whole production sector (with the exception of agriculture, forestry, fishing, as well as electricity & gas suppliers) and the whole services sector (with the exception of financial service providers), includes all large businesses and a representative sample of smaller businesses. Collectively, all of these businesses cover approximately 95 per cent of these sectors in terms of turnover.'

or services at time of production or consumption', while with CVM every series presented in real terms is estimated both in current prices and prices of the previous year (PYPs).

SIC07 Section	Title	SUT groups	Regional data source(s)
A	Agriculture, forestry and fishing	1-3	Output and intermediate consumption from ABS; Agriculture data from DEFRA
B	Mining and quarrying	4-8	Output and intermediate consumption from ABS
C	Manufacturing	9-52	Output and intermediate consumption from ABS; ABS turnover for the tobacco industry
D	Electricity, gas, steam and air conditioning supply	53-54	Output and intermediate consumption from ABS
E	Water supply; sewerage, waste management and remediation	55-58	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE
F	Construction	59-61	Output and intermediate consumption from ABS; Sole traders data from HMRC
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	62-64	Output and intermediate consumption from ABS
H	Transportation and storage	65-70	Output and intermediate consumption from ABS; Sole traders data from HMRC
I	Accommodation and food service activities	71-72	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE; Sole traders data from HMRC
J	Information and communication	73-78	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE; Sole traders data from HMRC
K	Financial and insurance activities	79-82	Output and intermediate consumption from ABS; Finance and insurance data from GVA(I)
L	Real estate activities	83-85	Output and intermediate consumption from ABS; Owner-occupied imputed rental from GVA(I)
M	Professional, scientific and technical activities	86-93	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE; Sole traders data from HMRC
N	Administrative and support service activities	94-99	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE
O	Public administration and defence; compulsory social security	100	Public administration data from GVA(I)
P	Education	101	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE
Q	Health and social work	102-104	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE
R	Arts, entertainment and recreation	105-108	Output and intermediate consumption from ABS; Public sector employment from BRES/NISRA; Public sector earnings from ASHE
S	Other service activities	109-111	Output and intermediate consumption from ABS
T	Activities of households as employers and for own use	112	Household data from GVA(I)

Figure 3.2 – Data sources used to compile regional GVA(P) [31]

[31] Office for National Statistics, Development of a regional measure of real Gross Value Added. For more details on the wage that these statistics are constructed, the ONS also provides an analysis on *'Things you need to know about this release, Balanced gross value added'. More specifically, they describe as below:*

3.3.2 Net Capital Stock (NCS) from the Office of National Statistics (ONS)

As in the case of GVA, Net capital stock (NCS) 'reflects the market value of the stock of fixed assets' in the economy according to OECD Statistics. Although NCS is an important indication of overall wealth, as it has already been mentioned, this is not a pure technical variable cleared from market prices. Net Capital Stock in ONS is calculated according to the Perpetual Inventory Method (PIM) that actually consists of a geometric depreciation rate of investment. A geometric, rather than algebraic, depreciation is used as more realistic, according to ONS. More specifically, according to Dey-Chowdhury (2008):

$$K_{at}^{i} = \sum_{\tau=0}^{\infty}(1-\delta_{a,t-\tau}^{i})^{\tau} \cdot I_{a,t-\tau}^{i} \qquad (3.23)$$

where K is the volume of net stock for a particular asset a in industry, i at the end of period t (beginning of period $t+1$), I is investment in a particular asset a in industry i and δ is the rate of depreciation for an asset purchased in a particular year. Like in GVA, chained volume measures (CVM) are used for capital as well, where the effect of price changes has been removed, but not the effect of prices according to ONS (UK Sector Accounts, 2016). Using net capital stock (NCS) instead of gross capital stock (GCS) differs in the way that NCS as input represents the price at which the asset could be bought in its present situation, while GCS as input represents the price at which the asset could be bought as if it was new. According to Blades and Meyer-zu-Schlochtern (1997), '(t)he reduced 'present state' prices have been argued to capture the reduced efficiency of older assets to higher repair costs or growing obsolescence'. An issue that arises is that while GVA and working hours are flow measures, a proxy to capital (NCS) consists of a stock measure. Using flow measures would be more consistent with a theoretically complete

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We have produced estimates of regional gross value added (GVA) using estimates from gross value added income (GVA(I)) and gross value added production (GVA(P)) to produce a balanced measure of regional GVA, known as GVA(B). GVA(I) is measured at current basic prices, which include the effect of inflation, excluding taxes (less subsidies) on products (for example, Value Added Tax). This involves adding up the income generated by UK resident individuals or corporations in the production of goods and services. It is calculated gross of deductions for consumption of fixed capital, which is the amount of fixed assets used up in the process of production in any period. GVA(P) is measured at both current prices and in chained volume measures (CVM). It is calculated for a given reference period as the total value of all goods and services produced (output), less goods and services used up or transformed in the production process, such as raw materials and other inputs (intermediate consumption). The production approach to compile GVA is conceptually equivalent to the income approach, but allows deflation of current prices to produce constant price measures, since the production components relate to goods and services that can be broken down into price and volume indices.' This is named as Regional economic activity by gross value added (balanced), UK: 1998 to 2017 ‘production function’. Two possible measures could be either Gross Fixed Capital Formation (GFCF) or Capital Consumption (CAPCONS). However, there are some practical issues that arise in case of their use in a production function.

To begin with, GFCF represents the new capital in market value that is created throughout a year. Although it is a flow measure, this would be more of an output, rather than input. Therefore, we would need to assume that GFCF is entering again the circle of production. It would still need to be calculated together with the existing capital (gross or net). In other words, we would need to use either GCS or NCS. Apart from that GFCF as a flow measure can take negative values, and this would create difficulties both in DEA and in logarithmised regression variables.

On the other hand, another flow variable that could be used is Capital Consumption. However, one of its biggest drawbacks would be that the input would be correlated with the output. GVA is already capturing capital consumption. According to According to Blades and Meyer-zu-Schlochtern (1997), ‘(i)n non-market producers (households or government) GVA is obtained by the sum of capital consumption and compensation of employed’. Therefore, this would lead to inconsistent results, especially in this dissertation where the public sector industries are not excluded, but on the contrary consist of an essential part of the empirical analysis. Consequently, for all these reasons Net Capital Stock is the proxy of capital input used in the following analysis over production inputs and outputs.

Step 7: Merging some industries

Although the industry code is common in every dataset (LFS and ONS), the lack of data in some industries led us to merge some of them. More specifically, LFS occasionally had some information on some industries that ONS did not and vice versa.

Table 3.4 – Merged industries

Dissertation industry code	SIC07	Description
5	**5**	Mining of coal and lignite
	6	Extraction of crude petroleum and natural gas
	7	Mining of metal ores
	8	Other mining and quarrying
	9	Mining support service activities
10	**10**	Manufacture of food products
	11	Manufacture of beverages
	12	Manufacture of tobacco products
13	**13**	Manufacture of textiles
	14	Manufacture of wearing apparel
	15	Manufacture of leather and related products
31	**31**	Manufacture of furniture
	32	Other manufacturing
	33	Repair and installation of machinery and equipment
37	**37**	Sewerage
	38	Waste collection, treatment and disposal activities; materials recovery
	39	Remediation activities and other waste management services.
43	**41**	Construction of buildings
	42	Civil engineering
	43	Specialised construction activities
55	**55**	Accommodation
	56	Food and beverage service activities
59	**59**	Motion picture, video and television programme production, sound recording and music publishing activities
	60	Programming and broadcasting activities
62	**62**	Computer programming, consultancy and related activities
	63	Information service activities
69	**69**	Legal and accounting activities
	70	Activities of head offices; management consultancy activities
74	**74**	Other professional, scientific and technical activities
	75	Veterinary activities
80	**80**	Security and investigation activities
	81	Services to buildings and landscape activities
	82	Office administrative, office support and other business support activities
87	**87**	Residential care activities
	88	Social work activities without accommodation
90	**90**	Creative, arts and entertainment activities
	91	Libraries, archives, museums and other cultural activities
	92	Gambling and betting activities

Table 3.5 - Industries based on their Industrial Code – after merging

Dissertation industry code	SIC07	Description	Dissertation industry code	SIC07	Description
1	**1**	Crop and animal production, hunting and related service activities	**49**	**49**	Land transport and transport via pipelines
2	**2**	Forestry and logging	**50**	**50**	Water transport
3	**3**	Fishing and aquaculture	**51**	**51**	Air transport
5	**5**	Mining of coal and lignite	**52**	**52**	Warehousing and support activities for transportation
	6	Extraction of crude petroleum and natural gas	**53**	**53**	Postal and courier activities
	7	Mining of metal ores	**55**	**55**	Accommodation
	8	Other mining and quarrying		**56**	Food and beverage service activities
	9	Mining support service activities	**58**	**58**	Publishing activities
10	**10**	Manufacture of food products	**59**	**59**	Motion picture, video and television programme production, sound recording and music publishing activities
	11	Manufacture of beverages		**60**	Programming and broadcasting activities
	12	Manufacture of tobacco products	**61**	**61**	Telecommunications
13	**13**	Manufacture of textiles	**62**	**62**	Computer programming, consultancy and related activities
	14	Manufacture of wearing apparel		**63**	Information service activities
	15	Manufacture of leather and related products	**64**	**64**	Financial service activities, except insurance and pension funding
16	**16**	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	**65**	**65**	Insurance, reinsurance and pension funding, except compulsory social security
17	**17**	Manufacture of paper and paper products	**66**	**66**	Activities auxiliary to financial services and insurance activities
18	**18**	Printing and reproduction of recorded media	**68**	**68**	Real estate activities
19	**19**	Manufacture of coke and refined petroleum products	**69**	**69**	Legal and accounting activities
20	**20**	Manufacture of chemicals and chemical products		**70**	Activities of head offices; management consultancy activities
21	**21**	Manufacture of basic pharmaceutical products and pharmaceutical preparations	**71**	**71**	Architectural and engineering activities; technical testing and analysis
22	**22**	Manufacture of rubber and plastic products	**72**	**72**	Scientific research and development
23	**23**	Manufacture of other non-metallic mineral products	**73**	**73**	Advertising and market research
24	**24**	Manufacture of basic metals	**74**	**74**	Other professional, scientific and technical activities
25	**25**	Manufacture of fabricated metal products, except machinery and equipment		**75**	Veterinary activities
26	**26**	Manufacture of computer, electronic and optical products	**77**	**77**	Rental and leasing activities
27	**27**	Manufacture of electrical equipment	**78**	**78**	Employment activities
28	**28**	Manufacture of machinery and equipment n.e.c.	**79**	**79**	Travel agency, tour operator and other reservation service and related activities
29	**29**	Manufacture of motor vehicles, trailers and semi-trailers	**80**	**80**	Security and investigation activities
30	**30**	Manufacture of other transport equipment		**81**	Services to buildings and landscape activities
31	**31**	Manufacture of furniture		**82**	Office administrative, office support and other business support activities
	32	Other manufacturing	**84**	**84**	Public administration and defence; compulsory social security
	33	Repair and installation of machinery and equipment	**85**	**85**	Education
35	**35**	Electricity, gas, steam and air conditioning supply	**86**	**86**	Human health activities
36	**36**	Water collection, treatment and supply	**87**	**87**	Residential care activities
37	**37**	Sewerage		**88**	Social work activities without accommodation
	38	Waste collection, treatment and disposal activities; materials recovery	**90**	**90**	Creative, arts and entertainment activities
	39	Remediation activities and other waste management services.		**91**	Libraries, archives, museums and other cultural activities
43	**41**	Construction of buildings		**92**	Gambling and betting activities
	42	Civil engineering	**93**	**93**	Sports activities and amusement and recreation activities
	43	Specialised construction activities	**94**	**94**	Activities of membership organisations
45	**45**	Wholesale and retail trade and repair of motor vehicles and motorcycles	**95**	**95**	Repair of computers and personal and household goods
46	**46**	Wholesale trade, except of motor vehicles and motorcycles	**96**	**96**	Other personal service activities
47	**47**	Retail trade, except of motor vehicles and motorcycles			

Table 3.6 – Mapping industries into Productive and Unproductive (based on Mohun 2006)

Productive Industries		Unproductive Industries	
DMU	**Description**	**DMU**	**Description**
1	Agriculture	**45**	Wholesale&Retail&Repair of Motorvehicles
2	Fishing & Aquaculture	**46**	Wholesale trade
5	Mining	**47**	Retail
10	Food-Beverages-Tobacco	**64**	Financial Services
13	Textiles-Apparel-Leather	**65**	Insurance and Pension
16	Wood	**66**	Auxiliary to fincing
17	Paper	**69**	Legal and Accounting
18	Printing&Reproduction of recorded media	**73**	Advertising and market research
19	Coke&Petroleum	**77**	Rental and leasing activities
20	Chemicals	**78**	Employment activities
21	Pharmaceutical	**79**	Travel agency, tour operator and other reservation service and related activities
22	Rubber&Plastic	**80**	Security and investigation activities
23	Non-metalic mineral	**84**	Public administration and defence; compulsory social security
24	Basic Metals	**94**	Activities of membership organisations
25	Metal Products	**95**	Repair of computers and personal and household goods
26	Computer, electronic and opticals	**96**	Other personal activities
27	Electrical equipment		
28	Machinery and equipment		
29	Motor vehicles&Tralers		
30	Transport equipment		
31	Furniture - OtherManf - Repair&Installation		
35	Electricity-Gas-Steam-Airconditioning		
36	Water collection, treatment and Supply		
37	Sweerage - Waste -Remediation		
43	Construction		
49	Land transport & Pipelines		
50	Water transport		
51	Air transport		
52	Warehousing and supporting transport		
53	Postal & Courier		
55	Accomodation & Food & Beverages		
58	Publishing Activities		
59	Motion video tv sound & Broadcasting		
61	Telecommunication		
62	Computer programming and consultancy		
71	Architecture and Civil Engineering		
72	R&D		
74	Other prof, scientific, technical & Veterinary		
85	Education		
86	Human Health		
87	Residential care and social work		

Step 8: Combining LFS with ONS data

After organising LFS and ONS statistics for 2002-2012, combining the two datasets with respect to industry is the final step before we proceed to our analysis.

Before this dissertation moves to Data Envelopment Analysis and the Regression Analysis, getting some basic information on the overall size of the variables used, their location and divergence statistics would be useful. As it has already been mentioned, there are 61 industries having an identical industry code (from 1 to 99) covering a period of 11 years (2002-2012). Several industries have been completely dropped from our observations as described previously, due to irrelevance or practical issues in general. The variables that are going to be used either at the same or different stages are:

Total Working Hours (LFS)
Basic Working Hours (LFS)
Unpaid Overtime (derived from LFS)
Paid Overtime (derived from LFS)
GVA (ONS)
NCS (ONS)

However, for different tests and analysis throughout the writing up of this thesis outside of the core analysis more variables have been tested, and these include:

Total Overtime Hours (LFS)
Gross Capital Stock (ONS)
Gross Fixed Capital Formation (ONS)
Capital Consumption (ONS)

One of the very first and the very impressive observations is that with simple calculations, unpaid overtime consists of the 5.77%[32] of the total working hours, which is a relatively high percentage. Generally, if the subjective estimation of each individual worker is taken into consideration together with the other ‘problematic’ issues regarding overtime and its remuneration, this 5.77% could be a real underestimation. Additionally, paid overtime includes even the overtime hours that are paid in a smaller rate than the normal hours, therefore the probability of underestimation is even higher. However, in order to get a clearer picture of the economy, changes in output, capital, basic hours and paid overtime need to be taken into account.

3.4 Descriptive Statistics

In this section the main variables with their natural logarithm are presented.

[32] Only completely unpaid overtime is 31800000
Unpaid overtime are 46600000
Total working Hours 89700000
This means that unpaid hours are 46600000/80700000 = 5.77%

Table 3.7 - Descriptive Statistics before dropping outliers

Variable	Obs	Mean	Std. Dev.	Min	Max
industry07~r	**671**			1	96
YEAR	**671**			2002	2012
TTUSHRT_adj	**670**	807000000	993000000	10800000	4300000000
BUSHRT_adj	**670**	745000000	915000000	10200000	4020000000
overT_adj	**670**	61300000	83600000	315000	560000000
unoverT_adj	**670**	46600000	71300000	0	531000000
paidover1T~j	**670**	4710534	8992899	0	71500000
paidover2T~j	**670**	9310762	11800000	0	96900000
paidover3T~j	**670**	267414.4	739787.1	0	6070189
paidover4T~j	**670**	410507	772556.2	0	6287212
Net_adj	**670**	7040000000	8500000000	73400000	40300000000
Gross_adj	**670**	9510000000	11400000000	96000000	54900000000
GFCF	**671**	4360000000	11500000000	-599000000	109000000000
GVA	**671**	20800000000	24800000000	242000000	167000000000
GCSb	**671**	1.03E+11	3.1E+11	1050000000	2590000000000
NCSb	**671**	61600000000	1.82E+11	624000000	1460000000000
CAPCONS	**671**	41800000000	1.29E+11	305000000	1140000000000
gfcf	**671**	4358.692	11500.39	-599	109000
gva	**671**	20770.63	24849.63	242	167000
gcs	**671**	103336.8	309991.9	1050	2590000
ncs	**671**	61581.66	181503.5	624	1460000
capcons	**671**	41778.71	129108.5	305	1140000
ttuthrs	**670**	806.6815	992.5339	10.8	4300
bushrs	**670**	745.2739	915.0671	10.2	4020
over	**670**	61.31557	83.57593	0.315	560
unover	**670**	46.62441	71.27087	0	531
paidover1	**670**	4.710534	8.992899	0	71.5
paidover2	**670**	9.310762	11.83429	0	96.9
paidover3	**670**	0.2674144	0.7397871	0	6.070189
paidover4	**670**	0.410507	0.7725562	0	6.287212
netwg	**670**	7043.822	8497.925	73.4	40300
grosswg	**670**	9507.525	11431.66	96	54900
paidhour_BUS	**670**	745.2739	915.0671	10.2	4020
paidover_all	**670**	14.69922	19.5595	0	133.9585
unpaidover	**670**	46.62441	71.27087	0	531
lgfcf	**667**	7.419329	1.328245	2.995732	11.5991
lgva	**671**	9.35636	1.152717	5.488938	12.02575
lgcs	**671**	10.38042	1.424711	6.956545	14.76717
lncs	**671**	9.838078	1.457749	6.436151	14.19395
lcapcons	**671**	9.461086	1.426041	5.720312	13.94654
lTTUSHRT	**670**	6.005345	1.25886	2.379546	8.36637
lBUSHRT	**670**	5.926083	1.259136	2.322388	8.299037
loverT	**670**	3.389883	1.305148	-1.155183	6.327937
lunoverT	**669**	3.052934	1.348781	-2.253795	6.274762
lpaidover1T	**586**	0.6659367	1.476147	-3.390873	4.269698
lpaidover2T	**638**	1.595228	1.294219	-2.624859	4.573679
lpaidover3T	**171**	-0.4861323	1.084648	-3.701746	1.80339
lpaidover4T	**305**	-0.6138563	1.079963	-3.529512	1.838518
lpaidhour_~S	**670**	5.926083	1.259136	2.322388	8.299037

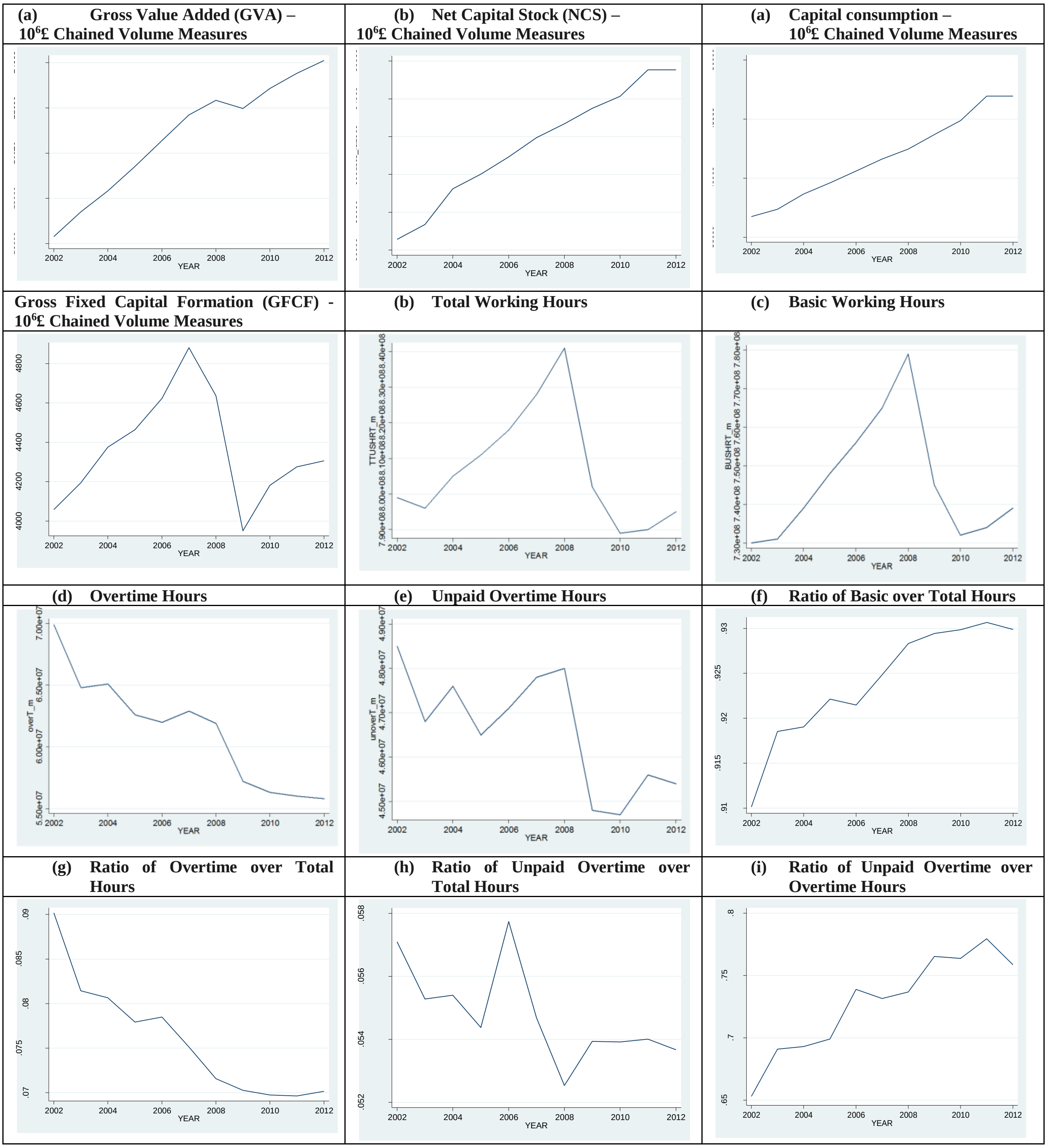

Figure 3.3 – Mean values of production variables for all industries over the years[33]

In the above figures we can firstly observe the growing GVA mean of all industries over the years. Additionally, the crisis' outburst in 2007 with the subsequent recession are also

[33] Figures are not drawn in the same scale because each variable is of different scale too. The main focus of these figures is the pattern.

captured by the graph. Similarly, NCS has also an upward slope with an evidence of stagnation after 2010. Capital consumption appears to have the same pattern as well. However, patterns in GFCF and the labour variables are more revealing. Regarding the GFCF, the peak of investment in 2007 lead to a bottom in 2009, and by 2012 it had not reached the pre-crisis level.

Regarding the labour variables, it is not surprising that they demonstrate the same pattern with GFCF. Total Usual Hours (TTUTSHR) including overtime and Basic Usual Hours (BUSHRT) excluding overtime reach their peak in 2008 and a bottom in 2010 failing to return to pre-crisis levels by 2012. This is a pattern still continuing by the time the dissertation is submitted. Overtime hours seem to be reduced, not necessarily because there is no working day extension, but also because of the lack of defining it in the upcoming labour contracts. Total working hours generally betray a shrinkage in economic activity regarding the use of labour, therefore, a reduced working day after the outburst of crisis would not be surprising.

However, in a ratio analysis one of the interest patterns that is observed is that basic hours consist of more and more percentage of total working hours (91%-93%), while overtime less and less (9%-7%). Therefore, a question arises: is it because the working day is reduced or because overtime hours are not reported at all by individual participants in the LFS. From the graphs below, it is evident that at least for the full time employees the working week experienced a drop until 2010, and after this year a rise. If this is combined with the employment patterns, we understand that Total working hours in the UK have a similar pattern showing that the increased/decreased working hours might come from a combined effect of increased/decreased working week and employment levels. However, if the increase in part-time jobs is taken into account, the increased Total working hours derived from the LFS (See Figure 3.3) might be partially due to the extension of working day and not necessarily due to the increase in full employment.

Additionally, from the graphs above we observe that unpaid overtime as a ratio of total overtime is increasing. In other words, in industries where employees reported that they work overtime it seems that it is more and more unpaid over the years (65%-77%). This is actually the main reason that this thesis is studying unpaid overtime. We can visualize algebraically the above patterns like this:

$$\textbf{Total Working Hours 2002} = 91\%\textbf{Basic W.H}_{\cdot 2002} + 9\%\textbf{Overtime}_{2002}$$
$$= 91\%\textbf{Basic W.H}_{\cdot 2002} + 9\%(65\%\textbf{Unpaid Overtime}_{2002} + 35\%\textbf{Paid Overtime}_{2002})$$
$$= 91\%\textbf{Basic W.H}_{\cdot 2002} + 5.8\%\textbf{Unpaid Overtime}_{2002} + 3.15\%\textbf{Paid Overtime}_{2002} \quad \textbf{(3.24)}$$

$$\textbf{Total Working Hours 2010} = 93\%\textbf{Basic W.H}_{\cdot 2010} + 7\%\textbf{Overtime}_{2010}$$
$$= 93\%\textbf{Basic W.H}_{\cdot 2010} + 7\%(77\%\textbf{Unpaid Overtime}_{2010} + 23\%\textbf{Paid Overtime}_{2010})$$
$$= 93\%\textbf{Basic W.H}_{\cdot 2010} + 5.4\%\textbf{Unpaid Overtime}_{2010} + 1.61\%\textbf{Paid Overtime}_{2010} \quad \textbf{(3.25)}$$

The percentages above are expressed as percentages of total working hours. A safe conclusion that one can make is that the ‘pattern’ of unpaid overtime over the years is gaining grounds over the paid overtime but less compared to basic hours, mainly to basic hours relative extension. In other words, it seems that basic working hours are increasing leading to less overtime work, and in cases there is overtime work, it is mainly unpaid.

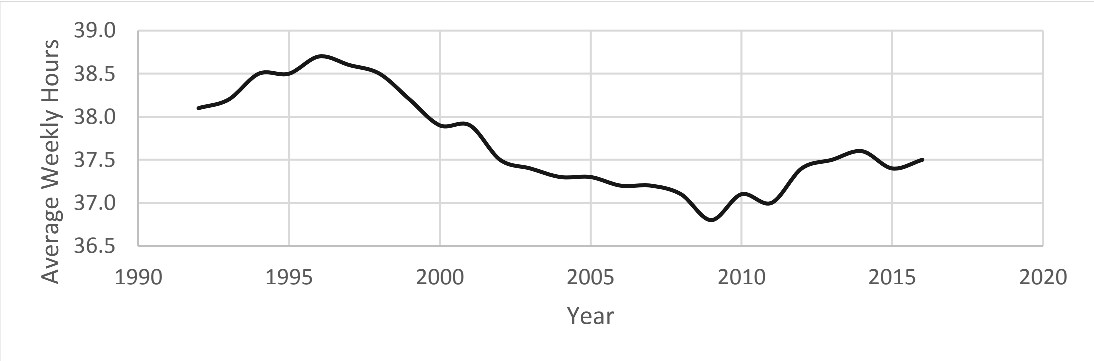

Figure 3.4 – Average actual weekly hours of work full-time workers (seasonally adjusted)

Source: ONS (2018), Average actual weekly hours of work for full-time workers (seasonally adjusted)

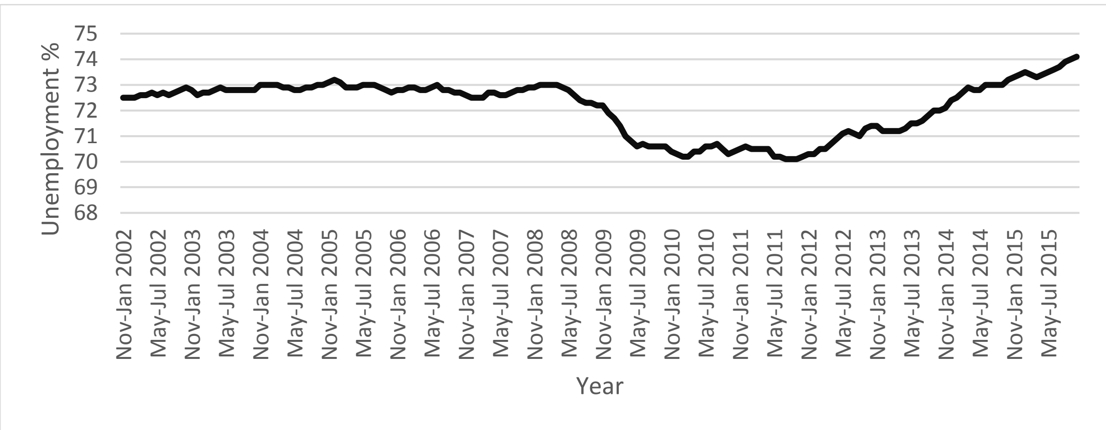

Figure 3.5 – UK Employment rate in percentage (%)

Source: ONS (2016), Statistical bulletin: UK Labour Market: February 2016, Estimates of employment, unemployment, economic inactivity and other employment-related statistics for the UK. ONS

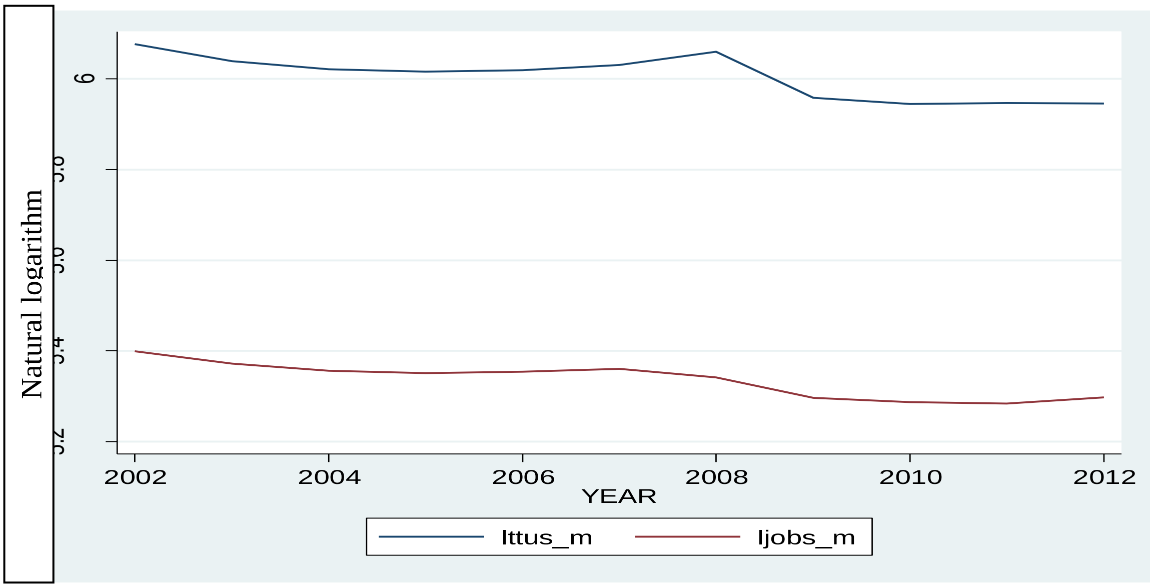

Figure 3.6 – Natural logarithm of total working hours (Average of all industries - lttus_m) VS Natural logarithm of total jobs ((Average of all industries - ljobs_m)

After taking the natural logarithm in order to acquire more comparable results, it is observed from the below box plot that most variables are close to normal, however with some outliers as expressed. In the next chapters an outliers' analysis follows with more details.

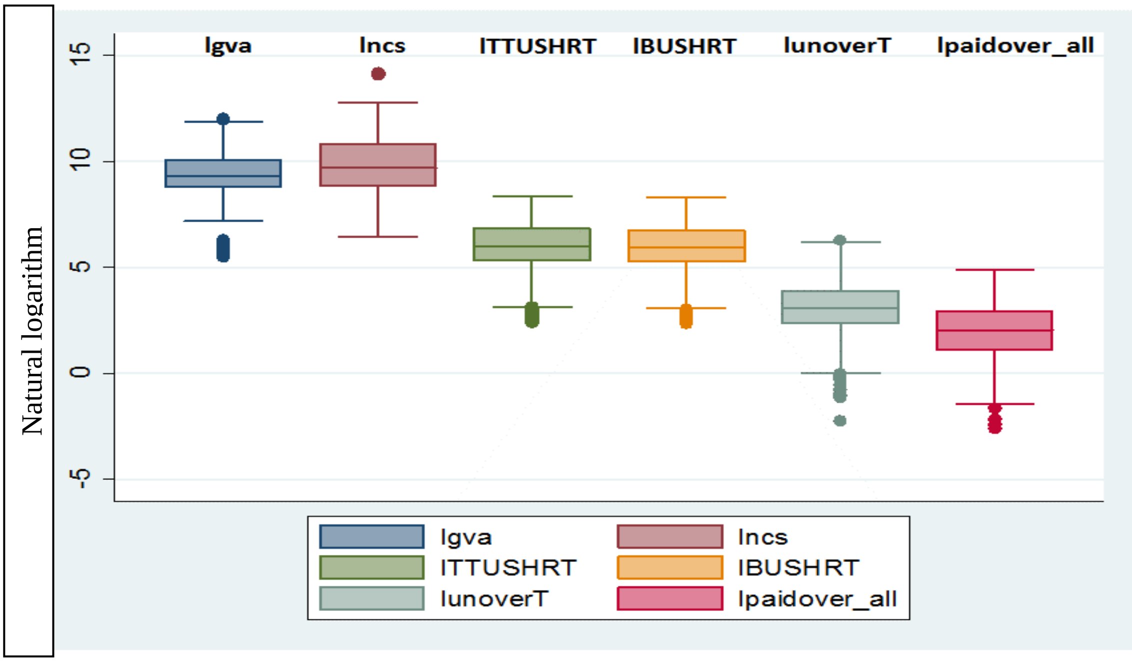

Figure 3.7 – Box Plot – before dropping outliers

Generally, the data gathering, organisation, merging, mapping etc. is a necessary step with quite a lot assumptions regarding aggregation and consists of the most challenging process. After combining these two datasets (LFS and ONS) this dissertation aspires to derive unpaid overtime's contribution to GVA in two different ways: a non-parametric way, with DEA and with Statistics (Pooled OLS, Panel Data, GLS). The following chapters in DEA and Statistics follow different ways in detecting outliers as well. There are some differences, but both methods mostly agree.

Chapter 4: Estimating the Impact of Labour on GVA: A Data Envelopment Analysis Approach

Table 4.1 – Data Envelopment Analysis – Chapter Outline

CHAPTER 4: DEA- MODEL SPECIFICATION	Data Envelopment Analysis and Unpaid Overtime	Pure Technical Input Efficiency, Value Based Models, ONS, LFS Data, Unpaid Overtime
DEA Suitability	Data Envelopment Analysis for Unpaid Overtime: theoretical and practical fit	DEA's contribution to analysing unpaid overtime DEA's limitations to this research
Mathematical representation of models	Mathematical model for Unpaid overtime	Total Labour - Pure Technical Input Efficiency Model • Envelopment Model • Value Based Model Decomposed labour - Pure Technical Input Efficiency Model • Envelopment Model • Value Based Model
Outlier Analysis	Detecting outlier industries and adjusting them to frontier	Detecting outliers with total labour as input Detecting outliers with Decomposed Labour (Basic, Paid overtime and Unpaid overtime) Dividing variables' real size with respective divisor
Marginal Rates of Substitution	Deriving Marginal Rates of Substitution and detecting patterns among industries	Marginal Rates of Substitution between Net Capital Stock and Total Labour Hours MRS among NCS - Basic-Paid-Unpaid model: • NCS-Basic, • Unpaid-Basic, • Paid-Basic, • Paid-Unpaid - ALL FACET - THREE FACET - PEERS
Among GVA Contributions	Analysing Contributions to Gross Value Added	Analysing Unpaid Overtime hours' Contributions to Gross Value Added - ALL FACET - THREE FACET - PEERS
Productive and Unproductive Industries	Analysing Marginal Rates of Substitution and Contributions to Gross Value Added of Productive and Unproductive Industries	

4.1 Data Envelopment Analysis for Unpaid Overtime: theoretical and practical fit

4.1.1 DEA's contribution to analysing unpaid overtime

DEA is used to assess contributions of labour and capital value trensfers. More specifically, the contribution of basic working hours, paid and unpaid overtime hours is assessed in combination with net capital stock. The UK industries consist the units of assessment over the 11 years of study. Before proceeding to any statistical analysis and assuming any a priori pattern of 'normal', working hours or overtime DEA is used for detecting potential patterns among different industries. There are two main reasons for using DEA:

- Firstly as a non-parametric method it does not require any assumptions about functional form linking labour and capital by type to GVA. This allows for flexibility with the method so that different industries may present different impacts of labour on GVA; it does also skip the problematic assumption of a concrete model specification. Therefore, there is no need for assuming Cobb-Douglas translog ect.
- Secondly DEA is a frontier method and so it would estimate the impact of labour per industry on GVA per industry, especially when labour is used as efficiently as can be determined from the data available. This in turn should narrow the range of feasible impact values making their estimation more accurate. Although the Critique of CPE, inefficiencies are not disturbing externalities but endogenised as part of the inter-industrial competition, this dissertation focuses, as purely as possible, on the effect of the decomposed labour inputs on UK industries' output.

As it is presented in Chapter 5 in the econometric analysis, the Ordinary Least Square (OLS) and Generalised Least Squares (GLS), will also be used to estimate the average level of output per unit labour by type. This will make it possible to contrast the findings by these two methods for additional insights. The main reason Stochastic Frontier Analysis (SFA), an alternative to DEA frontier method, is because with SFA we would require to assume a specific functional form and provide other assumptions on data. Generally, parametric approaches when they work provide a better understanding of the production process of the units being assessed However, there is a need to hypothesise the type of model to be estimated, and this might lead to misspecified models. Therefore, the dissertation starts with DEA, since it does not require the hypothesis of a functional form. Rather it creates a piece-wise linear frontier which envelops the data. Thus in essence the data dictates the shape of the functional form.

DEA as a linear programming technique that can be used to evaluate, rank or benchmark the performance of different businesses, non-profit organizations, and public sector agencies (Thanassoulis 2001). Issues with an industrial analysis have already been addressed mainly because of the lack of homogeneity among the units of assessment. In some cases, DEA has been used to evaluate national economies, such as the OECD countries (like Emrouznejad 2003). DEA assesses Decision Making Units (DMU), ie. units that decide over the output produced and inputs etc. In this dissertation, industries are comprised by smaller firms, with various market structures and therefore they do not have the immediate control of input/outputs. However, as past/present research shows that these industries can be dealt not as DMUs but units of assessment. E.g. Thanassoulis (2015) in an assessment of health care delivery teat each inpatient spell for a given medical condition as a DMU in order to assess potential cost savings by spell. Although patients cannot decide how much input the hospital is investing on them, patients can still units of assessment.

DEA is based on certain assumptions regarding the features of production (see Banker et al. 1984, Thanassoulis 2001). According to Thanassoulis (2001), the key assumptions are:

> ‘i. *interpolations (convex combinations) between feasible input-output correspondences lead to new input-output correspondences which are feasible in principle*, ii. *inefficient production is possible* and iii. *PPS is the smallest set meeting the foregoing assumptions and containing all input-output correspondences observed at the units being assessed’*.

The first assumption on convexity means that, comparisons in DEA between DMUs are made based on the assumption that each industry can represented by abstract labour, expressed with working time and dead labour (capital) transferring value to economy’s output. Although this would contradict with the New-Ricardian methodology, it would be adequate for the Marxist approach.

Including abstract labour expressed by working time and capital as value transferring to GVA allows for a creation of an average out of two or more industries as a potentially feasible ‘industry’. In other words, we can create an average ‘industry’ say between 27. Electrical Equipment and 26. Optical equipment in terms of labour and capital leading to some corresponding GVA. This assumption actually implies homogeneity among the units that are compared. It is likely to be closer to reality for combinations of similar industries and not so for others. However, we can in retrospect check the similarity of industries on which findings are based and accept them where appropriate. It should be noted that authors have compared countries on labour and capital (eg Fare et al. 1997 or Arcelus and Arocena 2000) where the assumption of homogeneity of the economies of countries is problematic.

The homogeneity of industries coming from abstract labour and the value-transfer capital to GVA is not as vital in this empirical analysis as it might be in performance management context where best practice is sought. The purpose of our analysis is not to find the best performing industry and compare it in absolute terms with others in order for them to get improved, but rather to assess the impact of labour (by remuneration type: normal hours, paid overtime and unpaid overtime) on GVA. This homogeneity is essential is essential because DEA identifies in which industries we have different contributions. Exactly because labour and capital are combined in different ways, it is interesting to see where it produces more wealth and where less.

The second assumption takes into account the very reality of inefficiency as DMUs can be inefficient. Usually, mainstream economists proceed in their analyses assuming that at the engineering level everything is optimal. Assuming rationality and optimal choices in labour and capital quantities excludes any possibility of inefficient production. However, it is the very inefficiency that rules reality and needs to be addressed. In this dissertation, inefficiency is not used to rank industries, but mainly to assess the impact inter-industrial competition with respect to of labour by type. Especially the inefficiency assumption is important as it takes inter-industrial competition as a real possibility.

Although DEA has strong links with the neoclassical production theory (convexity ect), the fact that it is a non-parametric method leads to having no need for priori assumptions about production techniques (Cobb-Douglas, linear, fixed factors, etc.). The lack of production function is facilitating an analysis based on the Critique of Political Economy that contradicts with neoclassical related production functions, such as the Cobb-Douglas that implies that factor payment is equal to factor productivity. . This facilitates a less misleading analysis like in the case of parametric approaches which can have mis-specified models.

In addition, common problems in statistical modelling like multicollinearity and heteroscedasticity are skipped with DEA. It actually provides *a measure of efficiency that is obtained empirically by comparing similar DMUs among each other.* Therefore, the weights derived for each input are not necessarily distorted as the coefficients in a regression analysis. As it is presented in the statistical analysis, 'basic' working hours and unpaid overtime are strongly correlated, ending up in multicollinearity in a simple OLS regression, disabling the detection of an isolated effect of each labour input (See Chapter 5).

This dissertation is conducting an input minimisation problem, and therefore Input Overall Efficiency will be checked. Efficiency generally can be decomposed to Technical and Allocative Efficiency. This can be decomposed into Technical Input Efficiency and Input Allocative Efficiency. Koopmans (1951; p. 60) refers to technical efficiency as

> *'an input-output vector is technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input'.*

The input orientation determines the Marginal Rates of Substitution (MRS) between labour and capital. Input orientation is suitable for the dissertation's purpose because we want to see how the balance between industries' 'input' is formed when we keep the output constant. Additionally, input orientation is also suitable to assess how input targets change after removing efficiencies, and also because of the fact that we have only one output MRSs can be more easily connected to the scale size. On the one hand allocative efficiency can be defined as a combination of inputs is chosen to produce a set quantity of output at minimum cost. Allocative efficiency would require us to have access to input prices (i.e. the unit price for each type of labour and of capital). We have set out to ascertain the implicit unit prices of labour and capital rather than to take them as given.

The *technical efficiency* of an industry is the estimated minimum fraction of its labour and capital that could have been used to secure its GVA. In our case, the minimum amount of net capital, basic working hours, paid overtime hours and unpaid overtime hours will be assessed for a given level of value added using DEA. For a fuller description of the method see Thanassoulis (2001).

However, when examining different units, the size of an industry can cause inefficiency. For instance an industry may be too large for the volume of activities that it is conducting; and therefore may experience *inefficiencies of scale*. In the presence of inefficiencies of scale, an industry is inefficiently large, unit costs increase as the scale of production increases. On the other hand, an industry may be too small for its level of operation, and thus also experience inefficiencies of scale. But even in this case an industry too big or too small cod betray the outcome of the inter-industrial competition as increasing costs that cause inefficiencies might lead a capitalist to shift activity for higher profit.

Additionally, DEA's technical efficiency allows us to focus on variables used in production (ie. working time) instead of variables that are determined in the sphere of income distribution (ie. wages). Therefore DEA facilitates this kind of analysis based on the Critique of Political Economy. In the case of unpaid overtime where there is no payment to analyse, technical efficiency matters. Working time and unpaid working time are basic elements with which industries' technical efficiency can be assessed, because it provides more information compared to an analysis where wages were used as a proxy for labour. Basic hours, total paid overtime and total unpaid hours of each UK industry are the actual inputs that with the use of capital are converted to industries' output (GVA).

Moreover, DEA is more suitable for small samples than parametric methods and this is an advantage in our case. In this dissertation, there are 60 industries to be analysed based on the Standard Industrial Classification of the UK (SIC2007 UK). Although this number is not small, in a secondary analysis of Manufacturing-Services or Productive-Unproductive industries, where the groups will contain less industries, this feature is quite useful.

Additionally, DEA is also suitable for ranking industries based on their efficiency. Although this is not the major focus of the thesis, ranking industries' performance in DEA regarding the amount of unpaid labour they use, could also provide some qualitative information about the kind of industries whose performance depends directly on the amount of unpaid overtime and working hours generally. There are industries appearing to be more efficient than others. DEA provides an analysis of 'peer' industries that act as a means for comparison regarding the use of unpaid overtime.

Finally, with DEA we can measure the efficiency change; the degree to which the Decision Making Unit (industry) has moved towards or away from the frontier in the next period relative to the previous one. The Marginal Rates of Substitution and the GVA contributions acquired for each year reveal also the technical change and the intertemporal worth of an industry.

4.1.2 DEA's limitations to this research

Although DEA provides a series of advantages there are certain limitations. For instance, DEA fits better in cases where random noise in the data is expected to be relatively low. However, we have no information on the noise of our data.

Additionally, DEA can only tell how well an industry is doing compared to its peers but not compared to an ‘ideal industry’ in terms of productivity. Even those industries that appear to be efficient in the sample might actually be inefficient in absolute terms, according to Akazili et al. (2008). However, this problem can be minimised by using a large enough sample data set. In this thesis, the sample is large enough (60) industries over 11 years. Therefore, if an industry appears to be systematically efficient over the years, then this result is more trustworthy compared to an industry that appears to be efficient only for a year.

Another limitation of using DEA is that the best model specification cannot be tested (Berg 2010). DEA’s best feature for not requiring model specification can become its most severe drawback. In other words, DEA as a non-parametric technique excludes statistical hypothesis testing. However, hypothesis testing that would be useful for analysing unpaid overtime’s statistical importance is used later on.

Finally, the relative nature of the assessment can lead to unstable results. How each type of decomposed labour day contributes to value added can change from one year to the next as more information is revealed through additional observations. This is not necessarily a disadvantage so long as the chances follow a pattern over time eg. rising contribution of a type of labour as productivity improves.

PART I: Data Envelopment Analysis modelling of Total labour and Capital

According to Thanassoulis (2001 p.63):

> *'the axioms underlying the transformation of inputs to outputs (…) make it possible to construct a set of constraints to a linear programming model so as to define feasible in principle input-output correspondences whether observed at DMUs or not. The objective function to the linear programming model can then be used in a variety of ways. (…) [I]t is used to give measures to the technical input or output efficiency of a DMU. (…) [T]he objective function can be used to yield other measures of efficiency of a DMU, target input-output levels and so on.'*[34]

To begin with, DEA models need to be defined based on the inputs and outputs that they examine, on their orientation (input-output) and on the returns to scale that are assumed. The inputs and outputs that are used have been thoroughly described. More specifically, there will be two models run: one model with total working hours and capital, and the second with the decomposed labour (basic working hours, paid overtime, and unpaid overtime) and capital. Gross Value Added per industry will be the output in both cases.

Table 4.2 - DEA models

	Total labour model		Decomposed labour model	
	Inputs	**Output**	**Inputs**	**Output**
Variables	Lt Total Labour Hours	GVA_i Gross Value Added (£)	Lb_i Basic Working Hours	GVA_i Gross Value Added (£)
	K_i Net Capital Stock (NCS £)		Lp_i Paid Overtime Hours	
			K_i Unpaid Overtime Hours	

As stated before, the orientation that is run for these two models is input oriented focusing on unpaid overtime' contribution across the industries. Regarding, industries' returns to scale, assuming Constant Returns Scale (CRS) would be too restrictive, especially if the different sizes and different activities are taken into account. Therefore, this dissertation is using Variable Returns to Scale (VRS) model, that measures pure technical efficiency and also any inefficiency due to returns to scale effects for each of the industries assessed. Scale efficiency can be measured by dividing the CRS efficiency

[34] Thanassoulis 2001 p.63 (book)

score by the VRS efficiency score. From the VRS model, it is possible to analyse whether an industry's production indicates increasing returns to scale, constant return to scale, or decreasing returns to scale by the sign of the variable ω (see following page).

Based on that, DEA analysis can be approached with two ways: with a *DEA envelopment model* and a *DEA value based model*. The PIM-DEA software Version 3.2 that was used for this dissertation conducts both models simultaneously. Therefore, in both parts of the analysis (with total labour and decomposed labour) both DEA models are solved.

4.2 Data Envelopment Analysis modelling of total labour and capital– All industries

This section is focusing on analysing industry based on the amount of total labour hours and capital that they use. This section is necessary to understand the general features of every industry regarding their capital composition. Additionally, this part is acting as a basis for comparison to the decomposed labour model. It is interesting to see what kind of industries rely on paid or unpaid overtime. It would make sense that the labour intensive industries are expected to be more prone to using unpaid overtime than the capital intensive ones. Additionally, knowing the contributions of labour day and capital per industry is also useful before moving to an analysis of decomposed labour. Therefore having a detailed analysis of the total working hours model is essential.

Table 4.3 - DEA Total Labour Model

Total labour model		
Variables	**Inputs**	**Output**
	L_t Total Labour Hours	GVA_i Gross Value Added (£)
	K_i Net Capital Stock (£)	

DEA envelopment model - Total Labour

The Envelopment models have an important practical use. They 'reveal' an assessment unit's pure technical input (or output) efficiency. In this case, the envelopment model shows industries' efficiency levels. This can reveal those industries that with the least amount of inputs provide the biggest amount of output, based of course on the pre-assumed homogeneity. This model with the total labour as input is compared later with the model with the decomposed labour. Industries might be efficient with one model but inefficient with the other. Therefore, taking this into account is of major importance.

Additionally, the envelopment version of the DEA model can also identify whether an assessment unit is acting as a Peer industry to others. It is important to highlight here that due to the fact that the non-peer industries derive their MRSs and contributions to GVA based on the 'role model' industry/ies that share common features in capital and labour. In other words, the peer industries are those that determine the results of the other industries. Therefore, we need to know them.

Moreover, the envelopment model provides input and output targets for the non-efficient industries. The target values show the quantity of inputs-outputs the industry would use if they were efficient. This is important because we can capture the effect of inter-industrial competition.

$$Min\ k_{j0} - \varepsilon(S_1 + S_2 + S_3) \tag{4.1}$$

Subject to:

$$\lambda_1 L_{t_1} + \lambda_2 L_{t_2} + \cdots + \lambda_{j0} L_{t\,j0} + \cdots + \lambda_{60} L_{t\,60} = k_{j0} L_{t\,j0} - S_1 \tag{4.2}$$

$$\lambda_1 NCS_1 + \lambda_2 NCS_2 + \cdots + \lambda_{j0} NCS_{j0} + \cdots + \lambda_{60} NCS_{60} = k_{j0} NCS_{j0} - S_2 \tag{4.3}$$

$$\lambda_1 GVA_1 + \lambda_2 GVA_2 + \cdots + \lambda_{j0} GVA_{j0} + \cdots + \lambda_{60} GVA_{60} = S_3 + GVA_{rjo} \tag{4.4}$$

$$\lambda_1 + \lambda_2 + \cdots + \lambda_{j0} + \cdots + \lambda_{60} = 1 \tag{4.5}$$

$$\lambda_1, \lambda_2 \ldots \lambda_{j0}, \ldots \lambda_{60} \geq 0 \tag{4.6}$$

$$S_1, S_2, S_3 \geq 0 \tag{4.7}$$

h_{j0} is the pure technical input efficiency of DMU j_0

0<< ε is an Archimedean infinitesimal

S_1, S_2, S_3 are slack values S_1, S_2 are slack values for labour and capital and $S_3$is a slack value for output: The constraint (7) restricts the input slack (S_1, S_2) and output slack ($, S_3$) variables to be non-negative

j represents the DMU under maximisation, j = 1…N. In our case j = 1…60

$L_{t_1} \ldots L_{t_{60}}$ is the amount of total labour hours used by industries j = 1…60

$NCS_1 \ldots NCS_{60}$ is the amount of Net Capital Stock (£) used by industries j = 1…60

$GVA_1 \ldots GVA_{60}$ is the amount of Gross Value Added (£) used by industries j =

1…60

The restrictions 2,3 and 4 form the convex reference technology

$\lambda_1, \lambda_2 \ldots \lambda_j, \ldots \lambda_{60}$ are the intensity variables. The non-zero optimal λ* identify the benchmarks for DMU_{j0} under evaluation. The constraint (6) limits them to be non-negative: The constraint (5) is the convexity constraint which is unnecessary under Constant Returns to Scale (CRS). According to Thanassoulis 2001 p. 130 '*it prevents any interpolation point constructed from the observed DMUs from being scaled up or down to form a referent point for efficiency measurement since such a scaling is not permissible under VRS*'.

However, the Envelopment Model does not provide sufficient information for the virtual input-output levels, which is the main focus of the dissertation. Therefore, DEA value-based models are also used to derive this additional information.

DEA value-based model – Total Labour

The DEA value based model defines efficiency with respect to the (implicit) values of inputs and outputs. The DEA value based models can also 'reveal' a DMU's pure technical input (or output) efficiency. Additionally to that, Value-based DEA models, according to Thanassoulis (2001, p.154), are most appropriate for

> *'getting a view on the robustness of the pure technical efficiency of a DMU. Such information is conveyed by the virtual input and output levels of the DMU being assessed in the same manner as under CRS (...) This means that in part the pure technical efficiency rating of the DMU concerned would be 'explained' by the scale at which the DMU operates'.*

In other words, the effect of industries' scale is removed when measuring efficiencies under VRS assumptions.

$$Max\ \ p_o = uGVA_{Jo} + w_1 - w_2 \qquad (4.8)$$

Subject to:

$$v_1 L_{t_{jo}} + v_2 NCS_{jo} = 1 \qquad (4.9)$$

$$uGVA_1 - v_1 L_{t_1} - v_2 NCS_1 + w_1 - w_2 \leq 0 \qquad (4.10i)$$

$$uGVA_2 - v_1 L_{t_2} - v_2 NCS_2 + w_1 - w_2 \leq 0 \qquad (4.10ii)$$

…

$$uGVA_o - v_1 L_{t_o} - v_2 NCS_o + w_1 - w_2 \leq 0 \tag{4.10$_0$}$$

...

$$uGVA_{60} - v_1 L_{t_{60}} - v_2 NCS_{60} + w_1 - w_2 \leq 0 \tag{4.10$_{lx}$}$$

$$u, v_1, v_2 \geq \varepsilon \tag{4.11}$$

$$\omega = w_1 - w_2 \text{ free, with , } w_1, w_2 > 0 \tag{4.12}$$

0<< ε is an Archimedean infinitesimal

p_o is the pure technical input efficiency of DMU j_0

u is imputed value for output (GVA)

v_1, v_2 are imputed values of inputs (L_t and NCS): $u, v_1, v_2,$ w_1 and w_2 are variables whose optimal values are to be determined by the model. The model determines their values so as to show industry $j0$ at maximum efficiency. u, v_1 and v_2 are interpreted as Marginal Rates of Substitution (among inputs). It is these rates that will interest us greatly.

ω (omega) is used as indicator to returns to scale. If the value of ω is greater than zero ($\omega > 0$) in all optimal solutions the DMU lies or is projected at an increasing returns to scale segment of the efficient frontier. If the value of ω is equal to zero ($\omega = 0$) the DMU lies or is projected at constant returns to scale segment of the efficient frontier, and if the value of ω is less than zero ($\omega < 0$) at decreasing returns to scale segment of the efficient frontier.

4.2.1 Detecting outliers with total labour as input

Before moving on to the full analysis by DEA, it is crucial to detect any outlier industries in terms of efficiency. Since, the units that are assessed are compared with the most efficient ones, having outliers and 'extremely' efficient units can distort the results. For instance, as it is demonstrated below industry 68 (Real Estate) appears to be super-efficient (is explained below) compared to any other industry. In other words, the industry due to various reasons is defining the frontier in a much higher level with all the other industries being quite distant from it. Therefore, extreme weights appear or no solution at all to most cases. After detecting outliers we are able to drop them and construct a production frontier without including them. Subsequently, including the dropped industries with their target vales to the frontier is the next step since we are still interested to see what are their input contribution to GVA is after removing their distorting efficiency levels. Consequently detecting outliers is one of the very basic preliminary steps in Data Envelopment Analysis.

Table 4.4 – Mapping industries into Productive and Unproductive (based on Mohun 2006)

Productive Industries		Unproductive Industries	
DMU	**Description**	**DMU**	**Description**
1	Agriculture	**45**	Wholesale&Retail&Repair of Motorvehicles
2	Fishing & Aquaculture	**46**	Wholesale trade
5	Mining	**47**	Retail
10	Food-Beverages-Tobacco	**64**	Financial Services
13	Textiles-Apparel-Leather	**65**	Insurance and Pension
16	Wood	**66**	Auxiliary to fiancing
17	Paper	**69**	Legal and Accounting
18	Printing&Reproduction of recorded media	**73**	Advertising and market research
19	Coke&Petroleum	**77**	Rental and leasing activities
20	Chemicals	**78**	Employment activities
21	Pharmaceutical	**79**	Travel agency, tour operator and other reservation service and related activities
22	Rubber&Plastic	**80**	Security and investigation activities
23	Non-metalic mineral	**84**	Public administration and defence; compulsory social security
24	Basic Metals	**94**	Activities of membership organisations
25	Metal Products	**95**	Repair of computers and personal and household goods
26	Computer, electronic and opticals	**96**	Other personal activities
27	Electrical equipment		
28	Machinery and equipment		
29	Motor vehicles&Tralers		
30	Transport equipment		
31	Furniture - OtherManf - Repair&Installation		
35	Electricity-Gas-Steam-Airconditioning		
36	Water collection, treatment and Supply		
37	Sweerage - Waste -Remediation		
43	Construction		
49	Land transport & Pipelines		
50	Water transport		
51	Air transport		
52	Warehousing and supporting transport		
53	Postal & Courier		
55	Accomodation & Food & Beverages		
58	Publishing Activities		
59	Motion video tv sound & Broadcasting		
61	Telecommunication		
62	Computer programming and consultancy		
71	Architecture and Civil Engineering		
72	R&D		
74	Other prof, scientific, technical & Veterinary		
85	Education		
86	Human Health		
87	Residential care and social work		

Outliers are detected by assessing each unit in turn without permitting the unit itself to be part of the frontier. This is equivalent to solving the model 4.8-4.12 without the constraint relating to DMUj_0 (4.10o). Where DMUj_0 was inefficient with the full model (i.e constraint j_0 was not binding at the initial optimal solution) dropping constraint 4.10o would make no difference. Otherwise DMUj_0 had been originally efficient, its efficiency now would be generally above 1, ie. the unit would be 'super-efficient' (meaning its GVA justifies larger inputs than those observed).

Super Efficiency was also enabled in PIM-DEA software and both Output and

Input orientation were used as under VRS super efficiency may not be defined in one of the orientations. This revealed cases where industries were significantly 'super-efficient'. We took 150% as a threshold for treating an industry as outlier. The results appear in Table 4.4.

Step 1: Enabling Super Efficiencies – 1st round

Table 4.5 - 1st round of Super Efficiencies – Outliers – Total Labour Model

Industries	Level of Efficiency	Orientation: Output	Orientation: Input
Not Enveloped		2 Fishing and Aquaculture 19 Manufacturing of Coke & Petroleum 95 Repair of computers and Personal household goods (partially not enveloped)	68 Real Estate
Super-Efficient			
	All years above 150%	68 Real Estate * 78 Employment Activities *	2 Fishing and Aquaculture * 78 Employment Activities *
	Most years above 150%	5 Mining 50 Water transport * 64 Financial Services *	5 Mining * 19 Manufacturing of Coke & Petroleum * 50 Water transport * 64 Financial Services * 85 Education*
	Few years above 150%	-	69 Legal and Accounting 95 Repair of computers and personal household goods *

Star (*) signifies inconsistent efficiency % across years

The first round of Super-Efficiency analysis shows that industries 2. Fishing and Aquaculture, 19. Manufacturing of Coke & Petroleum and 95. Repair of computers and personal household goods are not enveloped at all by the output oriented analysis, while industry 68. Real Estate is not enveloped by the Input oriented one.

Industry 19 is not output enveloped. Although we cannot speculate why there is no solution in the output orientation, we can still comment on the reasons of its high efficiency in the input oriented model. It is mainly labour efficient (not in capita) because of the nature of this industry. It uses too much capital compared to labour because it requires heavy machinery of 'humongous' dimensions, often located in the sea (extra equipment). It is not a labour intensive industry, since there are needs mainly for skilled labour. Therefore using relatively low amount of working hours compared to the market value of coke and petroleum that is produced places the industry in the input efficient (labour efficient).

Regarding industry 95. Repair of computers and personal household is an industry with no solution in the output orientation. This can be due to the nature (too many activities included) and the structure of the industry (too many small and independent producers). [35]

Moreover, 78. Employment Activities is also dropped because it appears to have efficiency levels above 150% in both orientations and also because it has huge variation and inconsistent efficiency as well. This can be attributed to the fact that the industry includes search and placement activities (job agencies) and also activities of theatrical casting agencies (excluding activities of agents for individual artist). This industry also includes human resources for client businesses, but not direct supervising of employees. In other words, the way that value added is calculated for 'simple' labour might have not included the industry to the supper efficient ones, but taking into account the value added produced when theatrical actors finally find a job (usually highly paid) could be the 'distorting' factor of this industry. Additionally, it is also a labour intensive industry, and the suggested targets (at this stage) for the industry would be to decrease labour and increase capital.

Regarding industry 68. Real Estate, Shaikh and Tonak (1997) are explaining that in orthodox national accounts, Real Estate is an industry that its value is a representative kind of a subjectively price given by individuals. Although, the demand-distorted production values are inevitable in orthodox statistics as explained before, industry 68.

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[35] According to Eurostat (Statistics Explained, 2017):
'The activities covered by Division 95 which forms the basis of this article are the repair and/or maintenance of:

- computers and computer peripherals such as printers as well as communications equipment like fax machines and mobile phones;
- home electronic goods (consumer electronics); garden equipment; clothing and footwear; furniture and furnishings; personal items such as watches and jewellery; most other consumer goods such as bicycles, toys, sports equipment and musical instruments.'

This is a peculiar industry division because of the variability of activities and the small in size but numerous firms consisting the industry. Additionally, UK has also some peculiarities regarding this industry, according to Eurostat (Statistics Explained, 2017):
'The United Kingdom accounted for almost a quarter (23.7 %) and France accounted for a fifth (22.4) of the EU-28's value added within the repair of computers and personal and household goods sector in 2014, some considerably greater shares than recorded by any of the other EU Member States'.
Therefore, it should not come as a surprise the fact that industry 95 appears as an outlier. Additionally, the suggested DEA targets for the industry are actually to decrease the amount of total working hours and capital used, confirming the above facts. Therefore, apart from the nature and structure, we choose to drop the above industries (19 and 95) for two reasons: first because in at least one orientation they are not enveloped, and second because they have extreme variations in their efficiency levels in the opposite orientation.

Real Estate is probably the most peculiar example taking into account that market values change from one year to the other even without having made any amendments to the house. Additionally, the fact that UK's Real Estate industry consists of a big part in country's accounts might contribute in this outlier behaviour even more. Therefore, industry 68 is dropped. After dropping it the new production frontier that is acquired shows that the rest industries-DMUs that are not that far from the efficient frontier (See Figures 4.1 and 4.2). Based on the new production frontier with only industry 68 completely dropped we get new target values and weights for inputs-output that enable an analysis on the Marginal Rates of Substitution (MRS) and input's contribution to Gross Value Added (GVA) in the following sections.

Therefore, at the 1st round of Super Efficiencies, 5 industries (2 19 68 7895) out of the 60 (8.33%) are dropped in total in order to proceed to the second stage of Super Efficiencies (See Table 4.5).

Step 2: Enabling Super Efficiencies – 2nd round

Table 4.6 - 2nd round of Super Efficiencies (2 19 68 78 95 Dropped)- Outliers – Total Labour Model

Industries	Level of Efficiency	Orientation	
		Output	**Input**
Not Enveloped		50 Water transport	43 Construction
Super-Efficient	**All years above 150%**	5 Mining*	50 Water transport *
	Most years above 150%	53 Postal & Courier	5 Mining *
		64 Financial Services *	64 Financial Services *
	Few years above 150%	-	53 Postal & Courier
			69 Legal and Accounting
			85 Education*
	Few years above 150%	-	53 Postal & Courier
			69 Legal and Accounting
			85 Education*

Star (*) signifies inconsistent efficiency % across years

In the second round of super efficiencies, although both orientations leave unenveloped different DMUs, *50. Water transport* is dropped because it is not enveloped in the output orientation and because it is super-efficient with a lot of inconsistent efficiency level. *5. Mining* and *64. Financial Services* are also dropped since they have huge variance in both orientations. 43. Construction is dropped too because it is not enveloped at all and 85 is also dropped because it is partially not enveloped ie. in some years the model is dropping it.

Therefore, only industry 2 Fishing and Aquaculture and 5. Mining make sense why they consist of an outlier. They both belong to what mainstream statistics include in the 'Primary' sector or what Political Economy includes in the Land industries. As it has been describe in the theoretical part, Agriculture (we add Fishing-Aquaculture and Mining here as parts of Primary sector analysis) depends on natural processes, and as Hegel (1991) states

'*the main part is played by nature, and human industry is subordinate to it*'.

In other words, since nature does the most job, using low amounts of labour time and capital market values make these industries look highly efficient. Therefore, they are dropped at this stage too.

Regarding industry 43. Construction is not enveloped in the input orientation. Therefore, there is no much speculation to analyse the industry. Regarding industry 50. Water transport being super-efficient is also something that depends on the nature of the industry. This industry is comprised by an extensive network of water pipelines having (probably) already been financially depreciated (therefore small amount of Net Capital Stock). Additionally, the industry might not require as much labour for its operations. Apart from that, the value added or the market value derived from water's transportation (especially after industry's privatisation) is the reason of a possibly high output. Industry 85 Education is outlier. Since Higher Education is included in the sector, the high value added produced compared to the labour and capital it uses can be attributed to the fact that high fees (market value of output) are distorting the analysis. DEA at this stage also suggests to increase labour and capital in the input orientation or to reduce output in the output orientation. Consequently, at this stage industries 43 50 64 68 and 85 are dropped, or in total 2 5 19 43 50 64 68 78 85 and 95. In other words, we choose to build a frontier with 16.66% of 60 industries missing.

Step 3: Scaling industries' values (inputs and outputs)

After having identified outlier industries, each variable has to be rescaled to get to low values to reduce round off errors. This is useful for getting sensible magnitudes for the DEA weights for each variable, while the efficiency results are scale-invariant. The divisors used for each input-output variable are as in Table 4.6.

Table 4.7 – Variables' divisors – Total Labour Model

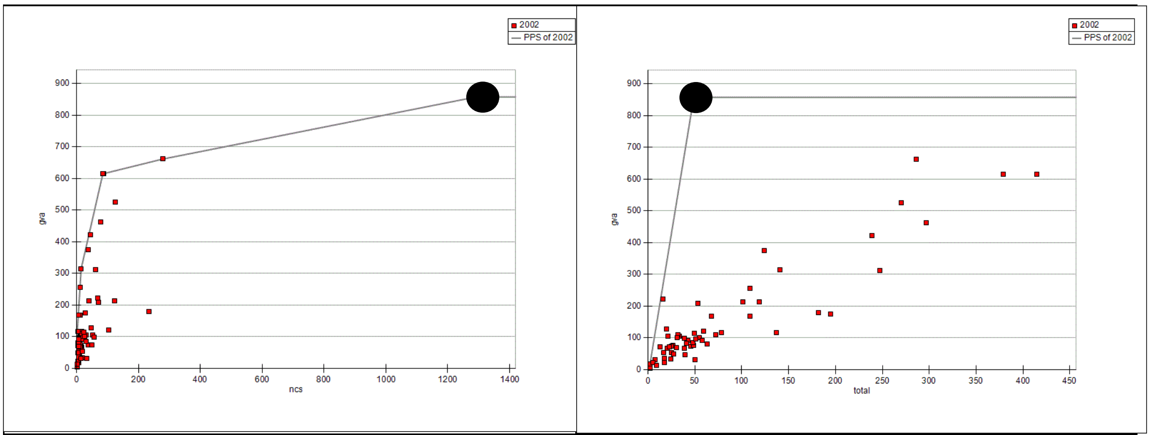
Variables	Measure	Divisor
Total working hours (Total)	Hours	10^7
Net capital stock (NCS)	Chain Volume Measure £	10^9
Gross Value Added (GVA)	Chain Volume Measure £	10^8

Step 4: Including dropped industries with their target values to the adjusted frontier

In this step, the VRS input oriented model is run normally (ie. without Super efficiencies) using the non-outlier industries. These industries define the clear from outliers' production frontier. However, we wish to retain the outlier industries but reflected on the frontier pertaining to non-outlier industries. To achieve this we have imported one outlier at a time using its targets that place it on the efficient frontier pertaining to the non-outlier industries. For those industries not enveloped in one orientation the target values of the opposite orientation are used in order to 'construct' the new adjusted frontier. After repeating this for the 10 originally dropped industries the adjusted frontier is ready for analysis.

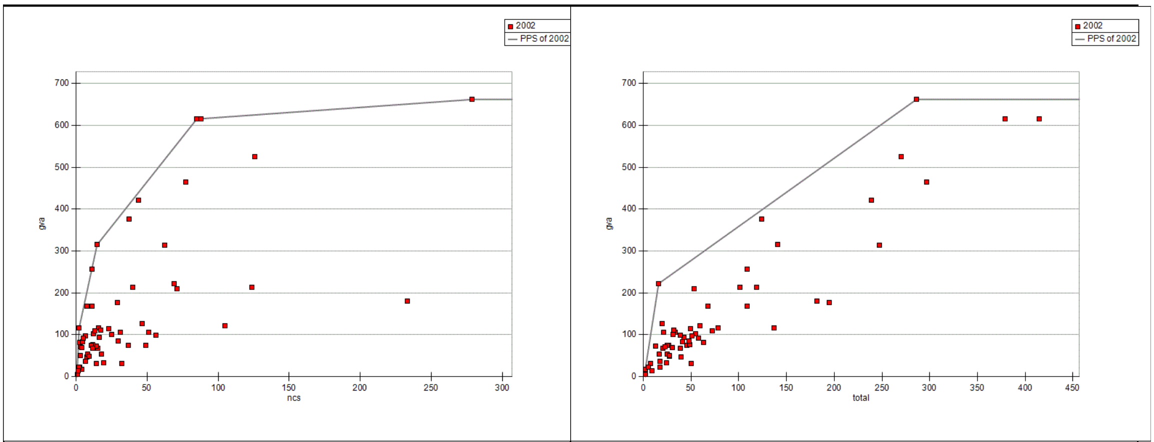
Step 5: Final detection of any outlier industry

However, even completing the above process there is one industry that defines the new adjusted frontier in a peculiar way. Industry *68. Real Estate* is the industry with the smallest working hours and the biggest output. Even in the decomposed labour model, and after a relevant adjustment it still appears as an outlier. In descriptive statistics in Chapter 5, industry 68 appears also as an outlier. An indicative example is its performance during 2002 (see figure 4.1). Although the figures are based on 2002 data, industry 68 has similar patterns throughout the 11 years that are studies. Especially in Labour-GVA production productivity set industry 68 highers the frontier substantially and further than the rest industries (See Figures 4.1 and 4.2). This creates more distorted targets, weights, peers etc for each industry. Therefore it is completely dropped from our analysis. This is mainly attributed to the factors mentioned above. The way that traditional National Accounts calculate Real Estate's value added is probably the most problematic among the industries. Therefore, even after adjusting the industry for its super-efficiency the distorting effect cannot be removed. Therefore, industry 68. Real Estate is dropped completely from the DEA analysis.



(a) Net Capital Stock (NCS) and Gross Value Added (GVA)	(b) Total Working Hours and Gross Value Added (GVA)

Figure 4.1 - Adjusted Frontier - The PPS including Industry 68. Real Estate (big black dot) in 2002



(a) Net Capital Stock (NCS) and Gross Value Added (GVA)	(b) Total Working Hours and Gross Value Added (GVA)

Figure 4.2 - Adjusted Frontier - The PPS excluding Industry 68. Real Estate in 2002

4.2.2 Outlier industries' analysis – total labour model

In this section, the Input oriented DEA model that is analysed contains two inputs (NCS and Total Hours Worked) and one output (GVA). Using the data adjusted to frontier, and after rescaling each input-output with their respective divisor, a *DEA value based model* derives the MRSs, using the PIM-DEA software was used to reach the solution. Solving the model for 649 observations, we get 581 industries over the 11 years with non-zero weights for total labour, capital and value added. In other words, most industries are represented in most years. The existence of positive weights implies that we can acquire information for the MRSs between inputs and that we can derive virtual inputs in relation to their output produced. In some cases the weight of at least one input (and output) is zero. In this case we do not have a full-facet or all-facet information.

However, there are years where some industries are not represented in the all-facet (3 facet here because of the 2 inputs) analysis, like industry 36. Water collection, treatment and Supply and 47. Retail Trade. The latter industry, has been identified already as an outlier partially or fully not enveloped in the outlier analysis already. In this case 47 industry's GVA weight is 0 for every year. Regarding industry 36, either its labour weight or its capital weight is 0. Therefore, there is no information for these industries in order to derive Labour-Capital Marginal Rate of Substitution (MRS) and the virtual inputs showing their contribution to output. However, the rest industries have an all-facet information for most of the 11 years.

Additionally, the acquired weights for deriving MRS and Virtual Inputs are derived based on their Peer Industry (ies) as discussed. These Peer industries are the efficient ones that determine the production frontier, and they are listed by year in which they are peer in Table 4.7.

Table 4.8 - Peer Industries (All Industries) –Total Labour Model

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	Fishing-Aquaculture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	Mining	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19	Coke & Petroleum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
21	Pharmaceutical								✓	✓	✓	
43	Construction	✓	✓	✓	✓	✓	✓					
47	Retail	✓										
50	Water transport	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
53	Postal & Courier	✓							✓	✓	✓	
62	Computer programming and consultancy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
64	Financial Services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
65	Insurance and Pension											✓
69	Legal and Accounting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
73	Advertising and Market Research	✓	✓	✓	✓	✓	✓	✓				
78	Employment Activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
79	Travel Agencies										✓	✓
85	Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
95	Repair of computers and personal household goods									✓	✓	✓

Only few industries act as peers consistently throughout the years. These are industries 2,5,19, 50, 62, 64, 69, 78 and 85. Their weights can be trusted more than the industries that act as peers only for a couple of years, such as 65 and 79. Additionally, the industries 2, 5, 50 and 78 that appear as consistent peers have been detected as outliers in the previous analysis and adjusted to the efficient frontier. Therefore, the fact that they act as efficient peers here does not cause much of a surprise. From an economic point of view it is not surprising either that the efficient ones are industries in the primary sector where the main role is played by nature (2. Fishing and Aquaculture and 5. Mining). From Manufacturing only 19. Coke and Petroleum appears to be efficient, and in the ‘wider’ manufacturing category, or in the category of productive industries, 50. Water Transportation. Generally, 19 and 62 are generally desirable activities for a capitalist to invest as they also offer high profit margins. Additionally, the frontier is also defined by industries that Britain is globally famous for, 64. Financial Services and 85. Education. The surprising industries that act as peers are 50, 69 and 79.

On the other hand, those industries that appear efficient only for a couple of years (65 and 79) are not necessarily to be taken into account. For instance, 65. Insurance and Pension has some peculiarities, especially regarding measuring GVA and capital. It contains pensions and also accident insurance and other schemes. The money saved by employees and employers consist of the industry’s capital and the money given back as pension or insurance cover taken as the output. Employment in this sector does not add any value based on the Critique of Political Economy. Labour here is a facilitator contributing in the materialization of surplus value, not to its production. As it has already been discussed, this industry could be part of the sphere of distribution/consumption. However, parts of the capital are allowed to be invested in funds nationally and internationally leading often to high returns (counted as GVA). These are factors that can justify why this industry is characterized by high output levels compared to the inputs used. Therefore, in the total labour model appears as a peer industry but only for 2012.

Peer analysis of Productive only and Unproductive only industries

In the previous part where all industries were analysed together, DEA derived weights for every input, leading to a different mapping of industries depending on the variable that was examined. Although every ‘angle’ was creating different groups there were some industries with similar patterns. For instance most of the Manufacturing industries were usually mapped together. More specifically, in most groups manufacturing of consumerable goods (Industries 10-18) were put together, and manufacturing of capital goods or durable ones (19-31) on their own. Generally, most industries seemed to gather in a single group, with few industries that had either too high or too low contributions. The MRS analysis was the part of analysis with most variations in categorising industries into various groups. However, regarding unpaid overtime in exchange to basic hours most industries demonstrated a similar pattern, as it is demonstrated later in the chapter. The reasoning of proceeding in a further analysis of productive and unproductive industries is related to the homogeneity issue that we have already discussed. Agriculture, Manufacturing, Health & Education and Financial services although they might have similar combinations of what traditional National Accounts define as capital and labour, their qualitative features are expected to be different.

In this part, despite that DEA tends to group most industries together in certain parts of the analysis, we want to see how the results change with respect to industries' ability in creating value (with Marxist terms), and therefore surplus value. As stated before, not everything marketable creates value, therefore including financial industries, Pension and Insurance, Public administration etc. can mainly distort the results and make this kind of industries appear efficient or super-efficient. Consequently, based on a previous scholars' mapping of industries, we repeat the same procedure as above. More specifically, following Mohun (2006), industries are divided in those that have overwhelmingly productive or unproductive kind of labour. However, Mohun's (2006) mapping is based on USA SIC codes. The Table 4.4 shows the dissertations' mapping based on the UK 2007 sic.

Although there are a lot of issues in national accounts, most of them tend to focus on peculiarities of capital and not on the kinds of labour. For instance, according to Shaikh, and Tonak (1997) treating durable goods as if they were equivalent to business capital, and even worse to impute fictitious profits to such goods is a wrong. In other words Health and Education should be distinguished from being analysed with traditional manufacturing industries. However, in this dissertation the mapping is not taking place based on the kind of capital, but on the kind of labour used. Therefore, because Health & Education is characterised by productive labour (creating new value, not just reselling a value created in previous stages of production).

However, some industries do not have only differences in the way that their capital is derived and/or calculated, but also in the kind of labour used. For instance, 64.

Financial services cannot be treated like any other producer. Therefore we need a separate analysis. Apart from that, most Unproductive industries in the previous stages of analysis appear as either efficient or with non-reasonable weights, especially with respect to MRS between unpaid overtime-paid basic or overtime.

Moreover, from the above industry mapping, industries 90. Arts & Libraries & Gambling and 93. Sports are not included. Amusement and recreation services are included in the Productive according to Mohun (2006), but Museums, botanical and zoological gardens are in the Unproductive. Additionally, industry 90 contains Gambling activities as well. Therefore this mix of industries does not make any theoretical or methodological sense. Consequently to avoid problematic results, we drop these industries from both groups.

Table 4.9 - Industries which are excluded from the productive-unproductive analysis

DMU	Description
90	Arts & Libraries & Gambling
93	Sports

Therefore, we group the productive industries together, as Table 4.10 shows. Apart from the Primary (Agriculture, Mining etc) and the Secondary sector (Manufacturing, Construction etc.), we also include all kinds of Transport (Pipelines, Land, Water, Air Transport) and industries like Health and Education. Some industries have been merged together because of lack of data. Their size was small or they were newly defined and therefore the size is small. These industries are shown in Chapter 3 (Table 3.3). In Total labour model we can analyse a full –facet model since from the 451 observations that we had originally, we end up with 425. There is quite rich information. Some of the above industries that appear as peer ones in the Productive industries were also so with the all-industries included, namely 2, 5, 19, 43, 50, 62 and 85. The rest of Productive industries were not acting as peers in the whole industries model.

Table 4.10 –Industries with majorly Productive labour

DMU	Description
1	Agriculture
2	Fishing & Aquaculture
5	Mining
10	Food-Beverages-Tobacco
13	Textiles-Apparel-Leather
16	Wood
17	Paper
18	Printing&Reproduction of recorded media
19	Coke&Petroleum
20	Chemicals
21	Pharmaceutical
22	Rubber&Plastic
23	Non-metalic mineral
24	Basic Metals
25	Metal Products
26	Computer, electronic and opticals
27	Electrical equipment
28	Machinery and equipment
29	Motor vehicles&Tralers
30	Transport equipment
31	Furniture - OtherManf - Repair&Installation
35	Electricity-Gas-Steam-Air-conditioning
36	Water collection, treatment and Supply
37	Sewerage
43	Construction
49	Land transport & Pipelines
50	Water transport
51	Air transport
52	Warehousing and supporting transport
53	Postal & Courier
55	Accommodation & Food & Beverages
58	Publishing Activities
59	Motion video tv sound & Broadcasting
61	Telecommunication
62	Computer programming and consultancy
71	Architecture & civil engineering
72	R&D
74	Other prof, scientific, technical & Veterinary
85	Education
86	Human Health
87	Residential care and social work

Table 4.11 - Peer Industries (Productive Industries) –Total Labour Model

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	Fishing & Aquaculture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	Mining	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19	Coke&Petroleum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
21	Pharmaceutical	✓							✓	✓	✓	✓
43	Construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
50	Water transport	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
53	Postal & Courier	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
62	Computer programming and consultancy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
71	Architecture and Civil Engineering	✓	✓									
85	Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
87	Residential care and social work										✓	✓

Table 4.12 - Common frontier industries between All and Productive Industries

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	Fishing-Aquaculture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	Mining	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19	Coke & Petroleum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
21	Pharmaceutical								✓	✓	✓	
43	Construction	✓	✓	✓	✓	✓	✓					
50	Water transport	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
53	Postal & Courier	✓							✓	✓	✓	
62	Computer programming and consultancy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
85	Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

This means that despite the removal of the unproductive industries, the frontier still consists almost of the same productive ones. Therefore the productive only analysis is expected to have similar results with the all industries, but with less inconsistences.

Table 4.13 - Peer Industries (Unproductive Industries) –Total Labour Model

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
47	Retail	✓	✓	✓	✓	✓		✓		✓	✓	✓
64	Financial Services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
65	Insurance and Pension			✓	✓	✓	✓	✓	✓	✓	✓	✓
69	Legal and Accounting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
73	Advertising and Market Rsearch	✓	✓	✓	✓	✓	✓	✓				
77	Rental&Leasing	✓										
78	Employment Activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
79	Travel Agencies								✓	✓	✓	✓
84	Public Admin and Defence & Social Security	✓	✓	✓	✓			✓		✓	✓	✓
94	Activities of Memberships Organisations									✓		
95	Repair of computers and personal household goods	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
96	Other personal activities									✓		

Regarding the Peers occurring from this analysis, some of the industries that appear as peer ones in the Unproductive industries are also included in the all industries model. Industries 64, 69, 73 and 78 act as peer industries for every year, both in the all-industries and in the unproductive. Thus, we could confidently say trust their results. Additionally, there were some industries that appeared only a couple of years as peers in the all industry model, but here they act as peers for most years, like industries 47, 65, 79 and 95, while the others occur for first time (77, 84, 94, 96).

Almost all of them act as peers. If every industry is efficient acting as self-assessors, it might be an indication either of the fact that the number of DMUs is smaller constructing a less demanding of performance efficient frontier, or that they do not have any homogeneity at all that cannot be comparable to each other. In either case, the results might not be as reliable as in the case of Productive only.

4.2.3 Marginal rates of Substitution

Running an input oriented model, we gain one group of weights between NCS and Total from the DEA value based model. From the original DEA value-based DEA model we can readily deduce that if dL_t and dNCS are marginal changes to the level of labour and capital respectively and v_1 and v_2 the optimal values of their respective weights, then for the industry concerned to remain on the efficient frontier equation 4.12 needs to hold:

$$v_1 L_t = v_2 NCS \qquad (4.13)$$

Thus if we set $dLt = 1$, we have:

$$dNCS = \frac{v_1}{v_2} \qquad (4.14)$$

In other words, one unit of Total Labour is compensated for by $\frac{v_1}{v_2}$ units of NCS. In the PIM software Total Labour was entered in units of 10^7 hours and NCS in units of 10^9 £'s. Thus, 10^7 hours is compensated by 10^9 $\frac{v_1}{v_2}$ £'s, or 1 hour is compensated for 100 $\frac{v_1}{v_2}$ £ of NCS. Based on this method, the UK industries different groups are shown in Table 4.8. These rates apply only at the frontier- i.e if the industry were to be operating efficiently in terms of the labour and capital inputs. In other words, this industry operates as efficiently as the benchmark industries identified by the model. However this is not absolute efficiency. Therefore a high rate of Labour relative to NCS (e.g. 1 hour of labour lost requiring a high level of NCS to compensate) for an industry to remain efficient would suggest that industry is using low labour levels relative to capital, when compared to other industries. The converse would be the case if 1 labour hour requires a low level of capital to be compensated for.

In examining a labour-capital MRS it should be recalled that capital is composed of various vintages; some will have been depreciated from many years ago but still functioning better than its depreciated value may suggest. This would tend to suggest higher labour is needed per unit capital than would be the case for more recent, non-depreciated vintages.

Every industry demonstrates a different pattern regarding the substitution of labour with capital. However, over the years and among the 57 remaining industries (3, 68, 37 and 47 are dropped) there are some common patterns. More specifically 5 different groups are created based on that, starting with the industries with the lowest MRS, where 1 hour is compensated with £1.7 of Net Capital Stock (NCS), and finishing with industries with the highest MRS where 1 hour of total labour is compensated with up to £780.

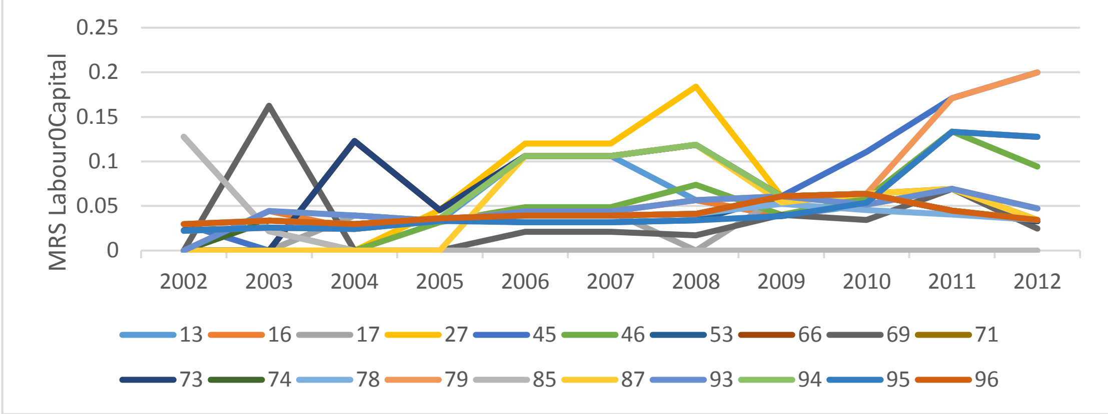
However, there are industries that demonstrate an inconsistent behaviour. The below Table 4.14 contains the range of values, the mean and the change of mean after the economic crisis of 2008. There are two mean values provided: one mean that includes extremely high or low values, but also a more 'purified' mean. The industries with faded grey are the non-peer ones.

Table 4.14 – Marginal Rate of Substitution (MRS) between Total Labour and Net Capital Stock (NCS) – All industries – 1 total working hour compensated wit £ of NCS

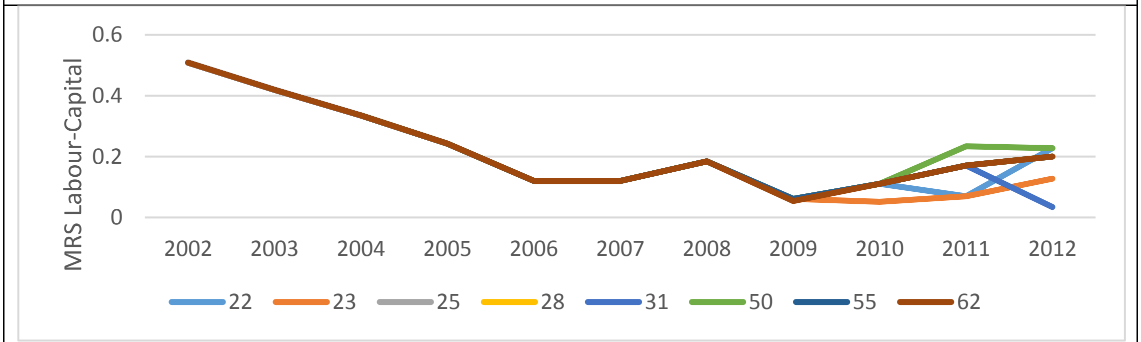
MRS	Lowest	Low	Medium	High	Inconsistent
TOT_NCS	**231 OBS**	**88 OBS**	**275 OBS**	**22 OBS**	
Range	£1.7 -20	£11 -£51	£64.7 - £333	£100- £780	
Average wide	12.6	25.6	132	469	
Average narrow	6	19.3	120	320	
Before Crisis	4.9	29	113	308	
After Crisis	6.8	13.5	132	410	
Industries	13 Textiles-Apparel-Leathe	**22 Rubber&Plastic**	1 Agriculture	**24 Basic Metals**	**2 Forestry**
	16 Wood	**23 Non-metalic mineral**	**5 Mining**	**35 Electricity-Gas-S**	18 Printing&Reproductio
	17 Paper	**25 Metal Products**	10 Food-Beverages-	**43 Construction**	**64 Financial Services**
	27 Electrical equipment	**28 Machinery and equi**	**19 Coke&Petroleum**		86 Human Health
	45 Wholesale&Retail&R	**31 Furniture - OtherMa**	20 Chemicals		
	46 Wholesale trade	**50 Water transport**	**21 Pharmaceutical**		
	53 Postal & Courier	**55 Accomodation & Fo**	26 Computer, electronic and opticals		
	66 Auxiliary to fiancing	**62 Computer programm**	29 Motor vehicles&Tralers		
	69 Legal and Accounting		30 Transport equipment		
	71 Architectural and Engineering		37 Sweerage - Waste -Remediation		
	73 Advertising and Market Rsearch		49 Land transport & Pipelines		
	74 Other prof, scientific, technical & Veterinary		51 Air transport		
	78 Employment Activities		52 Warehousing and supporting transport		
	79 Travel Agencies		58 Publishing Activities		
	85 Education		59 Motion video tv sound & Broadcasting		
	87 Residential care & Social Work		61 Telecommunication		
	93 Sports		**65 Insurance and Pension**		
	94 Activities of Memberships Organisations		72 R&D		
	95 Repair of computers and personal household good		77 Rental&Leasing		
	96 Other personal activities		80 Security and Investigation - Services to Buildings and Landscape &		
			84 Public Admin and Defence & Social Security		
			90 Arts & Libraries & Gambling		
PEERS	**Lowest**	**Low**	**Medium**	**High**	**Inconsistent**
Range	£2.2 -£16	£11 -£51	£67.4-£260	1- 7.8	
Average wide	9.7	25.7	168	-	
Average narrow	5.9	20.2	143	780	
Before Crisis	6	29	148	-	
After Crisis	5.87	17	142	-	

For accessing the data go to Appendix 5[36]

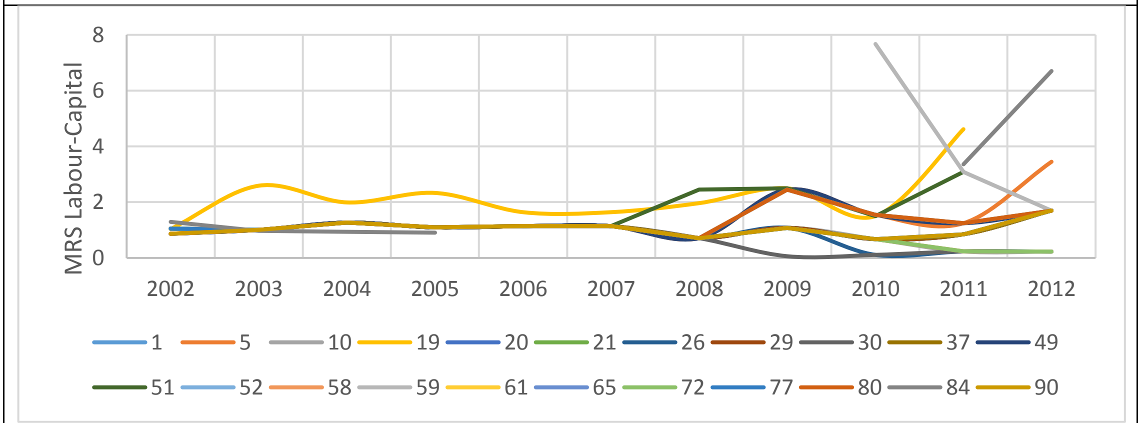
[36] The industries with bold letters are the peer industries defining the productive frontier.



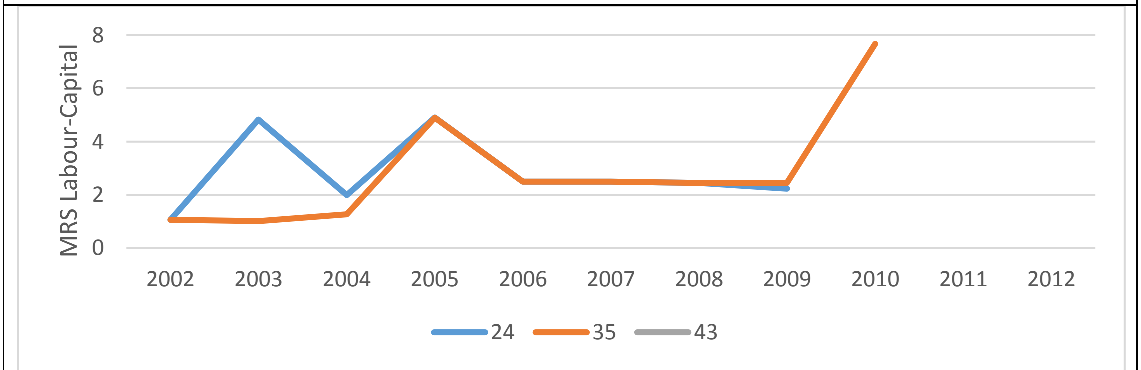
(a) Lowest group



(b) Low group



(c) Medium group



(d) High group

Figure 4.3 - MRS between Total Labour and NCS over the years in groups of industries - Total Labour

Model (All industries)

In the first group (Lowest MRS), mainly labour intensive industries are found: Textiles, Wholesale Trade, Education and Residential Care. Therefore, their low MRS comes as no surprise. As stated above, a low MRS means that the labour input is highly used in these industries. More specifically in the first group with the lowest MRS, 1 total working hour is compensated for 100*0.017 to 100*0.2 £, or £1.7 to £20. The average rate of substitution in this category is £6. Another thing that makes an MRS analysis useful is the pattern over time. It demonstrates which industries have increased or reduced their capitalisation after crisis. In the same group with the lowest MRS, there is an increase of the ratio. In other words, these industries experienced higher capitalisation or dropped labour (more possible) after crisis (See Figure 4.3).

This is the lowest capital composition, where it is overwhelmingly unproductive activities and 3 labour intensive manufacturing. In other words, industries like 53. Postal & Courier and Activities of Membership Organisation (Trade unions, religious etc) appear to be highly labour intensive. The degree of capital sophistication in these industries is not expected to be high. In this category the tendency that is observed has to do with a slight capitalisation over years that drops during crisis and then goes up again. Some industries' peak is 2007 and 2008, like 45. Wholesale Trade, 66. Auxiliary to financing, 74. Other Professional activities. These quickly responsive industries towards crisis are not a surprise As it was mentioned previously the high capital industries may respond with capital utilisation rather than changes in prices Here this quick response after crisis might reflect price changes on the one hand and/or investment in labour saving technology. This is a quite consistent finding with the Critique of the CPE, especially if we take into account that the capital composition of this group is not easily saturated, and therefore, there can be some space for labour saving technology. Additionally, during 2009 crisis is also consistent, since it is quite common practice to reduce working hours and labour costs, which is quite prevalent in these highly labour intensive industries. However, there are industries experiencing a consistent growth in their capital composition up to 2012 (ie. 16,17, 45, 46, 79, 95).

Apart from the individual weights that one can see in details in Appendix 6, we regressed in a simple OLS analysis the target inputs for labour and capital on the target output (GVA), which in this case would equal observed GVA. The target of working hours that was regressed is expressed in 10^7 hours and the target of capital in 10^9 £ over the real value of Gross Value Added expressed in 10^8 £. The derived coefficients for total labour is 0.95 and capital 4.69. Taking the Labour/Capital ratio we get 0.20. If we take into account that 10^7 of working hours is compensated by the above ratio times 10^9 £, we get that 1 working hour is compensated by £20, which matches the 'upper' limit in MRS that DEA gave us. This shows that following a regression analysis focused on targets gives us slightly different results, however, not that far from the DEA findings. It should of course be noted that regression as conducted here gives a linear approximation to the piece-wise linear DEA frontier which reflects better the varying MRS across industries.

The second group (Low MRS), that 1 total working hour is compensated for £11-£51 of net capital stock. In this category there are *productive* industries, or overwhelmingly manufacturing, that do require more capital than in the lowest category, but still low compared to other. The average MRS is £19.3. They are still labour intensive industries. In this group there are industries like 28. Machinery and equipment manufacturing, 50. Water transport and 62. Computer programming. This group shows an immediate change in its capital composition with regards to crisis that starts in 2007. Most of them recover after 2007 but they do not reach pre-crisis levels. All industries in this group have an almost U shape behaviour over the years (See Figure 4.3 b). Since, in this category there are still labour intensive industries, the changes in capital composition again do not probably reflect physical but mostly price changes, during the years of growth these industries counted a lot on using a lot of labour. It seemed that until 2006 these industries relied a lot on labour, a path that changed as 2006-2008 (that they have not experienced crisis yet), they invest in labour-saving technology. This investment was also interrupted (2008-2009) only to drop, reflecting a slight drop, reflecting a slight drop in capital utilisation, which restarted with recovering. We again regress the target inputs to the real GVA. In this group the targeted inputs give a ratio of 0.19 (1.77/2.29) or in other words, we get that 1 working hour is compensated by £19, which is within the range of values, and almost the same with the average MRS for the group.

The third group (Medium MRS) includes medium MRS where 1 total working hour is compensated for £67-£170. The average MRS is £120. In this group the majority of manufacturing industries can be found, with some industries from the services or the unproductive industries. Manufacturing and Transportation do not need to be explained why they are in this category. Employees in these industries are far fewer compared to others with respect to the amount of capital they use. Therefore, a higher MRS is expected. However, there are some industries from services (according to the traditional definition) or ‘unproductive’ industries that need further explanation. More specifically, industries 65. Insurance and Pension and 77. Rental and leasing, that are clearly belong to the ‘unproductive’ category are found in the medium capital composition grouping. This capital composition can be attributed to the way that their capital ‘value’ is calculated by orthodox statistics. For instance, in 65. Insurance and Pension as has been discussed previously, no transformational process has taken place, and it actually consists of values that have already been produced in the productive industries and transferred to the distributional sphere of economy (Pensions belong to distribution of wealth). Therefore, these accumulated values deriving form productive activities are high enough when they enter into their new industry as investment, adding up to the net capital stock. Regarding industry 77. Rental and leasing complications arise similar to those of industry 68. Real Estate as expressed above can be applied too. Generally, in this category there are ‘problematically’ valued industries. For instance, industry 84. Public Administration, Defence and Social Security, one could expect to have more labour intensive characteristics, but if we take into account that Defence is comprised by military bases, military equipment etc, this justifies the presence of this industry in the group of high capital. Additionally, industry 90. Arts and Gambling is also difficult to analyse, since the way of measuring Art’s and Gambling’s value can be extremely different. Moreover, these industries have pretty stable behaviour up until the outburst of the crisis in 2007. After that, they all display a different pattern. However, the dominant pattern is an increase in the MRS from £113 before crisis to £132 after. In the medium group the targeted inputs regression analysis is giving a ratio of 0.65 (1.92/2.9) or 1 total working hour is compensated for £69. This value is within the range derived from DEA and close to the lower limit. Except from the problematic industries described above, the rest experiences changes in MRS mostly reflecting physical and not price terms.

The last group of industries includes high composition of capital. More specifically, 1 total working hour is compensated for £100-£780. The average MRS is £320. Not surprisingly, industries with heavy equipment are found, like 24. Basic metals’ manufacturing, 35. Electricity-Gas-Stream-Air-conditioning and 43. Construction[37].

[37] For instance, in 43. Construction a crane driver needs a crane to work with. Therefore, crane driver’s working hour requires an extreme amount of net capital stock. Similarly, for 35. Electricity-Gas-Stream-

There is also similar increasing MRS tendency over time, compared to the other industry groups (See Figure 4.3 c). In the high MRS group the targeted inputs give a ratio of 9.66 (2.95/0.32) or £966. However, this is not fully consistent with the DEA finding but still high enough representing the high capital industry[38].

Finally, the analysis in Peer industries confirms almost the previous analysis of all industries with one exemption. The 'suspicious' increase in capitalisation in 2012 for Medium MRS Industries is an MRS derived from industry 65. Insurance and Pension that also acts as a peer industry, but not consistently over the years (just in 2012). This fact together with the issues of measuring 65 industry's value (see above) can disqualify this MRS as a trustworthy result. Therefore, the main conclusion for Medium industries' MRS pattern of capitalisation over time is that the industries reach a peak up to 2008-10 but this eventually stops without showing evidence of further increase. The only industry in Medium group that has an increase in capitalisation defined independently of industry 65 is 5. Mining, which is also a peer industry throughout the 11 years.

Generally, most industries seem to experience a slow-down in their capitalisation after the outburst of crisis in 2007. Some of them manage to increase it in levels higher than pre-crisis, but the majority, although have increasing pattern, they do not seem to reach the pre-crisis levels. This implies that up until 2012 the UK economy still experiences crisis, at least as expressed in the capital composition, as a growing economy or industry would be expected with much higher rates.

Regarding the Productive Industries, the Marginal Rates of Substitution between labour and capital are derived with the same way as above. Analysing the Productive industries only, similar patterns are observed and most industries are allocated in groups with similar range. The first thing that is observed here with a Productive industries analysis is that there are no inconsistent industries like in the all industries model. This happens because manufacturing is not compared with finance or retail trade, therefore we end up with more consistent results.

Air-conditioning huge electricity generators, gas collectors etc. increase the amount of Net Capital compensation for 1 total hour reduction.

[38] This can be attributed mainly to the fact that the regression analysis used only 22 observations (3 industries for 11 years) reducing the degrees of freedom and therefore the consistency of results.

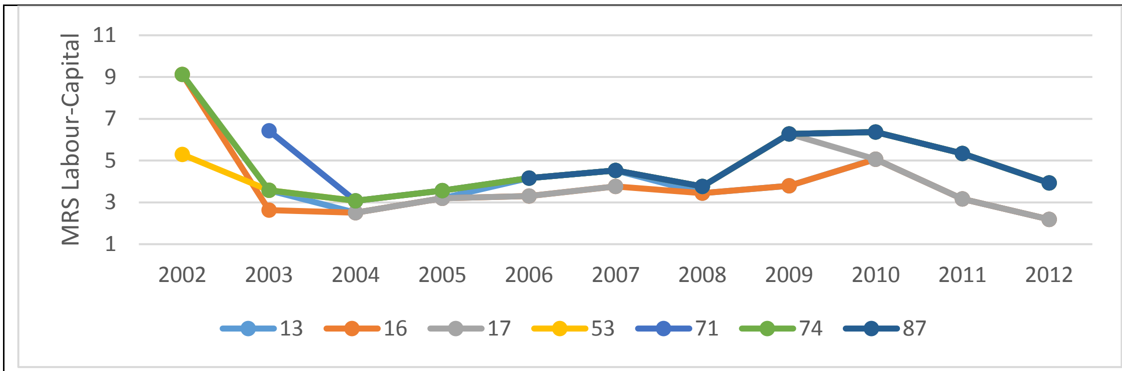
Table 4.15 - Marginal Rate of Substitution (MRS) between Total Labour and Net Capital Stock (NCS) – Productive industries – 1 total working hour compensated wit £ of NCS

MRS	Lowest	Low	Medium	High	Highest
TOTAL_NCS					
Range	£2.1- £6.4	£32-£92	£45-£520	£79-£760	£230-£6300
Average wide	£14.6541	£64.1228	£170.1718	£717.4162	
Average narrow	£4.2332	£62.0480	£153.0958	£276.3008	£2,003.4902
Before Crisis	£4.3681	£72.4756	£116.3874	£249.1306	£1,952.5637
After Crisis	£4.5273	£48.3784	£208.3579	£373.9652	£2,079.8798
Industries	13 Textiles-Apparel-Leathe	1 Agriculture	**19 Coke&Petroleu**	24 Basic Metals	**2 Fishing & Aquacult**
	16 Wood	**5 Mining**	**43 Construction**	35 Electricity-Gas-Steam-Airconditioning	
	17 Paper	10 Food-Beverages-Tob	51 Air transport		
	53 Postal & Courier	18 Printing&Reproductio	55 Accomodation & Food & Beverages		
	71 Architecture and Civil	20 Chemicals	59 Motion video tv sound & Broadcasting		
	74 Other prof, scientific, tec	**21 Pharmaceutical**	**85 Education**		
	87 Residential care and soci	22 Rubber&Plastic	**86 Human Health**		
		23 Non-metalic mineral			
		25 Metal Products			
		26 Computer, electronic and opticals			
		27 Electrical equipment			
		28 Machinery and equipment			
		29 Motor vehicles&Tralers			
		30 Transport equipment			
		31 Furniture - OtherManf - Repair&Installation			
		37 Sweerage - Waste -Remediation			
		49 Land transport & Pipelines			
		50 Water transport			
		52 Warehousing and supporting transport			
		58 Publishing Activities			
		61 Telecommunication			
		62 Computer programming and consultancy			
		72 R&D			
PEERS	**Lowest**	**Low**	**Medium**		**Highest**
Range	£3.1- £6.4	£32-£92	£45-£520		£230-£6300
Average wide	£10.4321	£59.4790			
Average narrow	£5.6031	£60.9803	£182.2445		£2,003.4902
Before Crisis	£4.2719	£73.4018	£149.1236		£1,952.5637
After Crisis	£6.4217	£48.5871	£226.0026		£2,079.8798

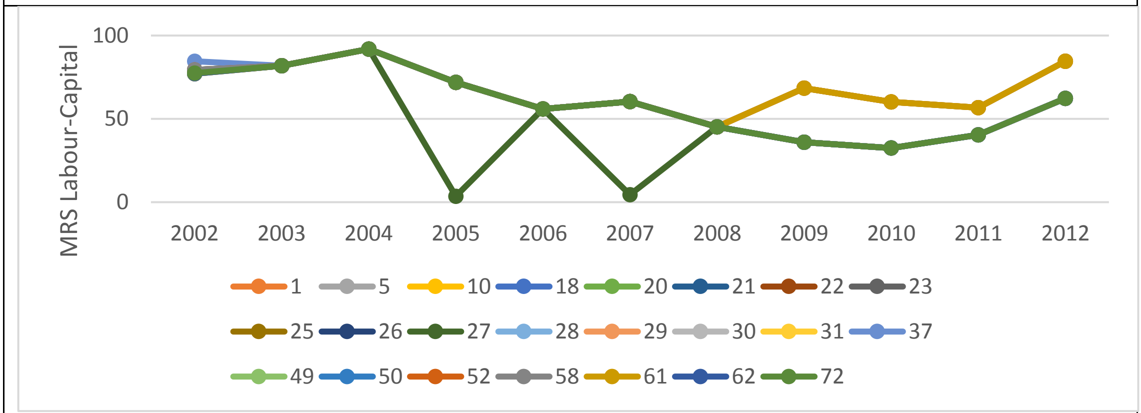
For access to data go to Appendix 7[39]

The lowest group industries are found in the same group with MRS range similar as in the all industry analysis. Regarding the rest groups, although their mapping into Medium and High has slightly changed, the MRS values still fall in the same range of values with the all-industry analysis. The improvement that is achieved now with the productive only industries is that we have a more consistent mapping with the literature of the Critique of CPE, as most manufacturing industries are grouped together. There are no unproductive ones (64, 77, 94) to disturb the results.

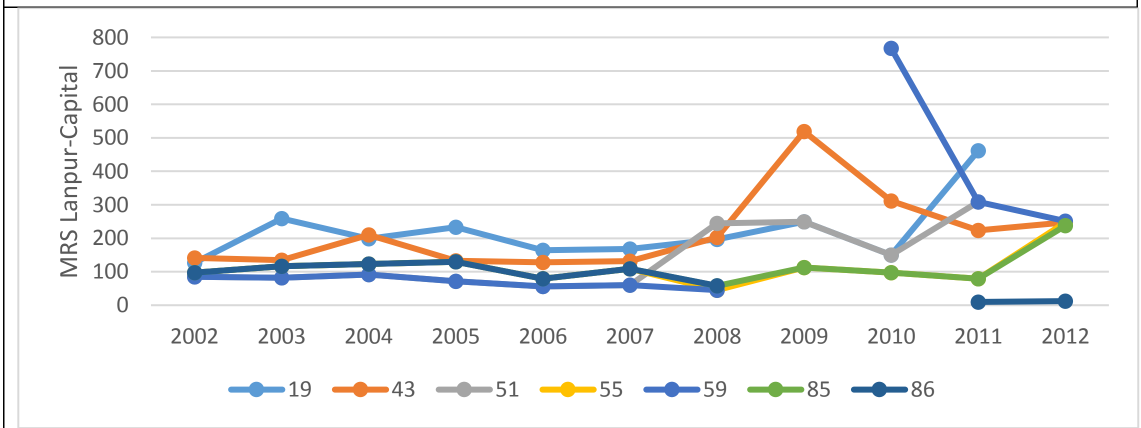
[39] The industries with bold letters are the peer industries defining the productive frontier.



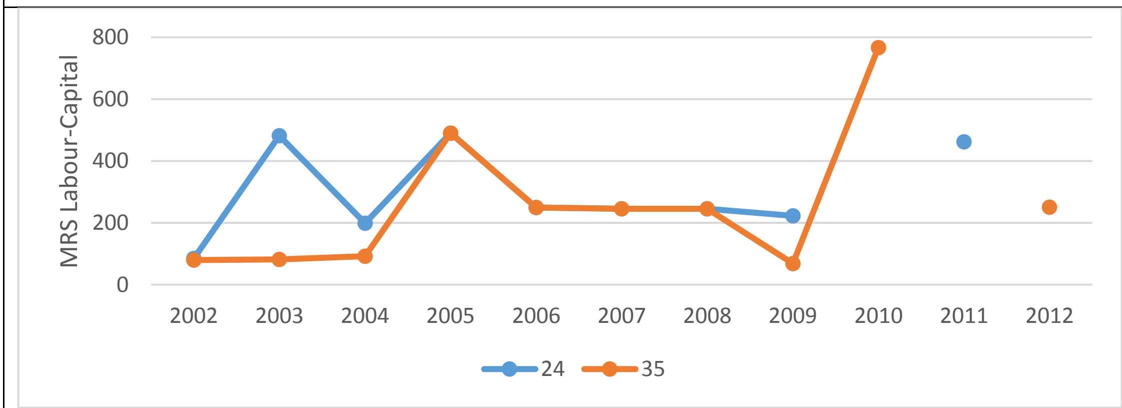
(a) Lowest MRS



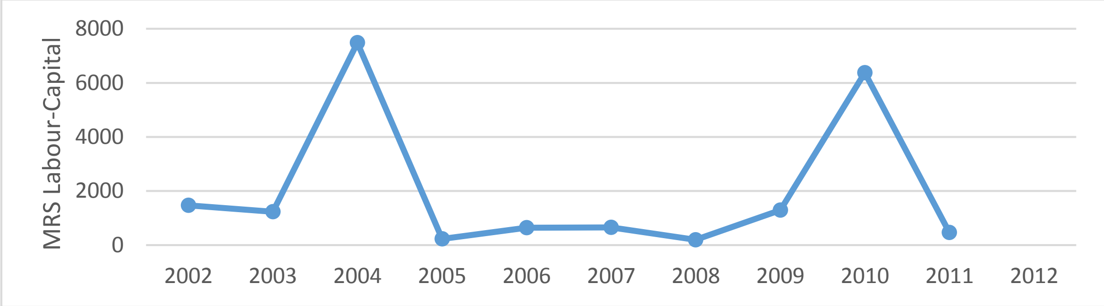
(b) Low MRS



(c) Medium MRS



(d) High MRS



(a) Highest MRS

Figure 4.4 - MRS between Total Labour and NCS over the years in groups of industries - Total Labour Model (Productive industries)

There are also clearer patterns over the years (agreeing with the all-industry analysis), as only the lowest group of labour intensive industries showcases a drop, despite the slight increase in 2007—09. This does not necessarily mean that during the crisis they have physically increased their capital, but rather dropped the working hours (which is expected during crisis), and with the recovery they started relying more on labour again. This result contradicts with the all-industry analysis that commanded the opposite pattern as the group contained most of the unproductive activities obscuring the physical change of the productive industries, with the highly probable changes in prices of the unproductive one.

Additionally, 85. Education and 18. Printing are not consistent with the all industry analysis. Particularly for 85. Education, it was earlier mapped in the same group as the unproductive activities giving a low capital composition, but in the productive only it is in the medium group, still with upward tendencies after crisis

Industry 2. Fishing and Aquaculture was inconsistent in the all-industries but in the Productive-only analysis appears having the highest MRS with capital. Mainly for the peculiarities that the industry has, and they have been presented previously, regarding the fact that the industry was appearing super-efficient.

Table 4.16 - Marginal Rate of Substitution (MRS) between Total Labour and Net Capital Stock (NCS) – Unproductive industries – 1 total working hour compensated wit £ of NCS

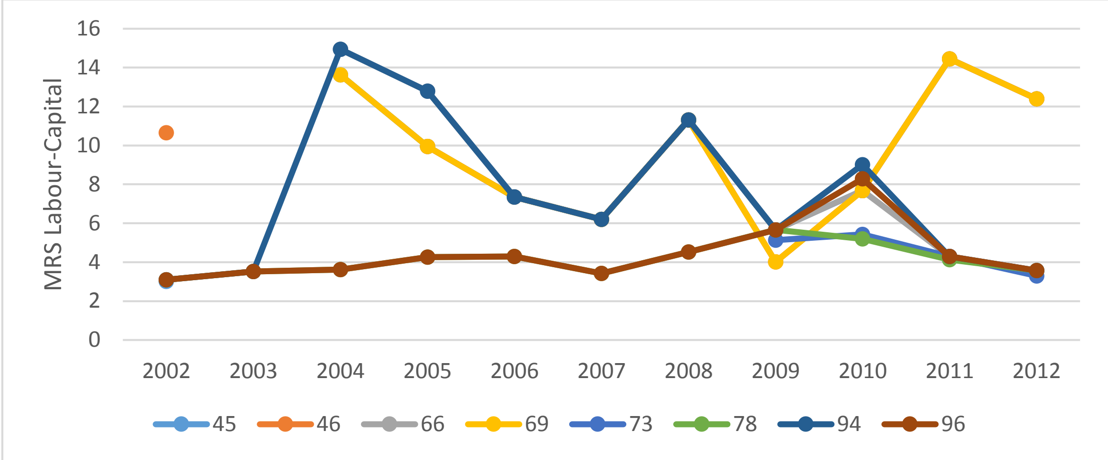
MRS		Low		Medium		Inconsistent
TOTAL_NCS						
Average narrow		£7.1663		£303.7374		
Before Crisis		£6.6590		£458.8867		
After Crisis		£7.3636		£217.0867		
Industries	**45**	**Wholesale&Retail&Repair of Motorvehicles**	**64**	**Financial Services**	**79**	**Travel Agencies**
	46	**Wholesale trade**	**65**	**Insurance and Pension**		
	66	**Auxiliary to fiancing**	**77**	**Rental&Leasing**		
	69	**Legal and Accounting**	**80**	**Security and Investigation - Services to Buildings and Landscape & Other Admin**		
	73	**Advertising and Market Rsearch**	**95**	**Repair of computers and personal household goods**		
	78	**Employment Activities**				
	94	**Activities of Memberships Organisations**				
	96	**Other personal activities**				
PEERS		**Low**		**Medium**		
Average narrow		£6.1285		£318.4641		
Before Crisis		£5.7184		£458.8867		
After Crisis		£6.3679		£223.7752		

For access to data see Appendix 8[40]

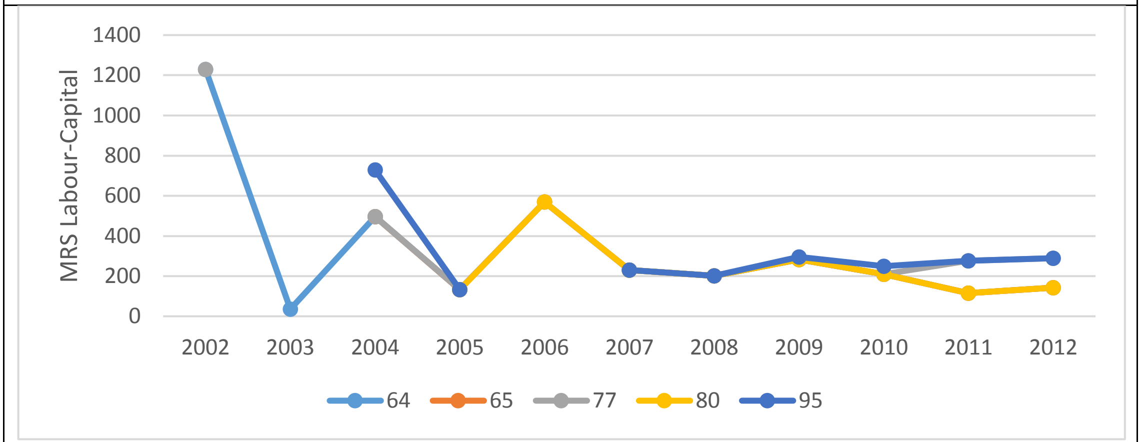
Although DEA can work with small number of DMUs, there is still an uncertainty of the below results for unproductive industries because there is even bigger heterogeneity among industries compared to the productive ones. Therefore, the results in Table 4.16 will be treated with caution, especially if there is a massive distance from the all-industries findings.

To begin with the MRS between labour and capital, there is no much variation, as there are mainly two groups with completely different scale of MRS, with the first having an average MRS is 1 working hours is exchanged for £7 of NCS, while in the second group, is 1 working hours is exchanged for £300 of NCS. Apart from 79 and 95 the MRS of the unproductive industries fal in the same range with the all industry analysis. Here it is suggested that in 64. Finance and 65. Insurance industries raising labour is the more effective means than capital in delivering value added, which makes sense if we take into account the nature of these industries. Generally, the larger the number of units the more reliable the results with the only issue being the homogeneity of the units.

[40] The industries with bold letters are the peer industries defining the productive frontier.



(a) Low MRS



(a) Medium MRS

Figure 4.5 - MRS between Total Labour and NCS over the years in groups of industries - Total Labour Model (Unproductive industries)

4.2.4 Analysing Inputs' Contributions to Gross Value Added in the total labour model

As it has already been mentioned the ultimate goal of this dissertation is to measure unpaid overtime's contribution to industries' output. However, before we proceed to decomposing labour, we need to see the amount by which total working hours contribute to GVA. This can be conducted both by DEA and by statistics. Regarding DEA the contribution of Total Labour Hours and Net Capital Stock to Gross Value Added (GVA) is given by $\frac{v_1}{u}$ and $\frac{v_2}{u}$.

v_1, v_2 and u are the weights for Net Capital Stock, Labour and Gross Value Added.

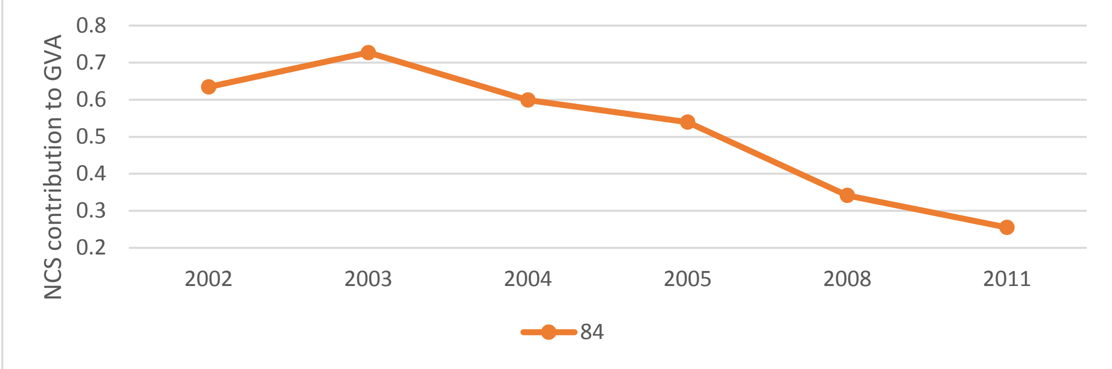
NCS value transfers to GVA – All industries

Although, NCS is calculated with the assumed depreciation been taken out from the Gross CS, it is still present in industries' disposal. It is also expected that its value is not consumed on a productive instance, but it stays for various fashions. So $\frac{v_1}{u}$ is the value transfer of £10^9 of NCS per £10^8 of GVA, and $\frac{v_2}{u}$ is the contribution of £10^7 of Total Working Hours per £10^8 of GVA. The meaning of the above virtual input is to discover 'what would be the contribution of an additional hour of labour and an additional £ of capital if the industries examined were performing at the efficient level'. Again for the 581 positive weights we derive the following contributions.

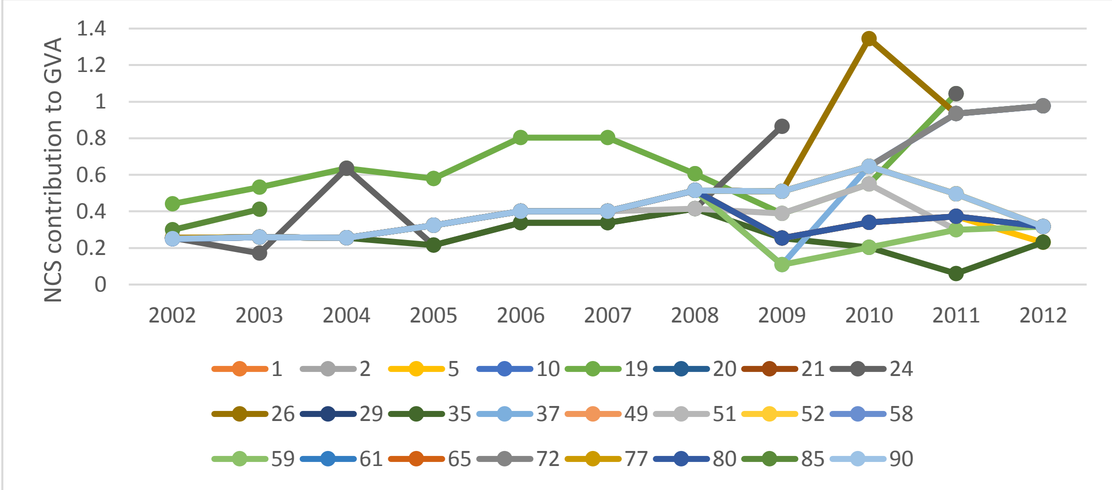
Table 4.17 - £1 of NCS value transfer s towards £ of GVA – Total Labour Model (All industries)

CONTRIBUTION	Lowest	Low	Medium	High	Inconsistent
NCS_GVA					
Average narrow	£0.0190	£0.0460	£0.4068	£1.4362	
Before Crisis		£0.0625	£0.3308	£1.2657	
After Crisis		£0.0239	£0.5258	£1.6402	
Industries	**43 Construction**	84 Public Admin and Defe	1 Agriculture	13 Textiles-Appar	86 Human Health
			2 Forestry	16 Wood	
			5 Mining	17 Paper	
			10 Food-Beverages-Tc	18 Printing&Reproduction of recorded i	
			19 Coke&Petroleum	22 Rubber&Plastic	
			20 Chemicals	23 Non-metalic mineral	
			21 Pharmaceutical	25 Metal Products	
			24 Basic Metals	27 Electrical equipment	
			26 Computer, electroni	28 Machinery and equipment	
			29 Motor vehicles&Tra	30 Transport equipment	
			35 Electricity-Gas-Stea	31 Furniture - OtherManf - Repair&Inst	
			37 Sweerage - Waste -	45 Wholesale&Retail&Repair of Motor	
			49 Land transport & Pi	46 Wholesale trade	
			51 Air transport	**50 Water transport**	
			52 Warehousing and su	**53 Postal & Courier**	
			58 Publishing Activities	55 Accomodation & Food & Beverages	
			59 Motion video tv sou	**62 Computer programming and cons**	
			61 Telecommunication	**64 Financial Services**	
			65 Insurance and Pen	66 Auxiliary to fiancing	
			72 R&D	**69 Legal and Accounting**	
			77 Rental&Leasing	71 Architectural and Engineering	
			80 Security and Investig	**73 Advertising and Market Rsearch**	
			85 Education	74 Other prof, scientific, technical & Ve	
			90 Arts & Libraries & (	**78 Employment Activities**	
				79 Travel Agencies	
				87 Residential care & Social Work	
				93 Sports	
				94 Activities of Memberships Organ	
				95 Repair of computers and personal hc	
				96 Other personal activities	
			Medium	**High**	
PEERS					
Average wide			£0.5809		
Average narrow			£0.4963	£1.3085	
Before Crisis			£0.3987	£1.0643	
After Crisis			£0.4869	£1.5576	

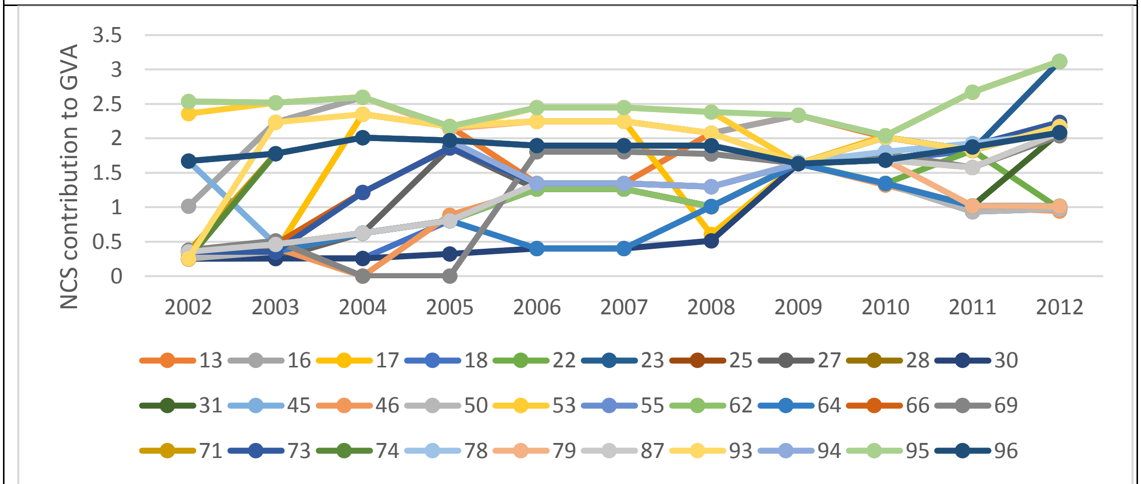
For access to data go to Appendix 9[41]



a) Low NCS value transfer



b) Medium NCS value transfer



c) High NCS value transfer

Figure 4.6 - £1 of NCS value transfer towards £ of GVA over the years in groups of Industries – Total Labour Model (All industries)

[41] The industries with bold letters are the peer industries defining the productive frontier.

The results of NCS value transfer towards GVA do not vary as much as most industries are found in the medium and high value transfer group.

To begin with, the Lowest group £1 of NCS transfers value to an average of £0.019 of GVA. This group includes industries that in order to produce £1 of GVA will require more NCS invested compared to other industries. In this group, 43. Construction is the only industry included. The very low contribution of capital to GVA can be possibly attributed to high indivisibilities[42]. Therefore, these kinds of capital investment are bound to be initially under-utilised. However, there is no information for more than a year in order to see if as years pass the contribution increases.

The second group is also comprised by one industry. 84. Public administration & National Defence, with an average contribution of £0.046 GVA. It is a peculiar industry, mainly because of combining administration and defence that on their own have very different features. It is probably the Defence part of the industry that makes the industry having such a small contribution of capital. The indivisibilities of the Defence industry can also cause this result.

In the third group of industries £1 off NCS contributes to £0.48 of GVA. This means that we need almost £2 of NCS to produce £1 of GVA. The majority of industries are productive industries. There are also some unproductive (65, 77, 80 and 90). Regarding Insurance-Pension and Rental-Leasing industries the way of calculating the NCS and GVA in traditional statistics is already discussed. Particularly for 65. Insurance and Pension, it is an industry that has appeared superefficient and the fact that such a small quantity can contribute to such a big GVA should not cause, much of a surprise. Regarding industry 77. Rental and leasing that uses the same method of calculating value like 68 Real Estate that has been discussed before. However, regarding the productive industries, judging from Mining, Manufacturing of Basic Metals, Land and Air transports, the way that these industries function, with a high amount of fixed capital used for a series of years causing indivisibilities (in less degree than in the previous industries that have been analysed) could also be a possible explanation for appearing such a low contribution. The majority of UK industries share similar characteristics with the above category. The relatively low contribution of NCS can be attributed to indivisibilities, it can also reflect

[42] For instance, in order to build a tower building the construction firm will need to buy a crane. A crane has a certain size and market value at which it becomes available to the Construction industry.

issues of technological lag (too much money to buy NCS but not as highly productive), it can also reflect a lag in workforce to catch-up with the new equipment invested. The majority of the above-mentioned issues can usually improve over time. Therefore, the increasing tendency before and after crisis (£0.33 - £0.528 respectively) might reinforce the above speculation too. The peers-only analysis shows also similar results.

The last group is the most populous one, where most of the UK industries find themselves. Contrary to the previous groups, in the High group of industries, £1 of NCS contributes to £1.4 of GVA. This group indicates possibly a 'leaner' structure of industries, where NCS can be 'divided' and/or be 'consumed' quicker. In this case the all-industry analysis shows that there is an increase in contribution after crisis from £1.26 to 1.6. The increasing tendency is also confirmed by the peer analysis.

Generally, over years it is observed that some industries are increasing their capital contribution, while other are decreasing it. From the Figures 4.6 Above, there is not uniform pattern for most of them. The tendency over the years is for capital's contribution seems to increase.

Although this dissertation though, does not have capital and its tendencies over time as the main focus, the changes over these years are connected with the changes in pattern in labour that appear increasing tendencies, but there groups of industries. This betrays labour's volatile nature and might also act as an indication that in industries like those experienced a saturation of occupying their employees for long hours, as the number of jobs does not vary as much (see Chapter 3). Literature review and empirical evidence before crisis indicate that mainly the second scenario is more plausible.

NCS value transfers to GVA – Productive industries

Running the productive model only, we get similar to the all industry model however, some of the industries in the medium group in Productive only industries, appeared in the high group with the all industry analysis. This means that when some productive industries are compared to the unproductive, the DEA assigns them with higher value transfers towards GVA.

Table 4.18 - £1 of NCS contributions towards £ of GVA – Total Labour Model (Productive industries)

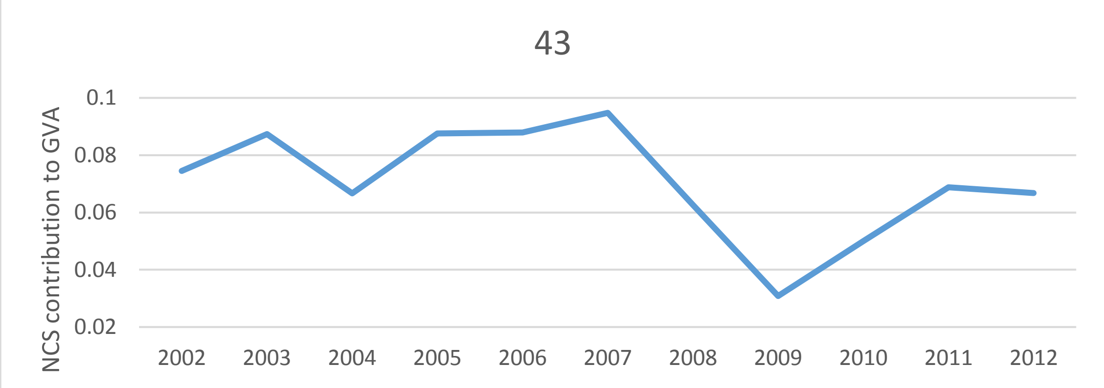
CONTRIBUTION	Low		Medium		High		Inconsistent	
NCS_GVA								
Average narrow		0.070727803		0.451157008		1.835162234		
Before Crisis		0.083147977		0.317679793		1.653625805		
After Crisis		0.055823594		0.614396036		2.053005949		
Industries	**43**	**Construction**	1	Agriculture	13	Textiles-Apparel-Leather	27	Electrical equipment
			2	Fishing & Aquaculture	16	Wood		
			5	**Mining**	17	Paper		
			10	Food-Beverages-Tobacco	**53**	**Postal & Courier**		
			18	Printing&Reproduction of recorded media	71	Architecture and Civil Engineering		
			19	Coke&Petroleum	74	Other prof, scientific, technical & Veterinary		
			20	Chemicals	87	Residential care and social work		
			21	**Pharmaceutical**				
			22	Rubber&Plastic				
			23	Non-metalic mineral				
			24	Basic Metals				
			25	Metal Products				
			26	Computer, electronic and opticals				
			28	Machinery and equipment				
			29	Motor vehicles&Tralers				
			30	Transport equipment				
			31	Furniture - OtherManf - Repair&Installation				
			35	Electricity-Gas-Steam-Airconditioning				
			37	Sweerage - Waste -Remediation				
			49	Land transport & Pipelines				
			50	**Water transport**				
			51	Air transport				
			52	Warehousing and supporting transport				
			55	Accomodation & Food & Beverages				
			58	Publishing Activities				
			59	Motion video tv sound & Broadcasting				
			61	Telecommunication				
			62	**Computer programming and consultancy**				
			72	R&D				
			85	**Education**				
			86	Human Health				

For access to data see Appendix 10[43]

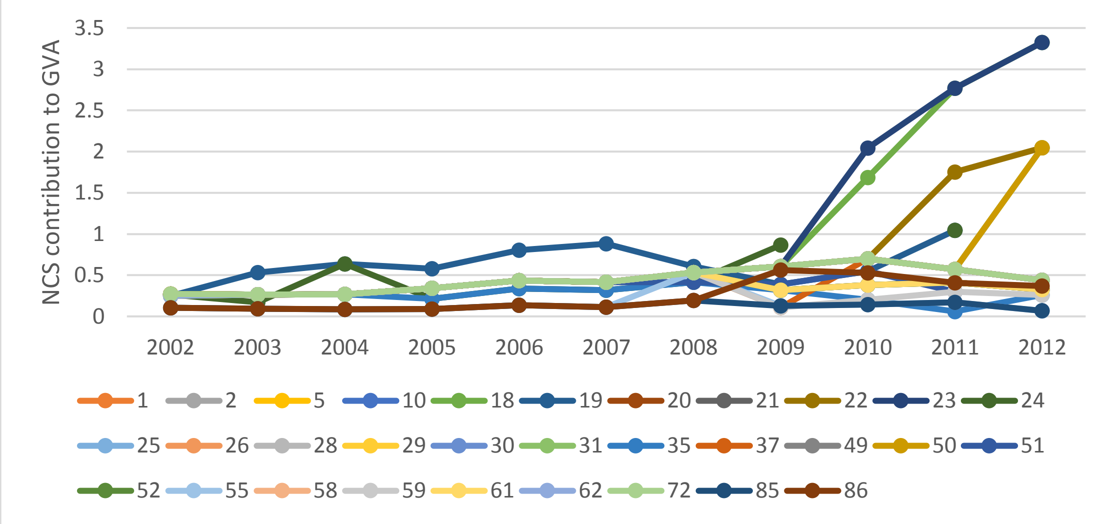
Here in the low category industries 18 22 23 50 are those that have an extremely high value transfers after 2009. This high contribution would tend to go with low use of capital. However, the question that occurs in this case is whether the capital has been depreciated or the investment has gone down. Since there are mostly capital intensive industries the changes should reflect mainly physical changes. From the descriptive statistics (Chapter 3) regarding Gross Fixed Capital Formation (GFCF) (See Figure 3.3) we can see a dramatic drop in the variable that acts as a proxy for investment. Therefore, it can be the lack of investment that makes NCS's contribution to GVA appearing larger. However, DEA is a comparative methodology and the results should be interpreted in

[43] The industries with bold letters are the peer industries defining the productive frontier.

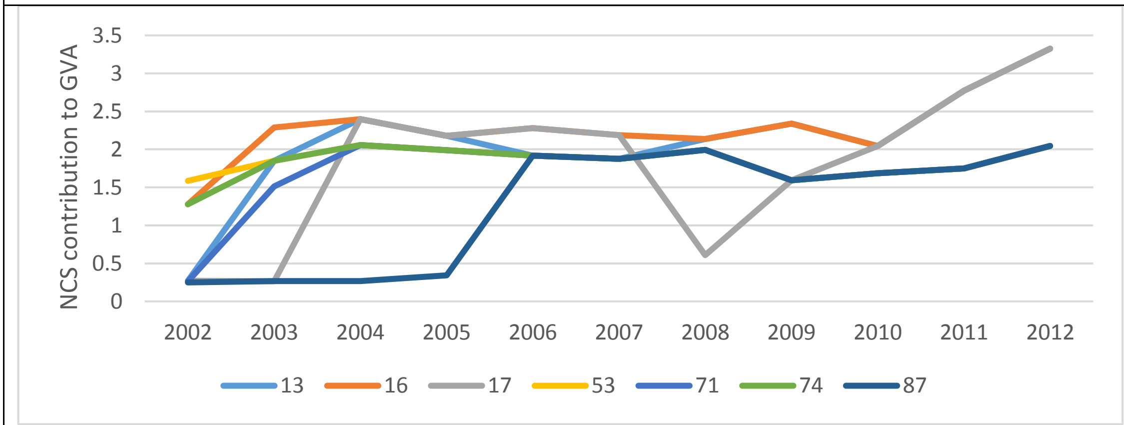
comparison to other industries, and not necessarily in absolute terms. Therefore this drop in investment betrays the drop in capital utilisation.



(a) Low NCS value transfer



(b) Medium NCS value transfer



c) High NCS value transfer

Figure 4.7 - £1 of NCS contributions towards £ of GVA over the years in groups of Industries – Total Labour Model (Productive industries)

Therefore, progressively over the years the industries that appear in the lower category here tend to increase their contribution leading –possibly- to higher group. Therefore, the productive industries analysis shows patterns that could not be detected earlier either.

NCS contribution to GVA – Unproductive industries

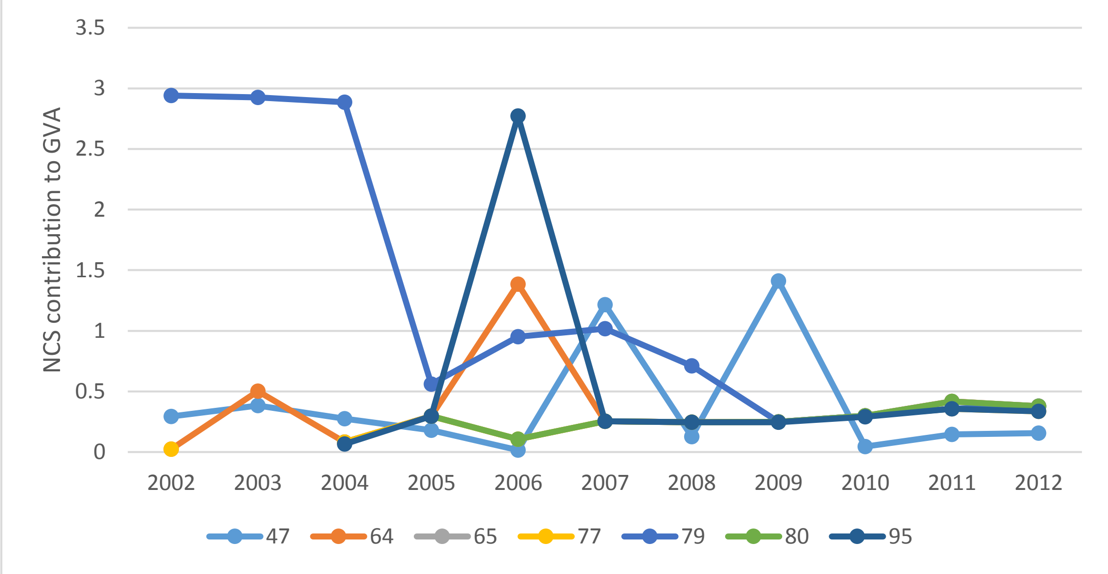
Table 4.19 - £1 of NCS contributions towards £ of GVA – Total Labour Model (Unproductive industries)

CONTRIBUTION		Low		Medium
NCS_GVA				
Average narrow		£0.4832		£1.3104
Before Crisis		£0.7108		£1.1353
After Crisis		£0.3316		£1.5124
Industries	**47**	**Retail**	45	Wholesale&Retail&Repair of Motorvehicles
	64	**Financial Services**	**46**	**Wholesale trade**
	65	**Insurance and Pension**	66	Auxiliary to fiancing
	77	**Employment Activities**	**69**	**Legal and Accounting**
	79	**Security and Investigation - Services to Buildings and Landscape & Other Admin**	71	Advertising and Market Rsearch
	80	Public Admin and Defence & Social Security	**73**	**Rental&Leasing**
	95	**Other personal activities**	**78**	**Travel Agencies**
			94	**Repair of computers and personal household goods**
			96	**Other personal activities**
PEERS		Low		Medium
Average wide		£0.3315		£1.2079
Average narrow		£0.3791		£1.0419
Before Crisis		£0.2749		£1.4156
After Crisis				

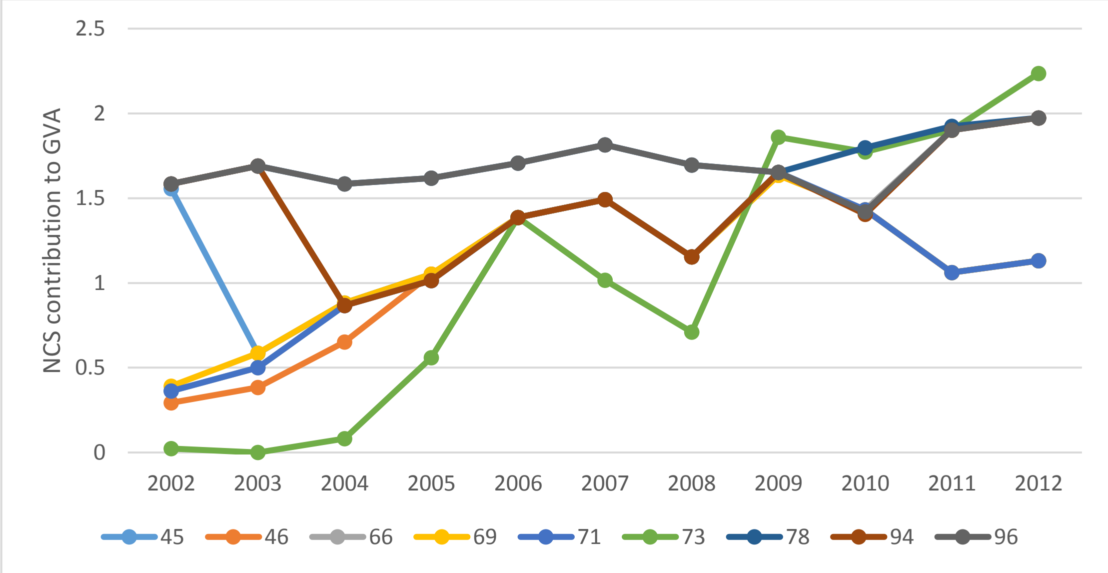
For access to data go to Appendix 11[44]

Similar to the productive industries the high value transfer group is consistent with the all industry analysis The NCS contribution to GVA of unproductive industries is very similar to the all-industries analysis, and the Medium experiences changes. The all-industry analysis assigned both some productive and some unproductive to the higher value transfer. The pattern over the years is also increasing like in the case of all-industries analysis.

[44] The industries with bold letters are the peer industries defining the productive frontier.



(a) Low NCS contribution



(a) Medium NCS contribution

Figure 4.8 – £1 of NCS contributions towards £ of GVA over the years in groups of Industries – Total Labour Model (Unproductive industries)

Total labour hours contribution to GVA – All industries

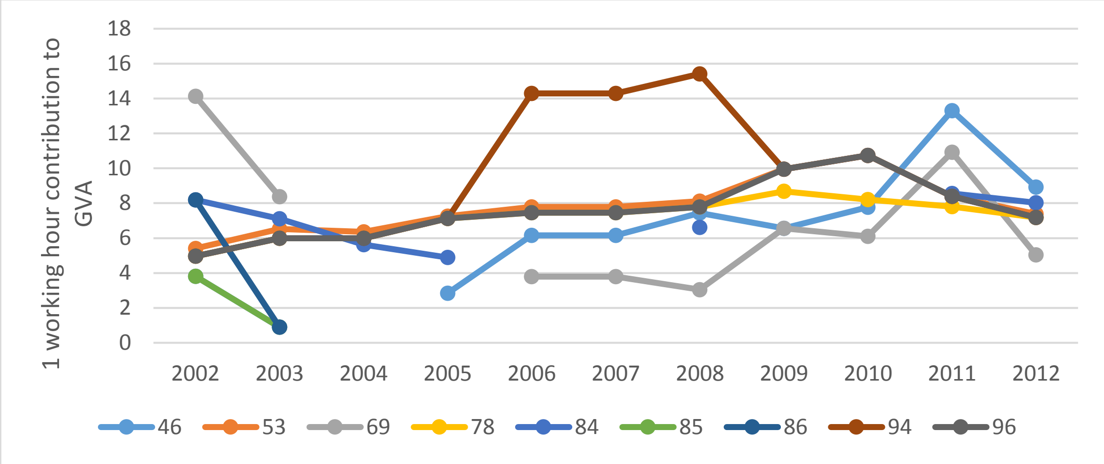
From the value-based model, the weights that are derived generate the below levels of total hours' contribution to GVA. Total Working Hours contribute to $\frac{v_2}{u}$ per £10^8 of GVA, or 1 working hour contributes to 10x$\frac{v_2}{u}$.

Table 4.20 – 1 hour of Total Working Hour's contributions towards £ of GVA – Total Labour Model (All industries)

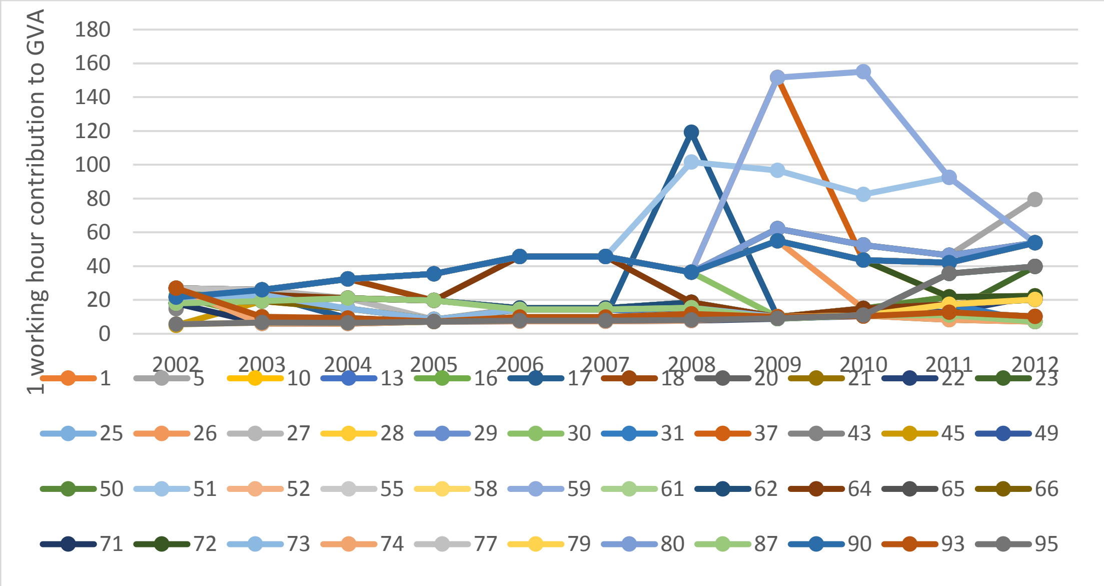
CONTRIBUTION	Low	Medium	High	Inconsistent
TOTAL_GVA				
Average narrow	£7.2995	£27.7078	£99.1468	
Before Crisis	£6.4894	£24.8708	£87.6851	
After Crisis	£8.4711	£31.1552	£125.9928	
Industries	46 Wholesale trade	1 Agriculture	**19 Coke&Petrole**	**2 Forestry**
	53 Postal & Courier	**5 Mining**	**24 Basic Metals**	
	69 Legal and Accounting	10 Food-Beverages-Tobacco	**35 Electricity-Gas-Steam-Airconditi**	
	78 Employment Activities	13 Textiles-Apparel-Leather		
	84 Public Admin and Defenc	16 Wood		
	85 Education	17 Paper		
	86 Human Health	18 Printing&Reproduction of recorded media		
	94 Activities of Membership	20 Chemicals		
	96 Other personal activities	**21 Pharmaceutical**		
		22 Rubber&Plastic		
		23 Non-metalic mineral		
		25 Metal Products		
		26 Computer, electronic and opticals		
		27 Electrical equipment		
		28 Machinery and equipment		
		29 Motor vehicles&Tralers		
		30 Transport equipment		
		31 Furniture - OtherManf - Repair&Installation		
		37 Sweerage - Waste -Remediation		
		43 Construction		
		45 Wholesale&Retail&Repair of Motorvehicles		
		49 Land transport & Pipelines		
		50 Water transport		
		51 Air transport		
		52 Warehousing and supporting transport		
		55 Accomodation & Food & Beverages		
		58 Publishing Activities		
		59 Motion video tv sound & Broadcasting		
		61 Telecommunication		
		62 Computer programming and consultancy		
		64 Financial Services		
		65 Insurance and Pension		
		66 Auxiliary to fiancing		
		71 Architectural and Engineering		
		72 R&D		
		73 Advertising and Market Rsearch		
		74 Other prof, scientific, technical & Veterinary		
		77 Rental&Leasing		
		79 Travel Agencies		
		80 Security and Investigation - Services to Buildings and Landscape &		
		87 Residential care & Social Work		
		90 Arts & Libraries & Gambling		
		93 Sports		
		95 Repair of computers and personal household goods		
PEERS	**Low**	**Medium**	**High**	**Inconsistent**
Average wide				
Average narrow	£6.9080	£25.8498	£120.1813	
Before Crisis	£6.0905	£23.2460	£118.1312	
After Crisis	£7.4623	£28.1919	£126.3930	

For access to data go to Appendix 12 [45]

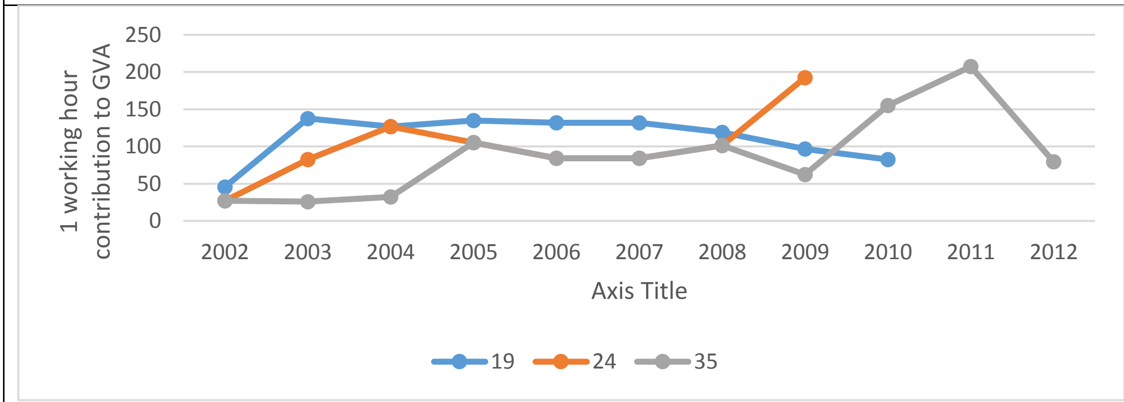
[45] The industries with bold letters are the peer industries defining the productive frontier.



(a) Low Total Labour Contribution



(b) Medium Total Labour Contribution



(c) High Total Labour Contribution

Figure 4.9 – 1 Total Working Hour's contributions towards £ of GVA over the years in groups of Industries – Total Labour Model (All industries)

To begin with, the first group seems to include industries where 1 working hour can contribute to an average in this group is £7.3 per working hour. This can be as low as £3.7. This finding shows that there are employees contributing less that the minimum hourly rate in the UK (For up to 2012 minimum wage was slightly above £6).

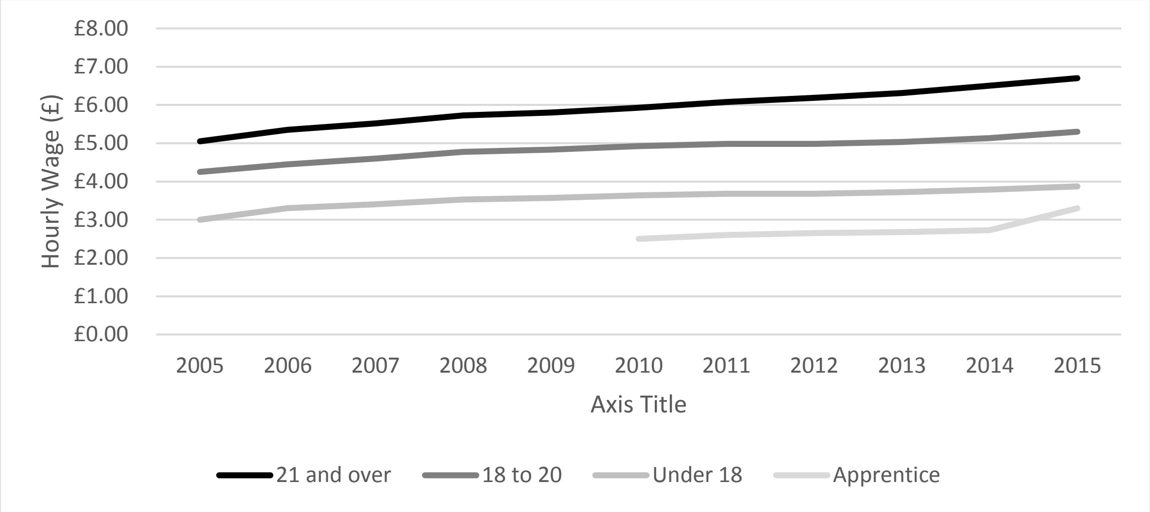


Figure 4.10 - National Minimum Hourly Wage and National Living Wage rates

Source: GOV.UK, National Minimum Wage and National Living Wage rates

This could be a shocking result for neoclassical economics that claim wage to be equal to the marginal product of labour. Even for heterodox schools of thought that maintain that employees can only receive less than they produce. The latter is not completely wrong, since the default situation in capitalism is to receive less wage that the actual value created by employees. However in a microeconomic analysis this can happen. This is actually one of the driving forces of intra and inter-industrial competition; the high profit rate that one industry can maintain cannot be followed by the other. More specifically, in Marxist analysis the rate of profit is defined as:

$$r_i = \frac{s_i}{c_i+v_i} \qquad (4.15)$$

$$\Rightarrow r_i = \frac{\frac{s_i}{v_i}}{\frac{c_i+v_i}{v_i}} \Rightarrow r_i = \frac{\frac{s_i}{v_i}}{\frac{c_i}{v_i}+\frac{v_i}{v_i}} \Rightarrow r_i = \frac{\frac{s_i}{v_i}}{\frac{c_i}{v_i}+1} \Rightarrow r_i = \frac{e_i}{g_i+1} \qquad (4.16)$$

r_i= rate of profit per industry i

s_i = rate of surplus value per industry i

c_i= constant capital (machinery, equipment, raw material) per industry i

v_i = variable capital (employees' wages) per industry i

e_i = rate of exploitation per industry i

g_i = organic composition of capital per industry i.

In other words, *ceteris paribus,* if V increases the rate of profit will drop. Therefore, in this case, with a low GVA per working hour (£5.3) and a relatively increasing V less rate profit will be generated, leading the industry to eventual decline.

Consequently, there are industries that can have low labour productivity but cannot pay their employees less because of the legislation, the accepted living standards that need to be maintained, because of the fear that employee's rebel etc. On the one hand, this result actually confirms that wage is not representing labour productivity (according to neoclassical analysis) but a variable defined in other sphere of economy. However, it is not only the legislation for having lower wages. As we discussed in previous chapters, wage levels are determined physically and historically reflecting the objective needs of the working class each period and depending on the degree of 'class struggle'.

In the group that we observe such a paradox there are industries that – apart from 85. Education and 86. Health – belong to the unproductive industries. As explained in the literature review, unproductive industries consume the surplus of the productive ones. Therefore, what appears in the mainstream accounts as 'product' in fact it is income, according to a Marxist analysis, and what appears to be a payment for labour, it is the surplus produced by the workers of the productive industries. Once again the inclusion of the unproductive industries does not provide trustworthy results.

Although we cannot have a clear picture from the Figure 4.9 what is the general pattern of total working hour's contribution, the average before and after crisis is £6.4 and £8.5 respectively showing an increase in the labour productivity in these particular industries. Or more specifically an increase in the share of national income allocated to those activities. Bringing total working hours' contribution to GVA after crisis closer to the minimum wage.

Regarding the second group there are higher GVA contribution per working hour with an average for the industry is £27.7 per hour. Here we find the majority of industries. Labour productivity in this group appears higher compared to the previous mainly due to the more sophisticated equipment that these industries use. For instance, Motion, Audio, Video production require a certain amount of working hours (need a specific number of employees) with the correct equipment (capital) to produce their output. In this category both the all industries and the peers-only analysis show that there is an increase in labour productivity. However, the peers-only analysis suggest slightly lower productivity increase. From the figure above, it is evident that there is an inconsistent increase (that drops but still higher than pre-crisis levels). Labour's contribution seems to be lowered as most industries approach 2007 when the crisis outbursts, and rises after that. This can be related to the fact that total working hours in the UK economy are reduced after the crisis' outburst (See Chapter 3, *Descriptive Statistics*). This means that by using less working hours (with a GVA that does not vary as much) output per employee appears higher. In cases that this reduction in labour hours is not due to less employees but due to a shorter working day, this pattern would imply the Marxist argument that regardless of the capitalists' intentions regarding the working day. It is intra-industrial competition urging them for a longer day.

The last group with the highest labour contribution shows that it the average working hour contribution for this category is £99, with the peers-only analysis suggesting £120 per hour. In this category, there are only productive industries with usually 'heavy' equipment (eg. *19. Coke and Petroleum*). The productive industries do occupy sophisticated and bulk of machinery, equipment, robots etc that with the use of labour boost labour productivity at a high level. Moreover, the all-industries analysis contradicts with the peers only as the former suggests an increase while the latter a decrease in labour productivity. Peers only is more trustworthy as they define weights for each variable.

Despite this, in the above figure regarding the labour contributions in the High group (19, 24, 35) we have can see this falling tendency in these industries. These appear to be the steam engines of the UK economy and after crisis have started slowing down, coming along with other analyses over the UK productivity puzzle.

Apart from the first group of industries that is mostly comprised by unproductive industries, the majority of the UK industries show that the GVA produced is much higher than the hourly rate, calculated with a 37.5 working week. In other words, average hourly wage is £9 to £12 for the period between 2002 and 2012, but the additional working hour would give us above £27 for most industries. See Table 4.20 and Figure 4.11.

Table 4.21 – Average UK Weekly and Hourly earnings

YEAR	Weekly Earnings (£)	Weekly Hours (£)	Hourly Earnings (£)
2002	340.00	37.50	9.07
2003	351.00	37.40	9.39
2004	366.00	37.30	9.81
2005	383.00	37.30	10.27
2006	401.00	37.20	10.78
2007	420.00	37.20	11.29
2008	435.00	37.10	11.73
2009	435.00	36.80	11.82
2010	444.00	37.10	11.97
2011	455.00	37.00	12.30
2012	461.00	37.40	12.33

Source dataset: ONS, 2018, Time series: LMSB SA AWE total pay WE Average Weekly Earnings time series dataset (EMP) And ONS, 2018, Time series: Average actual weekly hours of work for full-time workers (seasonally adjusted)

Figure 4.11 – Average UK Hourly wage (assuming 37.5 hours week)

Source dataset: ONS, 2018, Time series: LMSB SA AWE total pay WE Average Weekly Earnings time series dataset (EMP)

Comparing the above Table and Figure showing real wages with the relevant contributions derived earlier, derived from the respective weights, it becomes evident that the contribution of labour towards GVA if the industry(ies) if they wish to be efficient, is higher than the wages. This part of the research can also act as an extra argument in the debate for labour productivity and labour contribution in a national economy like the UK.

Total labour hours contribution to GVA – Productive industries

The all-industries analysis indicated that indeed as theory suggests productive industries should have significantly higher contributions than unproductive industries. The results that we get from a productive-industries analysis are again very similar to the all-industries ones. The average contributions of the below categories are also given in the previous analysis.

However, the differences are that we have some information for industries that were not appearing in the all-industry model, such us 18 and 53. Moreover, Education and Health have moved form the £7 contribution that had in the previous analysis to the £21.6. Therefore, by analysing productive industries only, two crucial industries appear to have higher contribution. The more homogenised the industries become, the more disputable industries will have different rates. On the other hand, industries 71 and 74 instead of having a contribution of £27, as shown in the whole industry model, they seem to have smaller here: £8.8. Generally, apart from the industries that have differences with the all-industries model, the rest could be trusted.

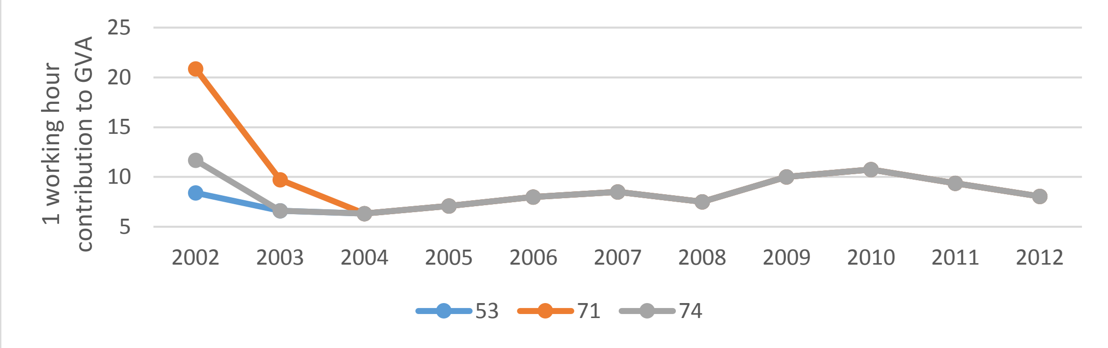
Table 4.22 – 1 hour of Total Working Hour's contributions towards £ of GVA – Total Labour Model (Productive industries)

CONTRIBUTION	Lowest	Low	Medium	High
TOTAL_GVA				
Average narrow	£8.8047	£21.6442	£126.0823	£264.3951
Before Crisis	£8.5315	£20.3418	£70.3547	£188.4832
After Crisis	£9.1326	£23.2555	£191.9823	£324.4911
Industries	**53 Postal & Courier**	1 Agriculture	**19 Coke&Petrol**	2 Fishing & Aqua
	71 Architecture and Civil Engin	**5 Mining**	**24 Basic Metals**	36 Water collectio
	74 Other prof, scientific, technic	10 Food-Beverages-Tobacco	**35 Electricity-Gas-Steam-Airconditi**	
		13 Textiles-Apparel-Leather	51 Air transport	
		16 Wood		
		17 Paper		
		18 Printing&Reproduction of recorded media		
		20 Chemicals		
		21 Pharmaceutical		
		22 Rubber&Plastic		
		23 Non-metalic mineral		
		25 Metal Products		
		26 Computer, electronic and opticals		
		27 Electrical equipment		
		28 Machinery and equipment		
		29 Motor vehicles&Tralers		
		30 Transport equipment		
		31 Furniture - OtherManf - Repair&Installation		
		37 Sweerage - Waste -Remediation		
		43 Construction		
		49 Land transport & Pipelines		
		50 Water transport		
		52 Warehousing and supporting transport		
		55 Accomodation & Food & Beverages		
		58 Publishing Activities		
		59 Motion video tv sound & Broadcasting		
		61 Telecommunication		
		62 Computer programming and consultancy		
		72 R&D		
		85 Education		
		86 Human Health		
		87 Residential care and social work		
PEERS	**Lowest**	**Low**	**Medium**	**High**
Average wide	£9.3204	£18.8553	£184.2659	£318.0409
Average narrow	£8.5315	£18.8052	£118.4355	£134.9932
Before Crisis	£9.1326	£18.9824	£263.2623	£379.0568
After Crisis				

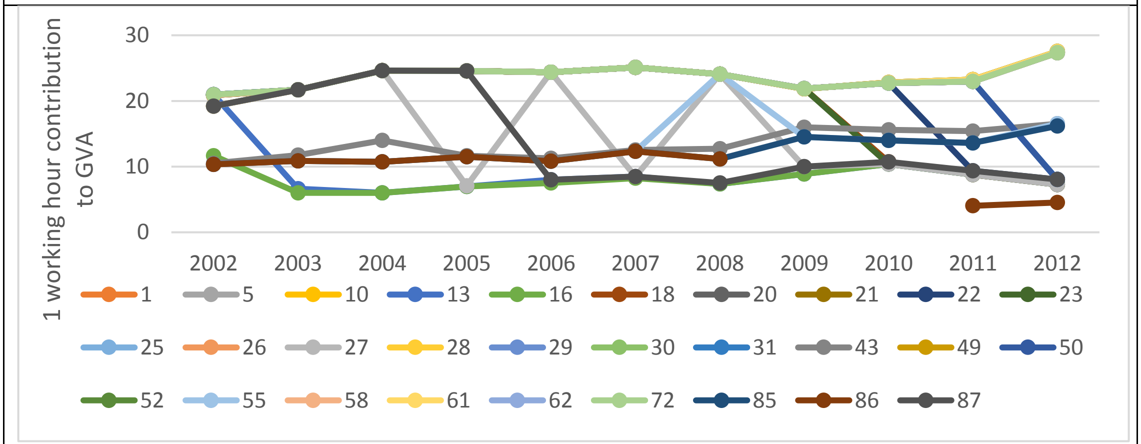
For access to data see Appendix 13[46]

[46] The industries with bold letters are the peer industries defining the productive frontier.

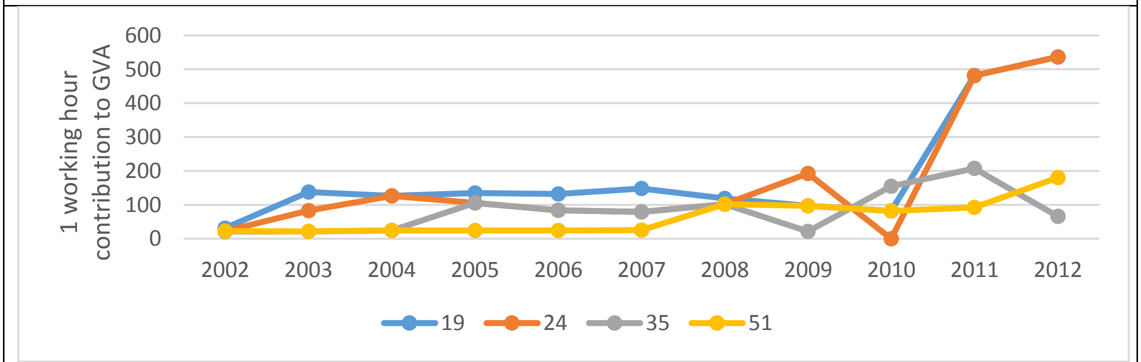
(a) . Lowest labour contributions



(b) Low labour contributions



(c) Medium labour contributions



(d) High labour contributions

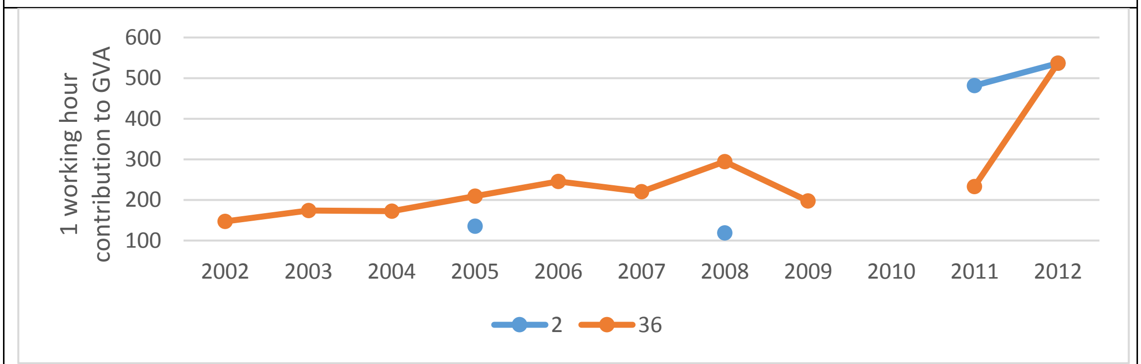


Figure 4.12 – 1 Total Working Hour's contributions towards £ of GVA over the years in groups of Industries – Total Labour Model (Productive industries)

One thing that strikes us is that there are only 3 industries with the minimum labour contribution: £8.8 on average with two of the industries (71 and 74) that were in the high group with the all industry analysis. Despite this low productivity, it is still higher than the national average hourly wage, showcasing that at least in the unproductive industries what appears as contribution to GVA can be lower than this average, due to the fact that they consume surplus.
Additionally, 85. Education and 86. That with the all industry appeared to be in the lower group, now are allocated with a higher GVA also showcasing that they are contributing more than they are paid. The rest industries have an average contribution above £21 per hour. These differences that are revealed between industries are detected mainly with the use of DEA, since it fits a piece-wise linear frontier. This shows again how far the average wage levels are compared to labour contributions to GVA for the majority of Productive industries.

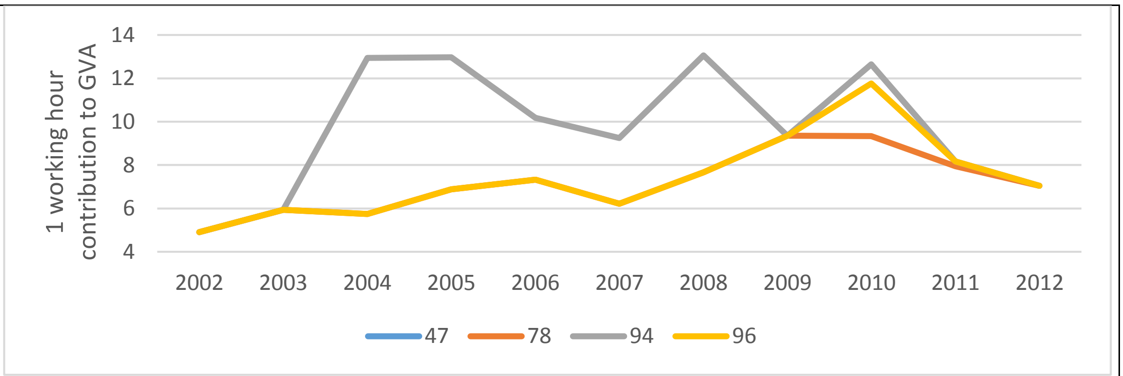
Total labour hours contribution to GVA – Unproductive industries

Table 4.23 - 1 hour of Total Working Hour's contributions towards £ of GVA – Total Labour Model (Unproductive industries)

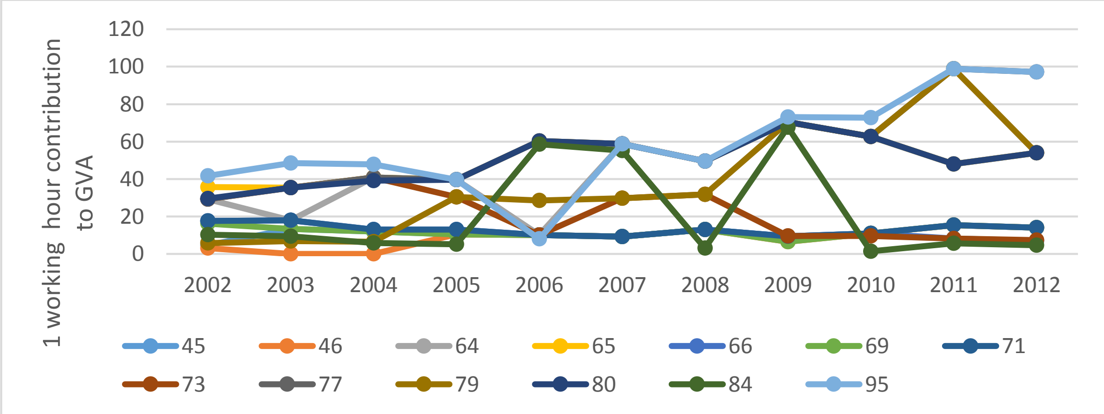
CONTRIBUTION		Low		Medium
TOTAL_GVA				
Average narrow		£7.9116		£31.0435
Before Crisis		£7.1613		£26.1820
After Crisis		£9.0419		£36.6904
Industries	**47**	**Retail**	45	Wholesale&Retail&Repair of Motorvehicles
	78	**Travel Agencies**	46	Wholesale trade
	94	**Repair of computers and personal household goods**	**64**	**Financial Services**
	96	**Other personal activities**	**65**	**Insurance and Pension**
			66	Auxiliary to fiancing
			69	**Legal and Accounting**
			71	Advertising and Market Rsearch
			73	**Rental&Leasing**
			77	**Employment Activities**
			79	**Security and Investigation - Services to Buildings and Landscape & Other Admin**
			80	Public Admin and Defence & Social Security
			84	**Activities of Memberships Organisations**
			95	**Other personal activities**
PEERS		**Low**		**Medium**
Average wide				
Average narrow		£7.5646		£37.0535
Before Crisis		£6.0213		£29.2697
After Crisis		£8.6529		£47.0445

For access to data go to Appendix 15[47]

In analysis of labour contributions of unproductive industries, there are also mainly similarities with the all industry analysis. Most industries have very similar labour contributions to GVA, with few exemptions: industry 46, 69 and 84 that appear contributing more in the unproductive industries analysis (1 total working hour contributes to £31 of GVA on average), compared to the all industries one (£7). Generally, when we analyse all the possible combination of rates different industries each time appear having different results from the all-industries analysis. Therefore, analysing unproductive industries might be even more difficult for the two reasons mentioned before: i) there is fewer number of observed industries over the years and ii) they seem to be allocated with a GVA that according to the Critique of CPE has been totally produced by the workers in the productive industries. However, there are a lot of similarities and the patterns over time are also confirmed. Additionally, in unproductive industries, it is evident that labour productivity appears lower compared to the productive industries only.



(a) Low Total labour contribution



(a) Low Total labour contribution

[47] The industries with bold letters are the peer industries defining the productive frontier.

Figure 4.13 – 1 hour of Total Working Hour's contributions towards £ of GVA – Total Labour Model (Unproductive industries)

Generally, the Total Labour model has shown that not every industry is developing linearly and in a constantly increasing way. Crisis effects have been captured representing different patterns over time.

Overall, some industries tend to increase their capitalisation, some other to decrease it. Additionally, using NCS as a variable for capital in DEA analysis shows generally smaller contributions that are sensible due to the fact that NCS is used in several fashions among the years. Some industries have increased indivisibilities due to high fixed costs, showing an even smaller value transfer. However, the fact that the NCS's value transfer increases over time is confirming a labour saving technology or the same results are also confirmed by analysing the Productive-only industries, the unproductive ones, are detected with a lot of differences.

Another finding from the DEA analysis of total hours' contributions is what it is known in the non-mainstream analysis, that labour might contribute more than it is paid. Although, the fact that the minimum wage can be bigger than the labour productivity for the unproductive, thing that in economic analysis cannot simply happen, is an indication that GVA that these industries are assigned with might be fictitious. The rest of the industries have far higher productivity compared to the average salary. This is an important finding of our analysis, confirming previous scholars' work who highlighted that labour productivity is increasing, but labour remuneration is decreasing. However, DEA is used for first time in analysing UK industries (in total) regarding labour and its contribution.

Regarding the analysis of the unproductive industries, as it is mentioned before, the limited sample of only 17 unproductive industries over the 11 year period lowers our confidence in this analysis especially when 75% of them act as peers that define the efficient frontier. Additionally, the productive industries (especially those in Manufacturing) have probably more homogenous characteristics, leading to more consistent results, compared to the unproductive ones with increasing heterogeneity (eg. Retail trade vs Insurance and Pension). Moreover, dividing industries in two groups: productive and unproductive has shown that more information is acquired for industries that compared the all-industry analysis. Firstly, because there were not many non-zero weights. Apart from that, some specific tendencies are detected with productive industries showing more consistency. For instance, some industries in the low capital category, are driven by labour saving technology as they are not capital intensive to play with capital utilisation. In the following part, we examined the decomposed labour model: Basic hours, Paid and Unpaid overtime. Therefore, analysing these different kinds of working hours with respect to capital used would not add much, as if we were focusing on MRSs of the three labour variables and their contributions to GVA.

PART II: Data Envelopment Analysis modelling of Decomposed Labour: Basic Hours, Unpaid and Paid Overtime

Moving to a decomposed labour model, a differently structured DEA model is analysed. The process and the steps that are followed are the same, with the only difference that total working hours are decomposed in 3 parts: basic working hours, unpaid overtime and paid overtime. In this part the main focus will be to analyse the MRSs among the three labour variables, to provide potential explanations, to detect the different contributions of basic hours that consist of the 93% of total working hours, to capture mainly unpaid overtime's contributions and to see how the groups of industries change with a slightly different model. The patterns of these variables are also analysed. Repeating the same process, the Envelopment model and the Value-based models are derived for acquiring the Peer industries, the inputs and output weights and the target values for every input. This model is particularly important to see the unpaid overtime's contribution. If there is a non-zero contribution to output this would reject all the mainstream theories that argue that unpaid overtime is not used for increasing output or earnings, but it acts as a signalling device, or as a gift or for any other reason away from capitalistic production's needs.

4.3 Data Envelopment Analysis modelling of decomposed labour and capital– All industries

Pure Technical Input Efficiency - Decomposed Labour

DEA envelopment model

As explained above, this model reveals those industries that with the least amount of inputs provide the biggest amount of output, providing us with the industries that shape the production frontier. Additionally, the envelopment model provides input and output targets for the non-efficient industries in order to 'contract' the virtual inputs.

$$Min\ \ k_{j0} - \varepsilon(S_1 + S_2 + S_3 + S_4 + S_5) \tag{4.17}$$

Subject to:

$$\lambda_1 L_{b_1} + \lambda_2 L_{b_2} + \cdots + \lambda_j L_{b_j} + \cdots + \lambda_{60} L_{b_{60}} = k_j L_{b_j} - S_1 \tag{4.18}$$

$$\lambda_1 L_{p_1} + \lambda_2 L_{p_2} + \cdots + \lambda_j L_{p_j} + \cdots + \lambda_{60} L_{p_{60}} = k_j L_{p_j} - S_2 \tag{4.19}$$

$$\lambda_1 L_{u_1} + \lambda_2 L_{u_2} + \cdots + \lambda_j L_{u_j} + \cdots + \lambda_{60} L_{u_{60}} = k_j L_{u_j} - S_3 \tag{4.20}$$

$$\lambda_1 NCS_1 + \lambda_2 NCS_2 + \cdots + \lambda_j NCS_j + \cdots + \lambda_{60} NCS_{60} = k_j NCS_j - S_4 \tag{4.21}$$

$$\lambda_1 GVA_1 + \lambda_2 GVA_2 + \cdots + \lambda_j GVA_j + \cdots + \lambda_{60} GVA_{60} = S_5 + GVA_{rjo} \tag{4.22}$$

$$\lambda_1 + \lambda_2 + \cdots + \lambda_j + \cdots + \lambda_{60} = 1 \tag{4.23}$$

$$\lambda_1, \lambda_2 \ldots \lambda_j, \ldots \lambda_{60} \geq 0 \tag{4.24}$$

$$S_1, S_2, S_3, S_4, S_5 \geq 0 \tag{4.25}$$

h_{j0} is the pure technical input efficiency of DMU j_0

$0 << \varepsilon$ is an Archimedean infinitesimal

$S_1, S_2, S_3\ S_4, S_5$ are slack values $S_1, S_2, S_3\ S_4$ are slack values for labour and capital and S_5 is a slack value for output: The constraint (4.23) restricts the input slack (S_1, S_2, S_3, S_4) and output slack (S_5) variables to be non-negative

j represents the DMU under maximisation, j = 1…N. In our case j = 1…60

$L_{b_1} \ldots L_{b_{60}}$ is the amount of basic labour hours used by industries j = 1…60

$L_{p_1} \ldots L_{p_{60}}$ is the amount of paid overtime hours used by industries j = 1…60

$L_{u_1} \ldots L_{u_{60}}$ is the amount of unpaid overtime hours used by industries j = 1…60

$NCS_1 \ldots NCS_{60}$ is the amount of Net Capital Stock (£) used by industries j = 1…60

$GVA_1 \ldots GVA_{60}$ is the amount of Gross Value Added (£) used by industries j = 1…60

The restrictions 4.16 to 4.20 form the convex reference technology

$\lambda_1, \lambda_2 \ldots \lambda_j, \ldots \lambda_{60}$ are the intensity variables. The non-zero optimal λ* represents the benchmarks for a specific DMU under evaluation. The constraint (4.22) limits them to be non-negative: The constraint (4.21) is the convexity constraint which can be removed under Constant Returns to Scale (CRS).

DEA value-based model

As we explained above, the DEA value based model define efficiency with respect to the (implicit) values of inputs and outputs. This model is useful because it provides the weights with which the MRS and Inputs' contributions is derived.

$$Max\ \ p_o = uGVA_O + w_1 - w_2 \tag{4.26}$$

Subject to:

$$v_1 L_{b_o} + v_2 L_{p_o} + v_3 L_{u_o} + v_4 NCS_o = 1 \tag{4.27}$$

$$uGVA_1 - v_1 L_{b_1} - v_2 L_{p_1} - v_3 L_{u_1} - v_4 NCS_1 + w_1 - w_2 \leq 0 \tag{4.28}$$

$$uGVA_2 - v_1 L_{b_2} - v_2 L_{p_2} - v_3 L_{u_2} - v_4 NCS_2 + w_1 - w_2 \leq 0 \tag{4.29}$$

...

$$uGVA_0 - v_1 L_{b_0} - v_2 L_{p_0} - v_3 L_{u_0} - v_4 NCS_0 + w_1 - w_2 \leq 0 \tag{4.30}$$

...

$$uGVA_{60} - v_1 L_{b_{60}} - v_2 L_{p_{60}} - v_3 L_{u_{60}} - v_4 NCS_{60} + w_1 - w_2 \leq 0 \tag{4.31}$$

$$u, v_1, v_2, v_3, v_4 \geq \varepsilon \tag{4.32}$$

ω= $w_1 - w_2 \leq$ free, $\quad w_1, w_2 \geq 0$

$0 << \varepsilon$ is an Archimedean infinitesimal

p_o is the pure technical input efficiency of DMU j_0

GVA is the variable for Gross Value Added (£)

L_b is the variable for Basic Working Hours

L_p is the variable for Paid Overtime Hours

L_u is the variable for Unpaid Overtime Hours

NCS is the variable for Net Capital Stock (£)

u is imputed value for output (GVA)

v_1, v_2, v_3, v_4 are weights of inputs (L_b L_p L_u and NCS): The constraint (11) means that when the weigthts are not infinitesimal they can be used to acquire the Marginal Rates of Substitution (among inputs) or the contributions of inputs towards the output.

ω (omega) = $w_1 - w_2$, is used as indicator to returns to scale. If the value of ω is greater than zero ($\omega > 0$) the DMU performs at Increasing returns to scale, if the value of ω is equal to zero ($\omega = 0$) at constant returns to scale, and if the value of ω is less than zero ($\omega < 0$) at decreasing returns to scale.

4.3.1 Detecting outliers with Decomposed Labour (Basic hours, Paid overtime and Unpaid overtime)

In this section the same process is repeated for detecting outliers as in the decomposed labour model. We cannot assume that the same industries as above will be outliers here, although we could expect some similarities.

Step 1: Enabling Super Efficiencies – 1st round

As it has already been mentioned Industry 3. Forestry was dropped from the beginning because there was lack of labour data for 2008. Therefore the remaining industries are 60.

The first round of Super-Efficiency analysis shows that industries 13 Manufacturing of Textiles-Apparel-Leather, 17 Manufacturing of Paper, 23 Manufacturing of Non-metallic mineral, 27 Manufacturing of Electrical equipment, 51 Air transport, 66 Auxiliary to financing, 71 Architectural and Engineering, 74 Other prof, scientific, technical & Veterinary, 79 Travel Agencies and 93 Sports are not enveloped in the analysis only for one year each (in different years in the input orientation.

Additionally, industry 68 Real Estate that has been detected as an outlier in the total labour model and finally dropped even after the adjustment, appears as an outlier industry in the decomposed model as well. Additionally, it appears to be super-efficient (above 150%) in the output orientation. Therefore, we can safely drop it at this stage as well.

Moreover, industry 78. Employment Activities is also dropped since it is super-efficient in both orientations, like previously in the total labour model.

However, there are three (3) industries that have an outlier behaviour in the 1st round of super-efficiencies in the decomposed model. These are industries 5. Mining, 50. Water transport and 64. Financial Services. 5. Mining and 64. Financial Services were also dropped in the total labour model in the second round of super-efficiencies, because of the huge variation in both orientations. Therefore, they are also dropped here in the 1st round of super-efficiencies since they are super-efficient for the most out of the 11 years of our analysis.

Industry 50. Water transport is dropped in the decomposed model as well, from the 1st round of super-efficiencies. It was also because in the total labour model since it was not enveloped in the output orientation and because it was super-efficient with a lot of inconsistent efficiency level. However this took place earlier in the second round.

Generally, industries that were not included in the total labour model are also indicated to be dropped in the decomposed model, some of them in different stage of super efficiencies. In total, five (5) industries are dropped at this stage: 5. Mining, 50. Water transport 64. Financial Services, 68 Real Estate and 78. Employment Activities. In other words 8.33% of industries are dropped here (5 out of 60).

Table 4.24 - 1st round of Super Efficiencies – Outliers – Decomposed Labour Model

Industries	Efficiency	Orientation	
		Output	**Input**
Not Enveloped		-	13 Manufacturing of Textiles-Apparel-Leather
			17 Manufacturing of Paper
			23 Manufacturing of Non-metallic mineral
			27 Manufacturing of Electrical equipment
			51 Air transport
			66 Auxiliary to financing
			68 Real Estate
			71 Architectural and Engineering
			74 Other prof, scientific, technical & Veterinary
			79 Travel Agencies
			93 Sports
Super-Efficient	**All years**	68 Real Estate*	78 Employment Activities *
	above 150%	78 Employment Activities *	85 Education*
	Most years	5 Mining *	5 Mining *
	above 150%	50 Water transport *	50 Water transport *
		64 Financial Services *	64 Financial Services *
			65 Insurance and Pension*
	Few years	16 Manufacturing of Wood*	16 Manufacturing of Wood *
	above 150%	65 Insurance and Pension*	19 Manufacturing of Coke & Petroleum
		72 Research and Development*	21 Manufacturing of Pharmaceuticals
		73 Advertising and Market Research	43 Construction *
		74 Other prof, scientific, technical & Veterinary*	47 Retail Trade*
		79 Travel Agencies	69 Legal and Accounting
			72 Research and Development*
			73 Advertising and Market Research
			74 Other prof, scientific, technical & Veterinary*
			79 Travel Agencies*

Star (*) signifies inconsistent efficiency % across years

Step 2: Enabling Super Efficiencies – 2nd round

Industry 65. Insurance and Pension is dropped as it is super-efficient and inconsistent (with extreme ups and downs) in both orientations. Industries 43. Construction and 85. Education are also dropped which are partially not enveloped in the input orientation. Therefore, in total 5, 43, 50, 64, 65, 68, 78 and 85 are dropped (13.33 %) in order to get the adjusted frontier to be the referent efficient level.

Table 4.25 – 2nd round of Super Efficiencies (5 50 64 68 78 Dropped) - Outliers – Decomposed Labour Model

Industries	Efficiency	Orientation	
		Output	**Input**
Not Enveloped		21 Manufacturing of Pharmaceuticals	24 Basic Metals
			43 Construction
			47 Retail Trade
			66 Auxiliary to financing
			71 Architectural and Engineering
			85 Education
			86 Human Health
			94 Activities of Memberships Organisations
Super-Efficient	**All years above 150%**	2 Fishery and Acquauo	
	Most years above 150%	65 Insurance and Pension *	65 Insurance and Pension *
	Few years above 150%	16 Manufacturing of Wood *	16 Manufacturing of Wood *
		19 Manufacturing of Coke & Petroleum*	19 Manufacturing of Coke & Petroleum*
		21 Manufacturing of Pharmaceuticals*	21 Manufacturing of Pharmaceuticals*
		35 Electricity-Gas-Steam-Air-conditioning*	35 Electricity-Gas-Steam-Air-conditioning*
		72 Research and Development*	72 Research and Development*
		73 Advertising and Market Research	73 Advertising and Market Research
		74 Other prof, scientific, technical & Veterinary*	74 Other prof, scientific, technical & Veterinary*
		79 Travel Agencies*	79 Travel Agencies*
		85 Education	84 Public Admin and Defence & Social Security
		96 Other personal activities	96 Other personal activities

Star (*) signifies inconsistent efficiency % across years

Generally, both the total labour and the decomposed labour model agree on the industries with outlier behaviour. However, there are industries that are detected as outliers in the total labour model, but not in the decomposed, like 2. Fishing and Aquaculture. Although 19. Manufacturing of Coke and Petroleum and 95. Repair of computers and personal household are partially captured as outliers in the decomposed labour model (for some years) they have not been dropped.

There are differences in outliers with the total labour model only in two industries: 2. Fishery and Aquaculture that acts as an outlier in the total but not in the decomposed model and 65. Insurance and Pension. That acts as outlier in decomposed but not with the total. The reason for industry 2. Fisher and Aquaculture is probably not related with the amount of NCS and basic hours (where basic hours is in aggregate between 93%-95% of total hours) but most possible with the paid and unpaid overtime. In other words, the industry 2 compared with its peers uses not the minimum amount of paid or unpaid overtime but similar to others, therefore it does not appear super-efficient with the decomposed one. Therefore, only industry 2 as it has been described in the theoretical part and the total labour outlier analysis, in Agriculture (Fishing as well) nature does most of the job, showing falsely that the low amounts of labour and capital are those to be accounted with this super-efficiency.

The opposite probably happens for 65. Insurance and Pension that acts as an outlier in the decomposed but not in the total one. This means again that it is not probably NCS or basic, but paid and unpaid in combination to NCS or basic that make this industry's efficient. More specifically in the super-efficient years.

Generally, the industry has been discussed also on the peculiarities of measuring GVA and capital. See peer analysis in the total labour model. In the superefficient years DEA shows that basic working hours and unpaid overtime need to be reduced, and increase paid overtime and capital. This implies that compared to other industries, 65. Insurance and Pension needs to 'support' its high output with more paid overtime and capital and less basic and unpaid overtime hours, implying that the industry relies too much on basic labour and unpaid overtime.

Additionally, efficiencies are not appearing consistently throughout the 11 years that are studied as 2006, 2010, 2011 and 2012 appear super-efficient in both orientations. Especially, if we take into account that with the most super-efficient years are those before the outburst of economic crisis in 2007 and immediately after the beginning of the recovery in the UK economy. So, 2007-8-9 are the years during recession where in both orientations all inputs should be reduced compared to the output produced, but during expansion DEA suggests they should stop relying only on the two certain labour inputs: basic and unpaid. Therefore, the superefficient indicate what theory suggests. During the expansion/growth industries in the UK rely too much on labour and particularly its unpaid part, confirm that between the two strategies that capitalists have to choose from a. increasing s/v (the rate of surplus value) or b. g/v (organic composition of capital), the British industries rely on the first.

Table 4.26 - Comparison of Outlier analysis in Total and Decomposed Labour Model (All Industries)

Industries Dropped (Super-Efficient or Not Enveloped)	Total Labour Model : 10	Decomposed Model : 8
2. Fishing and Aquaculture	✓	
5. Mining	✓	✓
19. Manufacturing of Coke & Petroleum	✓	
43. Construction	✓	✓
50. Water transport	✓	✓
64. Financial Services	✓	✓
65. Insurance and Pension[6]		✓
68. Real Estate	✓	✓
78. Employment Activities	✓	✓
85. Education	✓	✓
95. Repair of computers and personal household	✓	

Step 3: Scaling industries' values (inputs and outputs)

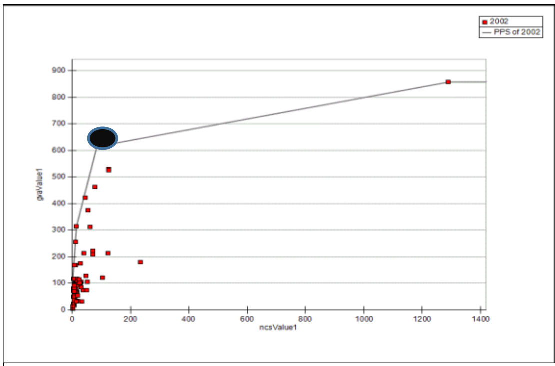
After having identified outlier industries, each variable has to be rescaled to get to low values, as we did with the total labour. In this section scaling labour variables means that basic working hours, paid overtime and unpaid overtime hours will also have a different divisor. The divisors used for each input-output variable are as in Table 4.26.

Table 4.27 – Variables' divisors – Decomposed Labour Model

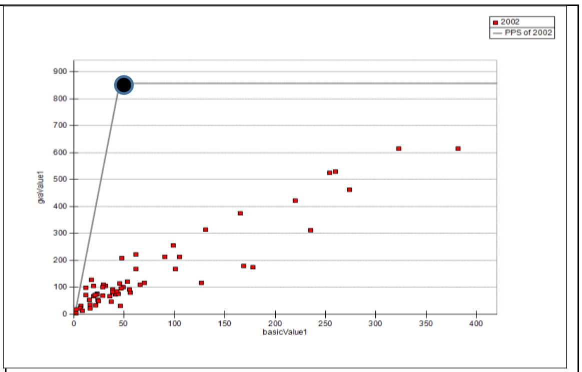
Variables	Measure	Divisor
Basic working hours (Basic)	Hours	10^7
Paid overtime hours (Paid)	Hours	10^5
Unpaid overtime hours (Unpaid)	Hours	10^6
Net capital stock (NCS)	Chain Volume Measure £	10^9
Gross Value Added (GVA)	Chain Volume Measure £	10^8

Step 4: Including dropped industries with their target values to the adjusted frontier

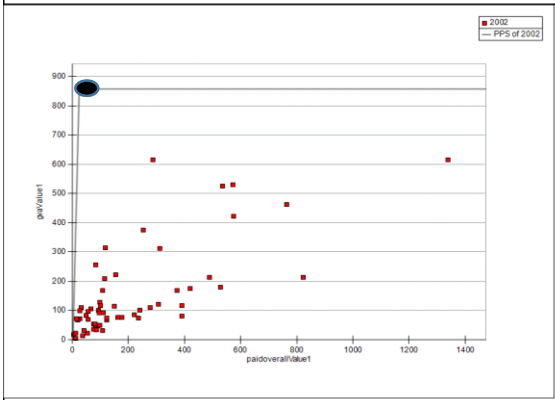
As in the total labour model, the VRS input oriented model is run in the normal manner to identify the efficient frontier pertaining to the non-outlier industries. Then the same process is repeated for the outlier industries so as to project the outliers one at a time on the efficient frontier pertaining to the non-outlier industries.



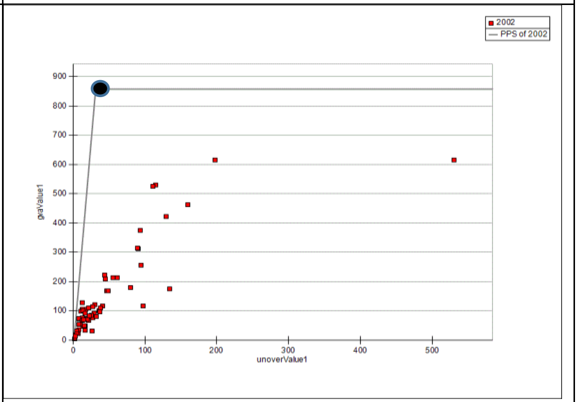
(a) Net Capital Stock (NCS) and Gross Value Added (GVA)



(b) Basic Working Hours and Gross Value Added (GVA)



(c) Paid Overtime Hours and Gross Value Added (GVA)



(d) Unpaid Overtime Hours and Gross Value Added

Figure 4.14 – Adjusted Frontier - The PPS including Industry 68. Real Estate (big black dot) in 2002

Step 5: Final detection of any outlier industry

Even in the decomposed labour model, after completing the above process industry 68. Real Estate is the industry with the smallest basic working hours, unpaid and paid overtime and the biggest output. An indicative example is its performance during 2002 (see Figure 4.14 and 4.15). It is quite distant from the rest. This result is interesting because Real Estate is a widely discussed and hotly disputed industry regarding the way that its 'value' and 'contributions' are calculated in the national accounts. Dropping completely 68. Real Estate from the decomposed model analysis leads to more sensible efficient frontier.

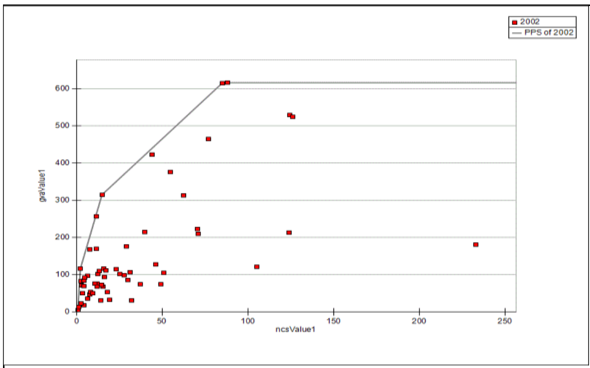
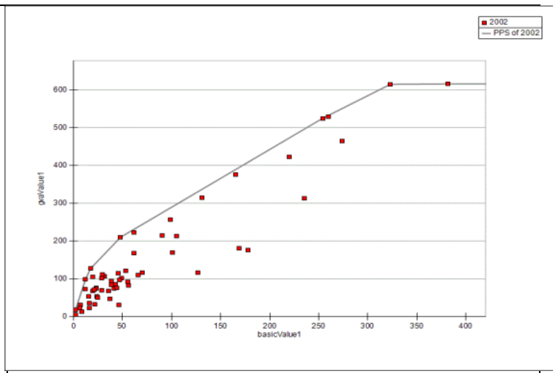
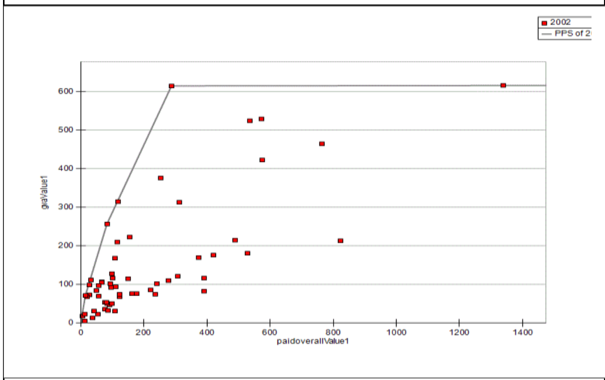
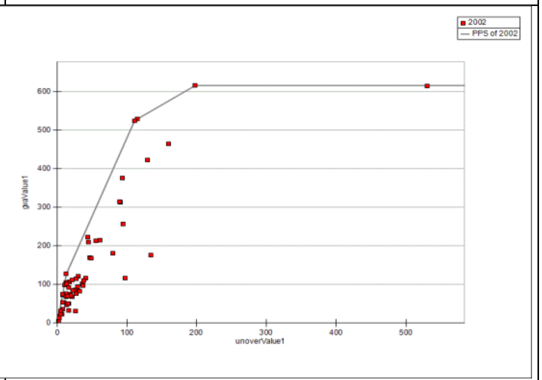
	
(a) Net Capital Stock (NCS) and Gross Value Added (GVA)	(b) Basic Working Hours and Gross Value Added (GVA)
	
(c) Paid Overtime Hours and Gross Value Added (GVA)	(d) Unpaid Overtime Hours and Gross Value Added (GVA)

Figure 4.15 – Adjusted Frontier - The PPS after dropping Industry 68. Real Estate in 2002

Peer industries in the Decomposed Labour Model

The first thing that is observed is that all of the 'adjusted' industries in the outlier analysis are included in the Peer industries (See Table 4.28). This finding is sensible if we take into account that they are adjusted to the efficient frontier already and by default they are efficient. Another finding is that the decomposed labour model appears to have some similarities with the total labour model. There are some industries consistently efficient over the years in both models. These industries are demonstrated in the table below. One reason is that most of the industries that are adjusted in the decomposed model are also adjusted in the total one. Only industry 2.Fishing and Aquaculture, 19. Coke and Petroleum and 95. Repair of Computers and Personal household that have not been adjusted in the outlier analysis of the decomposed model and appear to be genuinely peer industries without any prior modification. In other words, since the other industries in the frontier consist of outliers that artificially were brought in to the frontier, the frontier is actually defined by these 3 industries.

Consequently, in the following analysis the peer industries that appear in both models can be trusted regarding their weights of substitution and their inputs contribution during most of the years that are examined. However, another noticeable difference is that the decomposed model is comprised by far more industries than the total labour model. This means that there are industries that act as self-assessors. This is an indication that when industries are decomposed to the kind of overtime hours they use, they have less similarities to each other and therefore most of them act as self-assessors. Therefore, the weights that are going to be derived they will vary a lot.

Table 4.28 – Peer Industries (All Industries) –Decomposed Labour Model

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	Forestry	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	Mining			✓								
13	Textiles-Apparel-Leather											✓
16	Wood								✓			✓
19	Coke&Petroleum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
21	Pharmaceutical	✓	✓	✓		✓		✓	✓	✓	✓	✓
35	Electricity-Gas-Steam-Airconditioning	✓	✓	✓	✓	✓	✓	✓	✓			
43	Construction	✓			✓		✓	✓				✓
45	Wholesale&Retail&Repair of Motorvehicles		✓	✓	✓		✓	✓			✓	✓
46	Wholesale trade										✓	✓
47	Retail	✓	✓	✓	✓		✓	✓			✓	✓
50	Water transport	✓	✓					✓	✓	✓	✓	✓
53	Postal & Courier	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
58	Publishing Activities	✓					✓					
61	Telecommunication	✓		✓								✓
62	Computer programming and consultancy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
64	Financial Services	✓	✓	✓	✓	✓		✓	✓	✓		
65	Insurance and Pension	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
66	Auxiliary to fiancing										✓	
69	Legal and Accounting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
71	Architectural and Engineering	✓	✓									
72	R&D		✓	✓								
73	Advertising and Market Rsearch	✓	✓	✓	✓	✓	✓	✓	✓			
74	Other prof, scientific, technical & Veterinary	✓	✓				✓					✓
78	Employment Activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
79	Travel Agencies								✓	✓	✓	✓
84	Public Admin and Defence & Social Security	✓	✓	✓	✓		✓	✓		✓	✓	✓
85	Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
86	Human Health						✓				✓	✓
94	Activities of Memberships Organisations		✓	✓			✓				✓	✓
95	Repair of computers and personal household goods	✓	✓		✓		✓	✓	✓	✓	✓	✓
96	Other personal activities	✓	✓		✓	✓		✓	✓	✓	✓	✓

Table 4.29 - Common Peer Industries for Total and Decomposed Labour model (All industries)

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	Forestry	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
19	Coke&Petroleum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	?
62	Computer programming and consultancy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
64	Financial Services	✓	✓	✓	✓	✓	?	✓	✓	✓	?	?
69	Legal and Accounting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
73	Advertising and Market Rsearch	✓	✓	✓	✓	✓	✓	✓	?			
78	Employment Activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
79	Travel Agencies								?	?	✓	✓
85	Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Peer industries in the Decomposed Labour Model – Productive Industries

Table 4.30- Peer Industries (Productive Industries) – Decomposed Labour Model

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2	Fishing & Aquaculture	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	Mining	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13	Textiles-Apparel-Leather											✓
16	Wood		✓				✓		✓		✓	✓
19	Coke&Petroleum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
20	Chemicals					✓						
21	Pharmaceutical	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
30	Transport equipment			✓								
35	Electricity-Gas-Steam-Airconditioning	✓	✓	✓	✓	✓	✓	✓	✓			✓
43	Construction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
50	Water transport	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
53	Postal & Courier	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
58	Publishing Activities	✓	✓		✓		✓		✓			
61	Telecommunication	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
62	Computer programming and consultancy	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
72	R&D		✓	✓		✓						
74	Other prof, scientific, technical & Veterinary	✓	✓	✓	✓		✓		✓		✓	✓
85	Education	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
86	Human Health	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

The above Peer industries are not massively different from the decomposed model with all industries included, with only 20. Chemistry and 30. Transport Equipment being peer industries in the productive ones only (See Table 4.36). Additionally, some of the above industries acted as peers in the all-industry model too, but in the decomposed they are consistently peers throughout the years. Therefore, the frontier is defined differently by analysing Productive industries only. The model now assigns the productive industries with peers from the productive only, contrary to the all-industry model that they were also assigned with unproductive peers. This model is expected to provide more consistent weights than the all-industry ones.

Peer industries in the Decomposed Labour Model – Unproductive Industries

Table 4.31 - Peer Industries (Unproductive Industries) – Decomposed Labour Model

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
45	Wholesale&Retail&Repair of Motorvehicles		✓	✓	✓		✓	✓			✓	✓
46	Wholesale trade										✓	✓
47	Retail	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
64	Financial Services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
65	Insurance and Pension	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
66	Auxiliary to fiancing							✓			✓	✓
69	Legal and Accounting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
73	Advertising and Market Rsearch	✓	✓	✓	✓	✓	✓	✓	✓			✓
77	Rental&Leasing		✓	✓						✓	✓	✓
78	Employment Activities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
79	Travel Agencies						✓	✓	✓	✓	✓	✓
84	Public Admin and Defence & Social Security	✓	✓	✓	✓		✓	✓		✓	✓	✓
94	Activities of Memberships Organisations	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓

In the Unproductive industries analysis, there are 187 observations in total for 17 industries over the 11 years that are studied. Most industries shape the production act as peers to the remaining industries like in the case of total labour model. Only 71 80 95 and 96 do not act as peers. Contrary to the productive industries, here the group is not as homogenous, therefore these industries act mostly as self-assessors. Like in the case of total model the results in the unproductive industries. All of the above Peer industries are included in the all-industries model too, precisely for the same years. However the only industry that did not act as a peer one in the all-industries model is industry 77. Therefore, we can see a consistency here. However, not the same weights are expected like in the all-industry analysis because there are is no Productive industry defining the frontier in this case.

Additionally, comparing the Unproductive industries analysis of Total labour model with this one, there are still some industries consistently act as peers too: 47, 64, 69, 73, 78, 79 and 84. In the total labour model it was also industries 95 and 96shaping the frontier too. In the decomposed model however, it appears that the latter although might have used quite small amounts of labour (as total), they might not use as little overtime as other industries too, appearing inefficient compared to others.

4.3.2 Deriving Marginal Rates of Substitution for the Decomposed Labour (Basic hours, Paid overtime and Unpaid overtime)

In this part, the marginal rates of substitution from an Input Oriented DEA model are examined, and reflections over implied industries' behaviour towards the use of labour inputs are also provided. In this section there are 4 input variables (NCS, Basic Working Hours, Paid overtime and Unpaid Overtime). Therefore we can acquire 6 MRS (Basic-NCS, Paid-NCS, Unpaid-NCS, Paid-Basic, Unpaid-Basic and Paid-Unpaid). However, we are going to focus on 4 of them Basic-NCS, Paid-Basic, Unpaid-Basic and Paid-Unpaid. More specifically, the MRSs under examination are:

$$v_1 L_b = v_4 NCS \Rightarrow NCS = \frac{v_1}{v_4} L_b \quad (4.33)$$

$$v_1 L_b = v_2 L_p \Rightarrow L_b = \frac{v_2}{v_1} L_p \quad (4.34)$$

$$v_1 L_b = v_3 L_u \Rightarrow L_b = \frac{v_3}{v_1} L_u \quad (4.35)$$

$$v_2 L_p = v_3 L_u \Rightarrow L_u = \frac{v_2}{v_3} L_p \quad (4.36)$$

In other words, one unit of Basic working hours is compensated for by $\frac{v_1}{v_4}$ units of NCS. Particularly, in the PIM software Basic hours was entered in units of 10^7 hours and NCS in units of 10^9 £'s. Thus, 10^7 hours is compensated by 10^9 $\frac{v_1}{v_2}$ £'s, or 1 hour is compensated for 100 $\frac{v_1}{v_2}$ £ of NCS. Similarly, 10^5 of Paid overtime is compensated with $\frac{v_2}{v_1}$ of 10^7 Basic hours, or 1 Paid overtime hour is compensated with $\frac{v_2}{v_1} * 100$ Basic hours. 10^6 Unpaid Overtime hours are compensated with $\frac{v_3}{v_1}$ 10^7 Basic hours, or 1 Unpaid overtime is compensated with $\frac{v_3}{v_1} * 10$ Basic Hours. And finally 10^5 Paid hours are compensated with 10^6 of unpaid overtime.

Full-facet MRSs for input variables

As in the case of Total labour model there are years and/or industries not represented in the all-facet (4 facet here because of the 4 inputs) analysis. In the decomposed labour model, out of the 649 observations in total, 630 observations have positive GVA weights, 621 have positive NCS weights, 336 have positive basic working hours weight, 525 positive unpaid overtime weights and 141 positive paid overtime. This means that to appear at their most efficient most industries 'prefer' to be judged on their use of capital rather than labour. Moreover, when it comes to labour they would 'prefer' to point to their use of ('limited') basic, and especially unpaid overtime rather than paid overtime.

However, for a full-facet (5 positive weights) there is only information for 18 industries, and not for every year. Particularly, there are 28 observations for 18 industries, where in the best case scenario for 1 industry there can be weights for maximum 3 years. From those there is no information for 2006 and 2007 at all. Therefore, we acquire weights that derive the below MRS for the full-facet model.

Additionally, one aspect that is observed is that the derived MRSs are strikingly high when paid and unpaid overtime are compared with the rest of the inputs and their within combination do not make sense; eg in Table 4.29 for industry 19. Coke and Petroleum in 2002 1 basic working hour needs to be compensated with £12.9 of NCS, but 1 unpaid overtime hour is compensated for with 62.48 basic hours. This could imply that overtime contributes to GVA dozens of times more than a 'normally' paid hour. However, there are DEA specific factors that make these values look insensible. One factor that makes this happening is the fact that there is no weight restrictions among the input variables in the DEA model, therefore DEA gives as the most 'valuable' inputs those that are not in abundance. Moreover, unpaid and paid overtime are not separate inputs but they are a continuation f basic hours. Therefore, the 'normally' paid hours appear as a constant, while the overtime ones appear as a tiny input with big variation[48].

However, apart from the direct comparison of unpaid and paid overtime MRS to basic hours within the same industry, the comparison of MRS among the different industries is also interesting. This reveals the industry that emphasises unpaid overtime compared to another industry.

The numbers in the table indicate the rate at which one unit of the first variable in the column heading can be compensated for by the second word, eg. Basic_NCS = 12.9903 means that one basic hour is compensated for by £12.99 of NCS. From the below table it is evident that among the years there are differences even within the same industry. This also should not cause surprises if we take into account that DEA solves each year differently from the other. Normally we would expect an industry to have stable weights. However, we have a range of weights for some industries exactly because in different years they reflect on different facets. Another interesting observation is that the majority

[48] If within a week there are 40 basic working hours, we can have 4 unpaid overtime, and 1 paid leading the DEA model to value unpaid and paid (even more scarce) with higher weights. So the model is reflecting the fact that for efficient industries for every 62.48 hours of basic paid labour one hour of unpaid overtime is used.

of industries demonstrate a reverse relationship between paid and unpaid overtime as years pass (except from industry 64 and 74 Change 2). Generally, the results based on the full-facet model are quite intuitive- there is a range of paid and unpaid overtime within logical limits, taking reality into account. This is an issue we address later on with a ‘pooled’ DEA analysis for the years before and after crisis.

Table 4.32 - MRSs for Decomposed Labour Model – Full Facet – All industries

YEAR	DMU	PEERS	basic_ncs	paid_ncs	unpaid_ncs	paid_basic	unpaid_basic	paid_unpaid
2002	**19**	✓	12.9903	155.607	811.7596	11.9787	62.48969	0.191691
2004	**19**	✓	9.65566	47.791	1140.021	4.94955	118.0676	0.041921
CHANGE	**19**		-0.25670231	-0.69287371	0.404382529	-0.58680408	0.889393274	-0.7813095
2004	**21**	✓	9.65566	47.792	1140.021	4.94962	118.0677	0.041922
2004	**45**	✓	9.65566	47.792	1140.021	4.94964	118.0677	0.041922
2002	**50**	✓	10.5498	282.872	7579.542	26.81299	71.84537	0.373204
2004	**50**	✓	9.65567	47.791	1140.021	4.94956	118.0676	0.041921
CHANGE	**50**		-0.08475327	-0.83105079	0.504076368	-0.8154044	0.643357115	-0.88767269
2002	**58**	✓	45.44132	2632.165	868.3068	57.92448	19.10831	3.031377
2004	**58**		9.65564	47.792	1140.021	4.94962	118.0679	0.041922
CHANGE	**58**		-0.7875141	-0.98184308	0.312924188	-0.91455046	5.178877148	-0.98617064
2004	**64**	✓	9.65565	47.796	1140.021	4.95009	118.0678	0.041926
2012	**64**		69.22129	250.729	236.3051	3.62214	3.413764	1.06104
CHANGE	**64**		6.168993284	4.245815549	-0.79271864	-0.26826785	-0.97108641	24.30744645
2004	**66**		1.67498	57.434	316.285	34.2893	188.8287	0.181589
2002	**69**	✓	88.65271	399.391	306.692	4.50512	3.459477	1.302255
2009	**71**		5.19563	20.659	11.1678	3.97613	2.149456	1.849833
2010	**71**		4.6709	27.412	13.8848	5.86873	2.972626	1.974259
2004	**72**	✓	10.70855	7443.063	860.1299	695.0578	80.32178	8.653417
2012	**72**		15.59678	1704.736	363.1739	109.3005	23.28519	4.693992
CHANGE	**72**		0.456479169	-0.77096311	-0.57776854	-0.84274617	-0.71010117	-0.45755625
2005	**73**	✓	13.38735	763.112	613.0391	57.00247	45.79241	1.244802
2009	**74**		5.367	19.915	2.9985	3.71059	0.558698	6.641489
2010	**74**		0.41029	366.778	74.6498	893.9563	181.9457	4.913313
2011	**74**		2.27871	2564.164	51.639	1125.268	22.66146	49.65559
CHANGE 1	**74**		-0.9235532	17.41717299	23.89571452	239.920258	324.6601957	-0.26020912
CHANGE 2	**74**		4.553900899	5.991051808	-0.30824999	0.258750568	-0.87544932	9.106335583
2002	**78**	✓	1.06008	10.517	29.6876	9.92121	28.00506	0.354265
2010	**79**	✓	3.2029	152.34	34.1021	47.56312	10.64725	4.467174
2012	**80**		202.7793	23.537	1610.27	0.11607	7.940995	0.014617
2009	**87**		5.19563	20.658	11.1677	3.97607	2.149433	1.849824
2003	**93**		3.30689	779.655	261.1441	235.7667	78.96966	2.985535
2004	**94**	✓	9.65566	47.791	1140.021	4.94949	118.0677	0.041921
2008	**94**		1.60691	4.515	165.1994	2.80957	102.8055	0.027329
2010	**94**		3.2029	152.34	34.1021	47.5632	10.64725	4.467183
CHANGE 1	**94**		-0.83357844	-0.90552615	-0.85509091	-0.43235162	-0.12926651	-0.3480833
CHANGE 2	**94**		0.993204349	32.74086379	-0.79357007	15.92899625	-0.89643307	162.4594387

Moreover, mainly the Peer industries can confirm whether this ratio is the efficient one or not. There are industries where unpaid overtime is needed for every 118 hours of basic hours used like industries 19. Coke and Petroleum, 50. Water transport and 64. Financial Services (only for 2004). What is observed here is that in efficient industries (Peers) for 100 each basic pay hours 1 hour of unpaid overtime is used. In other words, efficient industries sharing these input-output characteristics should not use much overtime. This group of industries does not cause much of a surprise regarding the little amount of unpaid overtime it uses compared to the basic working hours.

Table 4.33 - Full-facet MRSs for input variables – Productive Industries

YEAR	DMU	basic_ncs	paid_ncs	unpaid_ncs	paid_basic	unpaid_basic	paid_unpaid
2002	**5**	55.956	2112.06	1954.877	37.745	34.93597	1.08041
2007	**17**	11.1585	16.35	21.78	1.4652	19.5189	0.75068
2004	**26**	6.6922	200.38	741.516	29.9428	110.803	0.27023
2007	**27**	11.1585	16.35	21.78	1.4653	1.95189	0.75069
2004	**50**	20.0245	104.7	640.89	5.2285	32.00526	0.16337
2009	**61**	81.6033	16,254.33	3,971.17	199.1871	48.66436	4.09308
2003	**72**	9.5333	1874.74	314.892	196.6505	33.03065	5.95358
2002	**74**	24.0885	829.5	404.946	34.4354	16.81073	2.04842
2004	**74**	6.6922	200.38	741.516	29.9425	110.803	0.27023

Table 4.34 - Full-facet MRSs for input variables – Unproductive Industries

YEAR	DMU	basic_ncs	paid_ncs	unpaid_ncs	paid_basic	unpaid_basic	paid_unpaid
2004	**45**	15.2369	334.98	3671.224	21.98443	240.9423	0.091244
2011	**45**	51.6731	2424.07	957.7577	46.91161	18.53495	2.530981
2012	**46**	75.5396	1668.49	866.5037	22.08764	11.47085	1.925544
2004	**64**	15.2368	334.96	3671.231	21.98375	240.9448	0.09124
2004	**65**	15.237	334.98	3671.226	21.98468	240.9423	0.091245
2011	**65**	49.3413	3275.42	1013.225	66.38289	20.53505	3.232663
2011	**69**	49.3412	3275.42	1013.226	66.38314	20.53509	3.232668
2004	**73**	58.3583	534.29	3161.753	9.15531	54.17832	0.168985
2005	**73**	26.0618	897.32	971.0557	34.43025	37.25971	0.924061
2006	**73**	13.5904	4893	2177.082	360.0322	160.1922	2.247501
2004	**77**	49.2385	422.16	3057.547	8.57369	62.09669	0.13807
2011	**79**	49.3412	3275.42	1013.224	66.38307	20.53507	3.232669
2011	**84**	49.3412	3275.41	1013.224	66.38283	20.53506	3.232659
2004	**90**	15.2369	334.98	3671.223	21.98444	240.9428	0.091243
2010	**90**	8.866	2358.38	4244.614	266.0032	478.7538	0.555616
2003	**93**	57.3873	9397.63	3794.632	163.7578	66.12318	2.476557
2004	**94**	49.2385	422.16	3057.548	8.57377	62.09666	0. 138071
2008	**94**	6.4558	429.14	96.7607	66.47421	14.98823	4.435094
2011	**94**	49.3412	3275.42	1013.224	66.38308	20.53505	3.232671
2012	**94**	111.2432	2993.39	858.7623	26.90855	7.71968	3.485708
2005	**95**	26.0618	897.32	971.0557	34.43031	37.25972	0.924063
2006	**95**	13.5905	4892.99	2177.082	360.0312	160.1919	2.2475
2011	**96**	38.8188	2841.78	1007.771	73.20625	25.96092	2.819864

However, separating productive from unproductive industries still gives similarly varying results. On the other hand there are industries with lower MRS where1 unpaid overtime hour is used every 10 basic hours, or 20 in the clustered model, like in industry 79. Travel Agencies, and industries with even lower, where in efficient industries for every 3.5 basic pay hours, or 20 for the clustered model, 1 hour of unpaid overtime is used like in industry 69. Legal and Accounting. These industries generally are detected with undefined working day, and if defined usually working limits are violated. What it is mainly observed from the above clustering into productive and unproductive industries is that a) we still get as few full facet results as in the all industry analysis, b) we still get varying results among the years, even within the same industries, and c) we are a bit more cautious for the results of unproductive industries as almost all of them act as efficient.

Three facet Analysis of Decomposed Model MRSs

In the total labour model there was already some rich information with the all-facet (2 positive input weights facet) model, therefore we avoided proceeding to an analysis with 1- positive input weight facet. However, in the decomposed model, the DEA does not provide non-zero weights for all the 4 input variables. Therefore, for richer information, we keep those industries among the different years that have at least 3 of the input weights (and the output) above zero. Consequently, we are left with only 330 observations where we have 3 facet out of 649 that our original data were.

Marginal Rate of Substitution of Net Capital Stock and Basic Hours - Three facet

As it has been already stated the decomposed labour part does not aim for a further capital-labour analysis, since this has already been contacted in the total labour model with richer information.

However, it would be enlightening to see what is the difference in trade-offs between total working hours and Net Capital Stock (NCS) with the basic working hours and NCS. More specifically, the Table 4.30 above is comparing the Total – NCS MRS with the Basic – NCS with 3 facet information, Basic – NCS with all-facet and Basic-NCS with the Peers only.

There are several interesting findings. First and foremost, only for 20 industries out of the 61 there are similar ratios between total labour or basic hours and the Net Capital Stock. These are the firstly presented on the table with the light grey colour. The medium-grey shade differ slightly, but with a lot of similarities. This category includes 8 industries. Therefore we end up with 29 industries where the total labour model is in disagreement with the decomposed one. Particularly the dark grey category differs massively; the majority of the inconsistent industries present a lower ratio of basic hours compared to the total ones. But even in this category the lower limit of total labour appears as upper limit for basic hours.

One factor that creates this difference between the two models is that DEA is emphasising the variables that are used less (unpaid overtime and paid) making basic and NCS have smaller weights in general, and thus smaller MRSs. As mentioned before, a high weight is given generally to an input that you use a little of relative to other industries. This makes industries appear efficient as the high weight on unpaid overtime forces into DEA inefficiency the industry's comparators. As discussed before, the frontier is comprised by different industries deriving different weights.

Although there are less industries represented, the decomposed labour Peers-Only weights group is demonstrating more similarities to the total labour model compared to the basic hours with Three-facets. Especially, in the dark grey area with the higher capital composition where the major differences between total and basic hours are found, the Peers-Only model with information on the Three-Facet model is more consistent with the total hours' one. Therefore, industries that are not represented in the ALL-facet will be analysed with the Peers-Only group. However, in the decomposed model comparing NCS with the rest of the labour variables would not be as enlightening as focusing mainly on the MRSs among the latter.

Marginal Rate of Substitution of Basic Hours and Unpaid Overtime - Three facet

Analysing the MRS between basic labour and unpaid overtime is actually the main focus of this dissertation. An important issue that needs to be stressed is that working hours is an input with the same features, either if it is paid or unpaid, allowing for some differences in quality (wear and tear) and therefore productivity. Despite that unpaid overtime is not a different separate input used as t the same time with basic hours, but a continuation, bh theory and conventional logic require that any overtime hour would be subjected to wear and tear and therefore it would not be as productive as basic working hours.

Table 4.35 - Marginal Rate of Substitution (MRS) between Unpaid Overtime and Basic Working Hours – All industries – 1 Unpaid overtime hour compensated with Basic Working Hours

MRS	Low	Medium	Medium - High	High	Inconsistent
UNPAID_BASIC					
Range	23 - 379	34 - 1180	188 – 11610	**702.7-1161**	
Average wide	39.05	57.38	268.87	704.6899391	
Average narrow	10.57	39.87	115.69	931.9448333	
Before Crisis	20.5	52.63	119.73	1161.187333	
After Crisis	6.27	28.32	128.42	702.7005889	
Industries	**5 Mining**	1 Agriculture	**45 Wholesale&Retai**	**35 Electricity-Gas-S**	20 Chemicals
	21 Pharmaceutica	10 Food-Beverage	**47 Retail**	52 Warehousing and	**46 Wholesale tra**
	61 Telecommunic	13 Textiles-Appar	49 Land transport &	77 Rental&Leasing	**58 Publishing Act**
	80 Security and I	16 Wood	**50 Water transport**		**69 Legal and Acc**
		17 Paper	51 Air transport		**71 Architectural a**
		18 Printing&Repr	**53 Postal & Courier**		**84 Public Admin a**
		19 Coke&Petroleu	87 Residential care & Social Work		**86 Human Health**
		22 Rubber&Plasti	90 Arts & Libraries & Gambling		
		23 Non-metalic mineral			
		24 Basic Metals			
		25 Metal Products			
		26 Computer, electronic and opticals			
		27 Electrical equipment			
		28 Machinery and equipment			
		29 Motor vehicles&Tralers			
		30 Transport equipment			
		31 Furniture - OtherManf - Repair&Installation			
		43 Construction			
		62 Computer programming and consultancy			
		64 Financial Services			
		65 Insurance and Pension			
		66 Auxiliary to fiancing			
		72 R&D			
		73 Advertising and Market Rsearch			
		74 Other prof, scientific, technical & Veterinary			
		78 Employment Activities			
		79 Travel Agencies			
		85 Education			
		93 Sports			
		94 Activities of Memberships Organisations			
		95 Repair of computers and personal ho			
		96 Other personal activities			

PEERS	Low	Medium	Medium - High	High	Inconsistent
Range		5 -3200	188 – 11610		
Average wide		44.82	389.63		
Average narrow		31.23	528.83		
Before Crisis		42.71	614.94		
After Crisis		33.59	388.92		

For Access to Data go to Appendix 16[49]

However, the DEA results in the three-facet version (3 positive input weights) are not massively different from the full-facet one. MRSs between basic usual hours and unpaid overtime appear to be quite big emphasising unpaid overtime massively. 259 positive weights for unpaid-basic over the years, were derived the MRS.

In efficient industries in the first category for each basic pay 10 hours 1 hour of unpaid overtime is used. This makes sense if we take into account that every 8 or 10 basic

[49] The industries with bold letters are the peer industries defining the productive frontier.

working hours there can be an hour of unpaid overtime. In other words, this group of industries (Mining, Pharmaceuticals, Telecommunications and Security and Investigation) rely on unpaid overtime quite frequently. Apart from Mining, all the other industries in this category are expected with high unpaid overtime, since they occupy usually labour that does not depend on machinery's pace, like in most Manufacturing sectors. Therefore, there is a flexibility in the working day that can be easily extended. Additionally the pattern observed over the years is that there is an eventual increase of unpaid overtime after crisis; 1 unpaid overtime hour every 20.5 basic hours before crisis this group moved to 1 unpaid overtime hour every 6.27. Apart from 2002 that raises the MRSs, for the observations we have it is evident that the rest of the years have an MRS below 10 (For more details go to Appendix 17). Therefore, despite that total working hours have dropped the ratio of unpaid overtime over the total hours has gone up. This result confirms what is detected in Chapter 5, with some extra descriptive statistics.

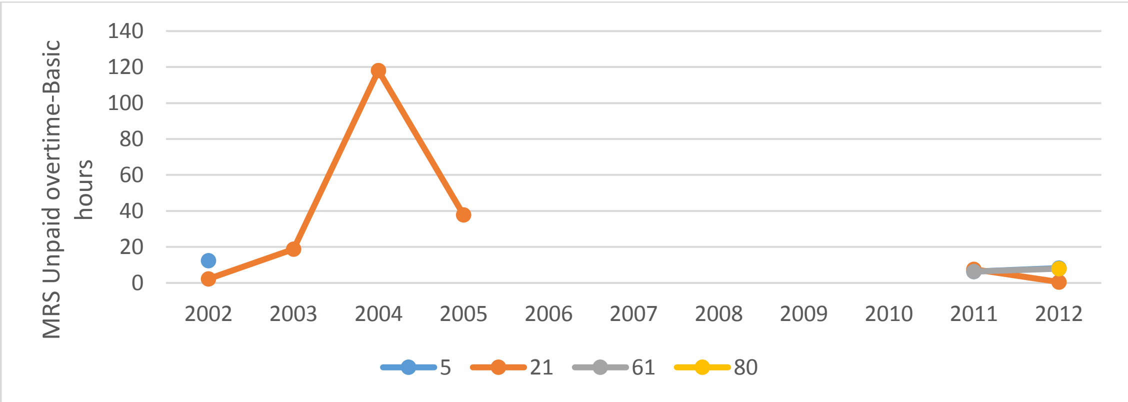


Figure 4.16 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries - Total Labour Model (All industries) - Low MRS group

Regarding the second category, in efficient industries for every 40 (39.87) basic pay almost hours 1 hour of unpaid overtime is used. In other words, a whole working week uses only 1 unpaid overtime hour. This is the most populous group of industries regarding the MRS Unpaid-Basic grouping. This shows that most industries in the UK to be efficient would use at least 1 unpaid overtime hour per week. There are manufacturing industries and services, or both productive and unproductive industries. Because of this variety it is quite hard to explain the industries specific characteristics. As for the pattern of this ratio over time, there is a reduction in the pattern after the outburst of crisis; from 1 unpaid hour every 52.6 to 1 unpaid overtime hour every 28 basic working hours. As the figure below shows, most years after the crisis of 2007-8 have usually 1 unpaid overtime hour every up to 20. After 2008-9 this ratio drops even more although there are less observations left to show the pattern (For more details go to Appendix 17), confirming also that unpaid overtime becomes more frequent after crisis not only is absolute terms, but also with respect to the GVA assigned to the industry.

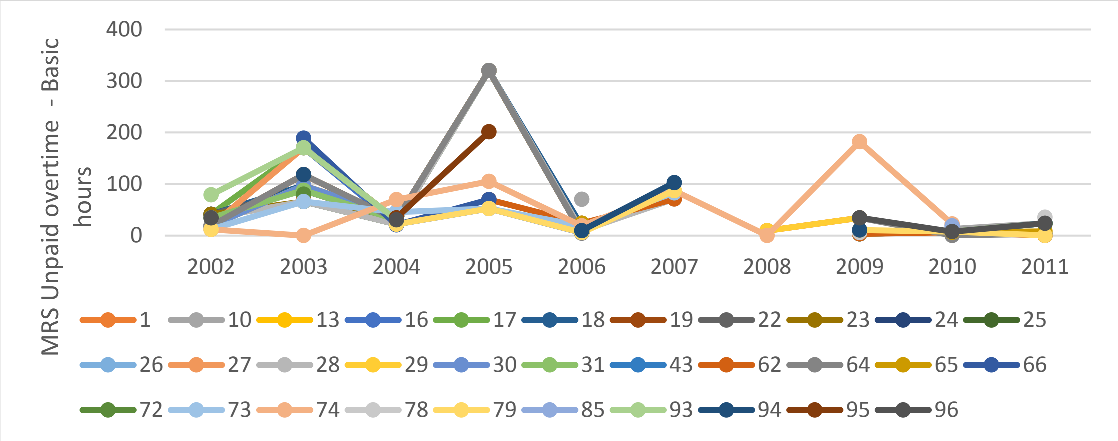


Figure 4.17 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries - Total Labour Model (All industries) - Medium MRS Group

Additionally, in order to compare the validity of the above MRSs, we use regression analysis. In this part we regress the targeted inputs to the real output. As target levels of each unit are used the following holds:

$v_1 EL_{bi} + v_2 EL_{ui} + v_3 EL_{pi} + v_4 ENCS_{ti} \ = uGVA_{ti}$ (4.35)

v_1, v_2 , v_3, v_4 and u are the weights for Basic Labour Hours, Unpaid overtime, Paid overtime, Net Capital Stock, and Gross Value Added respectively

$ENCS_{ti}$ is the target value for Net Capital Stock expressed in 10^9

EL_{bi} is the target value for Basic Labour Hours expressed in 10^7

L_{ui} is the target value for Unpaid overtime hours expressed in 10^6

L_{pi} is the target value for Paid overtime hours expressed in 10^5

GVA_{ti} is the real value of Gross Value Added expressed in 10^8

Thus if we divided in 4.35 both sides by u (when non-zero) we have the contribution to GVA per unit of each input. We can also estimate these contributions as an average for all industries if we use regression of efficient input levels on the real output level. The results of the regression for this group show the contribution of inputs (if the industries were operating in an efficient level) to the output. The regression coefficient for basic working hours is almost close to the DEA results[50]. Therefore a basic working hour contributes 20 times more than an unpaid hour, or 1 unpaid overtime is used for every 20 basic hours.

Regarding the MRS analysis of the Medium-High group, there very few industries and none of them with consistent results over the years (For more details go to Appendix 19). In the Medium-High group there is 1 unpaid overtime every 115 basic working hours. This result has two aspects, because it contains two kinds of industries: industries 45. Wholesale & Retail of Motor vehicles, 46. Retail Trade and 87. Residential and Social Care, which are notoriously known for the ‘flexible; working relations and also 49. Land, 50. Water and 51. Air Transport, where employees work depends on the operational line strictly defined, without allowing much ‘freedom’ to varying working time patterns. In other words, in the first unproductive ‘subcategory’ of the above industries unpaid overtime might appear so rare in LFS interviewees’ responses mainly because there is no overtime notion defined in their contracts (undefined part-time limits, zero-hour contracts etc), but in the second subcategory unpaid overtime can be lower indeed. However, clustering productive from unproductive industries is more enlightening (see below).

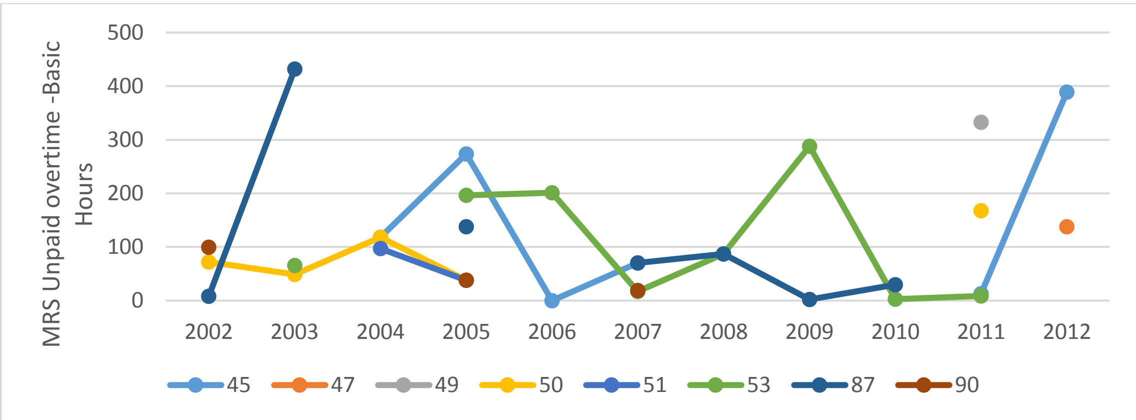


Figure 4.18 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries – Decomposed Labour Model (All industries) - Medium-High MRS

Regarding the high group of industries the weights appear to be much higher; 1 unpaid hour every 931 basic hours. Again this category mainly for 2 years (For more details go to Appendix 17). Therefore, together with the fact this is a three-facet analysis these results cannot be trusted, especially when three industries are only included.

[50] 0.9551313 expressed in 107 and for unpaid overtime hours 0.4889886 expressed in 106. Taking the MRS between basic and unpaid overtime hours we get: 0.9551313*107/0.4889886 *106 = 20.

Generally, the MRS analysis over Unpaid-Basic hours shows some consistency with reality. The main evidence is that despite that after crisis total working hours, basic working hours and overtime are reduced, from the MRS analysis becomes quite evident that unpaid overtime occurs more often, at least based on information for the most populous group of industries. However, there are industries' MRS that mainly due to lack of full-facet and full-year do not seem representative of reality. Again, the issue of homogeneity among industries appears here as well. The peers-only averages also confirm the results of the three-facet analysis.

Three facet Analysis of Decomposed Model MRSs – Productive Industries

Out of 440 observations of Productive industries over the 11 years, we end up with 158 that have at least 3 non-zero weights. Focusing on the results for MRS between unpaid overtime and basic working hours, the results are similar with some interesting differences. The first thing that is observed is that the overwhelming majority of Productive industries use 1 unpaid overtime for every 31.5 hours of basic hours. This is very close to the all-industries analysis, where the majority of industries there had 1 unpaid hour every 40 hours, but obviously with the productive industries only this becomes more frequent.

Apart from that, we do not observe as big values as in the all-industries analysis that reached up to 1 unpaid overtime hour every 1161 basic hours. In the productive industries analysis the maximum value is 1 unpaid hour every 316 basic hours. Additionally, in the lowest category it appears that 1 unpaid overtime can take place almost every 3 basic hours. This implies, that in an 8 hour working day an employee might offer up to 3 unpaid overtime. However, the fact that in the lowest category, only one industry is detected (ind.22) that is not even acting as a peer industry, leads us treat this result cautiously. Industry 22 was also belonging to the Medium group in the all-industries analysis, with average frequency 1 unpaid overtime hour every 40.

Table 4.37 - Marginal Rate of Substitution (MRS) between Unpaid Overtime and Basic Working Hours – Productive industries – 1 Unpaid overtime hour compensated with Basic Working Hours

MRS	Low	Medium	High	Inconsistent
UNPAID_BASIC				
Range	2.6-4.3	7- 96	110-316	
Average wide		34.66		
Average narrow	3.46	31.48	178.88	
Before Crisis		35.47		
After Crisis		25.85		
Industries	22 Rubber&Plast	1 Agriculture	31 Furniture - OtherI	10 Food-Beverages-'
		2 Fishing & Aqua	**74 Other prof, scient**	**16 Wood**
		5 Mining		**21 Pharmaceutical**
		17 Paper		23 Non-metalic mine
		18 Printing&Reproduction of recorded r		**53 Postal & Courier**
		19 Coke&Petroleum		**85 Education**
		24 Basic Metals		
		25 Metal Products		
		26 Computer, electronic and opticals		
		27 Electrical equipment		
		28 Machinery and equipment		
		29 Motor vehicles&Tralers		
		30 Transport equipment		
		35 Electricity-Gas-Steam-Airconditioning		
		36 Water collection, treatment and Supply		
		43 Construction		
		49 Land transport & Pipelines		
		50 Water transport		
		51 Air transport		
		52 Warehousing and supporting transport		
		58 Publishing Activities		
		59 Motion video tv sound & Broadcasting		
		61 Telecommunication		
		62 Computer programming and consultancy		
		72 R&D		
		86 Human Health		
PEERS	Low	Medium	High	Inconsistent
Range		10.3-96	11-31.6	
Average wide		41.62	148.14	
Average narrow		30.92	213.81	
Before Crisis		32.34		
After Crisis		32.86		

For access to data go to Appendix 19[51]

Clustering the industries into productive and unproductive, the MRS between basic hours and unpaid overtime are slightly different. Again most industries are found in the medium group with average MRS 30 basic hours per unpaid overtime (in the all industry analysis it was 40). However, most productive industries that were compared with unproductive appeared to have smaller frequency of unpaid overtime, but now

[51] The industries with bold letters are the peer industries defining the productive frontier.

higher. The peer analysis shows similar results with the only difference that the peer only show a slight drop of unpaid overtime compared to the productive industry (no peers only). This contradicts both with the all industry analysis (peers and all peers) but also with productive only (no peers). Therefore, there is no strong evidence showing a clear tendency.

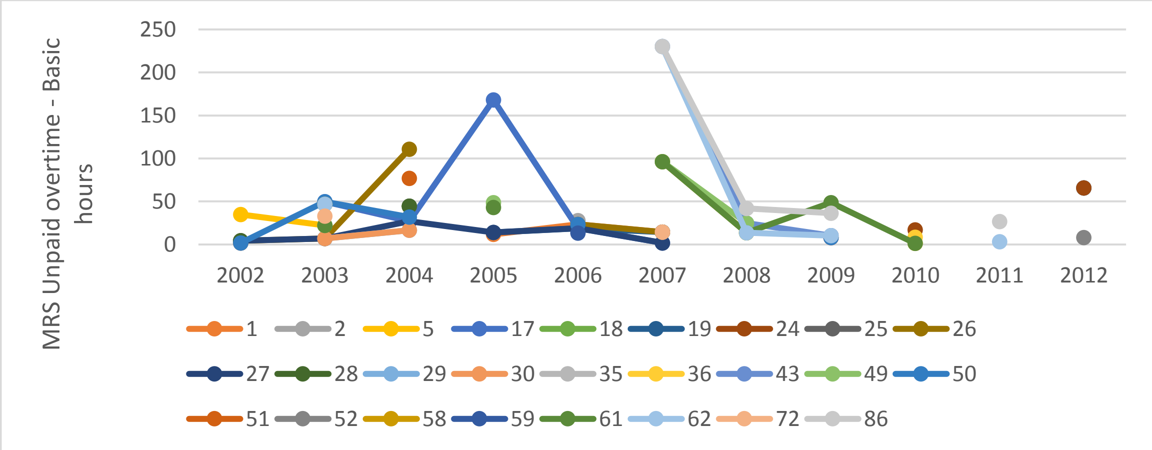


Figure 4.19 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries – Decomposed Labour Model (Productive industries) - Medium MRS

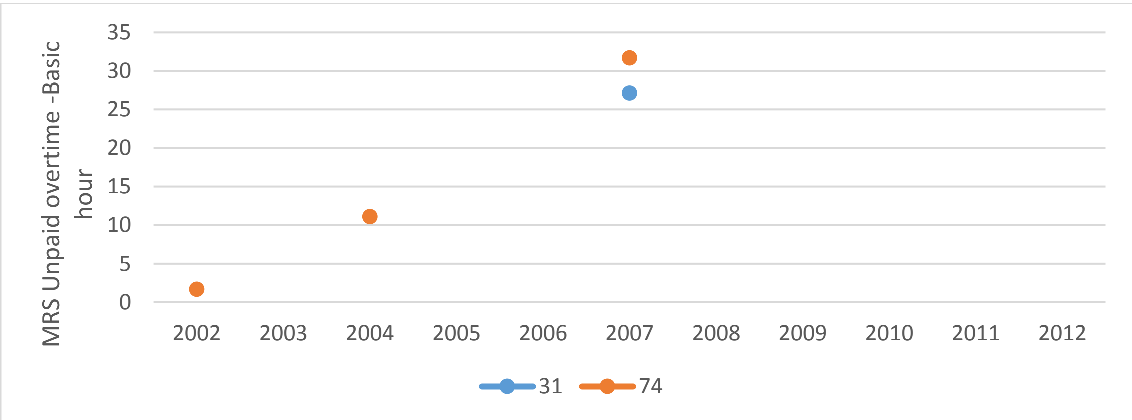


Figure 4.20 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries – Decomposed Labour Model (Productive industries) – High MRS

Three facet Analysis of Decomposed Model MRSs – Unproductive Industries

Again, the decomposed model does not provide an all-facet information for every observation. Therefore, like previously, we are based on the three-facet one, where out of the 187 observations we remain with 127 OBS in the 3-facet model.

Table 4.38 - Marginal Rate of Substitution (MRS) between Unpaid Overtime and Basic Working

MRS	Low	Medium	High	Highest	Inconsistent
UNPAID_BASIC					
Range	2.2	7.7-62	15-308	83-2740	
Average wide		50.09	129.04	439.38	
Average narrow	2.23	23.98	68.72	616.09	
Before Crisis		46.52	100.26	193.53	
After Crisis		16.92	36.64	982.68	
Industries	**80 Security and I**	**46 Wholesale trad**	66 Auxiliary to fianci	**45 Wholesale&Reta**	**65 Insurance and**
		47 Retail	**73 Advertising and M**	**64 Financial Service**	**69 Legal and Acc**
		94 Activities of M	**77 Rental&Leasing**	**78 Employment Acti**	**84 Public Admin a**
			79 Travel Agencies		
			95 Repair of computers and personal household goods		
			96 Other personal activities		
PEERS	**Low**	**Medium**	**High**	**High**	**Inconsistent**
Range	2.2	7.7-62	15-308	90-2740	
Average wide		52.21	67.78	295.37	
Average narrow	2.23	22.98	75.2	422.68	
Before Crisis		62.1	104.88	193.53	
After Crisis		16.51	36.64	670.06	

For access to data go to Appendix 20[52]

Apart from industry 94, the rest seem to have different weights with the all-industries analysis. As described before, there are only 17 Unproductive industries only, with most of them acting as peers. It is also far from the Productive industries where the frequency was ever 31 hours. Here the frequency seems to be rarer, thing that we know from theory and other research cannot be true. If we focus on their pattern over the years, we see that the average before crisis was 1 in every 100, but after crisis 1 in every 36, which is quite close to the previous cases.

Apart from that, contrary to the Productive industries-only, we do observe big values, like in the all industries analysis (Category Highest). As in the all-industries analysis that reached up to 1 unpaid overtime every 1161 basic hours, in the unproductive industries the maximum value is 1 unpaid hour every 2740 basic hours. Additionally, in the lowest category it appears that 1 unpaid overtime can take place almost every 2 basic hours. This implies, that in an 8 hour working day an employee might offer up to 4 unpaid overtime. However, the fact that in the lowest category, only one industry is detected (ind.80) that is not even acting as a peer industry, leads us treat this result cautiously. Although the industry 80 was also belonging to the smallest group in the all-industries analysis, with average frequency 1 unpaid overtime hour every 10, we still need to treat this with caution. However, the nature of this industry preoccupies every analyst that there must be high overtime (investigation can take place out of normal working hours).

[52] The industries with bold letters are the peer industries defining the productive frontier.

Generally, the unproductive industries provide unreasonable results.

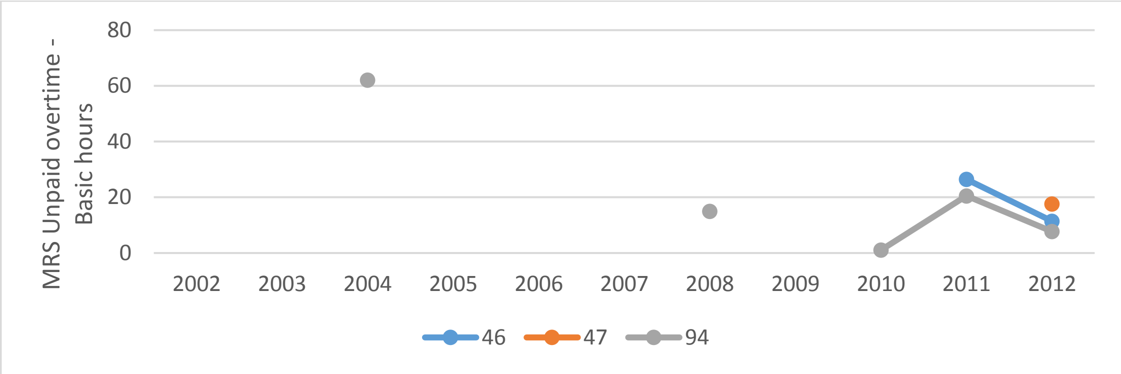


Figure 4.21 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries – Decomposed Labour Model (Unproductive industries) - Medium MRS

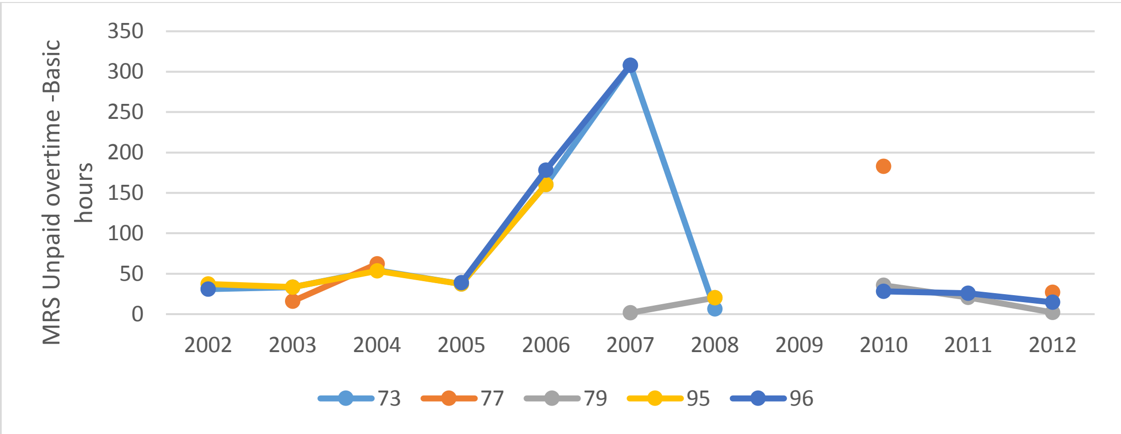


Figure 4.22 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries – Decomposed Labour Model (Unproductive industries) - High MRS

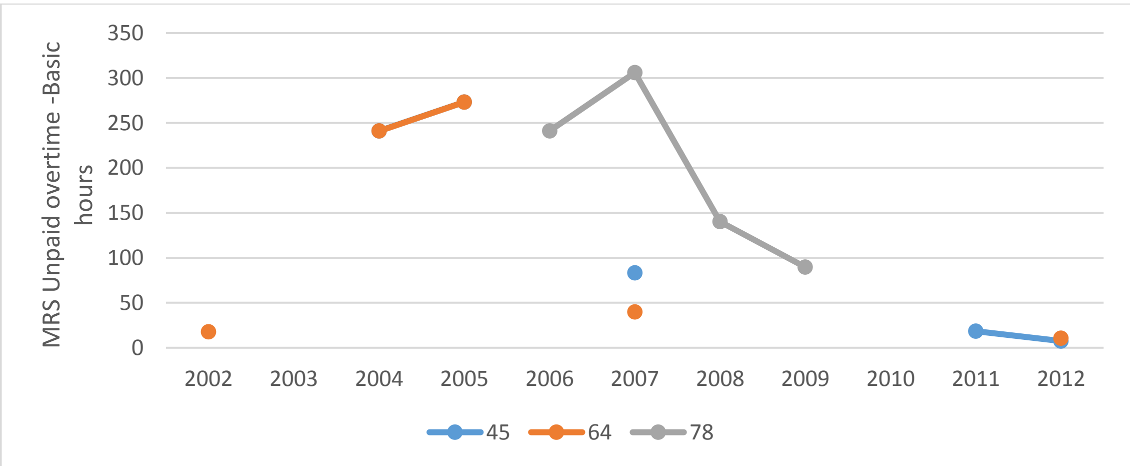


Figure 4.23 – MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries – Decomposed Labour Model (Unproductive industries) - Highest MRS

Marginal Rate of Substitution of Paid Overtime and other variables

This is an interesting part of our analysis, since unpaid overtime cannot be examined without analysis of tendencies in paid. It is obviously expected that the patterns among industries and overtime will be diverse. Generally, from the descriptive statistics it occurs that paid overtime is less than the reported unpaid. Paid overtime is the variable that causes most of the trouble both in the DEA analysis and the Statistical analysis later on. The fact that most industries use it in such a small degree lead industries in DEA to appear efficient. We are examining these peculiarities. Additionally, in the DEA software cannot reach a feasible solution when paid overtime is included. The DEA solution shows that out to the 649 observations we have information on paid overtime for 50 only industries. This makes us cautious with the results (See Appendix 21). Generally, paid overtime consists only of 5% of overtime, and overtime almost 5% of total working hours (See Chapter 3 and 5, Descriptive statistics), therefore 0.25% of the total working hours. Consequently, the variable is omitted to derive less problematic values.

Generally, the MRS analysis in the decomposed model confirms what it is expected intuitively from ratios among the different kinds of labour. Additionally, there are no big differences among the 3 and the 4 positive input weights facet and the peers-only analysis. Therefore, we can trust the three-facet analysis, unless disproved by the peers-only. Generally for the majority of industries there is 1 unpaid overtime hour every 20 basic. This also agrees with the descriptive statistics showing more than 5% of unpaid compared to total working hours. The regression analysis also shows an 'average' of 1 unpaid hours for every 20 basic for the majority of industries if they were to be efficient. Additionally, not every industry demonstrates the same pattern, which is what we would expect. DEA does have the flexibility to capture varying patterns of use of unpaid labour across industries. However, the majority of them a similar one especially for unpaid-basic and paid-unpaid MRS, showing that despite that all working hours experiencing a drop after the 2007-8 crisis outburst unpaid overtime is taking over compared both to basic and paid overtime, considering the behaviour of industries if they were performing at the efficient level. This confirms the descriptive statistics provided in the Chapter 3, and in the ratio analysis shown in Chapter 5. We have an agreement achieved with DEA with the descriptive statistics regarding the fact that the relative use of unpaid overtime has gone up.

4.3.3 Analysing Inputs' Contributions to Gross Value Added for the Decomposed Labour (Basic hours, Paid overtime and Unpaid overtime)

All facet Analysis of Decomposed Model Contributions

Table 4.39 - Inputs' Contribution to GVA (All Industries) – Full Facet

YEAR	DMU	v(ncs)/u(gva)	v(basic)/u(gva)	v(paid)/u(gva)	v(unpaid)/u(gva)
2002	**19**	0.35772	4.64689	55.6637	290.3827
2004	**19**	0.2920709	2.820139	13.9584	332.9671
2004	**21**	0.292071	2.820137	13.9586	332.9672
2004	**45**	0.2920708	2.820136	13.9587	332.967
2002	**50**	0.3739833	3.945448	105.7893	283.4622
2004	**50**	0.2920709	2.820139	13.9585	332.9671
2002	**58**	0.1622495	7.372833	427.0675	140.8824
2004	**58**	0.2920708	2.820131	13.9586	332.967
2004	**64**	0.2920713	2.820138	13.9599	332.9676
2012	**64**	0.1447111	10.01709	36.2833	34.19597
2004	**66**	0.6582199	1.102508	37.8042	208.1851
2002	**69**	0.1798835	15.94716	71.8439	55.16884
2009	**71**	1.645341	8.548588	33.9903	18.37481
2010	**71**	1.750984	8.178675	47.9985	24.31214
2004	**72**	0.2144761	2.296729	1596.359	184.4773
2012	**72**	0.5070199	7.907877	864.3348	184.1364
2005	**73**	0.4534173	6.070055	346.0082	277.9625
2009	**74**	1.707452	9.163899	34.0035	5.11986
2010	**74**	1.422321	0.583559	521.6759	106.176
2011	**74**	0.8856056	2.018042	2270.838	45.73177
2002	**78**	1.593262	1.688985	16.7568	47.30014
2010	**79**	1.631726	5.226256	248.577	55.64526
2012	**80**	0.08497749	17.23168	2.0001	136.8367
2009	**87**	1.645341	8.548582	33.9898	18.3746
2003	**93**	0.7412625	2.451275	577.9289	193.5763
2004	**94**	0.2920709	2.820138	13.9582	332.967
2008	**94**	1.071175	1.721285	4.8361	176.9575
2010	**94**	1.631725	5.226251	248.5773	55.64519

Regarding DEA the contribution of Basic Working Hours, Unpaid, Paid Overtime and Net Capital Stock to Gross Value Added (GVA) we can find their marginal contributions as we did in the total labour model. Therefore, $\frac{v_1}{u}$ is the contribution of 10^7 of Basic Working Hours to GVA in units of 10^8, $\frac{v_1}{u}$ is the contribution of 10^6 of Unpaid Overtime Hours in units of £10^8 of GVA, $\frac{v_1}{u}$ is the contribution of 10^5 of Paid Overtime Hours in units of £10^8 of GVA and $\frac{v_4}{u}$ is the contribution of £10^9 of NCS in units of £10^8 of GVA.

As we did previously, there are three different groupings that are examined: i. the four positive weight-facet group, with 28 observations of 18 industries, ii three-positive weight group with 330 observations of 56 industries, and iii. the peers-only group with 201 peer observations of 32 industries among the years. The full-facet is examined first.

Table 4.40 - Inputs' Contribution to GVA (Productive Industries) – Full Facet (4 positive input weights)

YEAR	DMU	v(ncs)/u(gva)	v(basic)/u(gva)	v(paid)/u(gva)	v(unpaid)/u(gva)
2002	**5**	0.078374	4.385481	165.53	153.211
2007	**17**	1.43314	15.99169	23.4316	31.21403
2004	**26**	0.329657	2.206129	66.05759	244.4457
2007	**27**	1.43314	15.99169	23.43193	31.21405
2004	**50**	0.324758	6.503126	34.00183	208.1342
2009	**61**	0.045377	3.702893	737.5687	180.1989
2003	**72**	0.386667	3.686225	724.8981	121.7584
2002	**74**	0.321345	7.740717	266.5544	130.1271
2004	**74**	0.329657	2.206129	66.05711	244.4457

For the all-facet model we end up with 9 observations only. Only some tiny piece of information is acquired. As the Table shows, the results are not any different compared to the all industries analysis. Paid and unpaid overtime again seem to contribute in higher degree compared to basic working hours. However, the only industry for which we have an all facet information and we can compare with the all-industries analysis is industry 50. Water transport. The results are very similar, however NCS, basic hours and paid overtime are appearing to be contributing more, while unpaid overtime, still higher than any other input but, less than in the all-industries analysis.

Table 4.41- Comparison between All Industries and Productive-Only - Inputs' Contribution to GVA – Full Facet

	YEAR	DMU	v(ncs)/u(gva)	v(basic)/u(gva)	v(paid)/u(gva)	v(unpaid)/u(gva)
ALL INDUSTRIES	**2004**	**50**	0.2920709	2.820139	13.9585	332.9671
PRODUCTIVE ONLY	**2004**	**50**	0.324758	6.503126	34.00183	208.1342

Therefore, for a more industry-focused analysis on unpaid overtime's contribution to GVA we move on with the 3-fact model.

For the all-facet model we end up with 23 observations only, giving us restricted information is acquired. As the Table shows, the results are not any different compared to the all industries analysis. Paid and unpaid overtime again seem to contribute in higher degree compared to basic working hours.

Table 4.42 - Inputs' Contribution to GVA (Unproductive Industries) – Full Facet

YEAR	DMU	v(ncs)/u(gva)	v(basic)/u(gva)	v(paid)/u(gva)	v(unpaid)/u(gva)
2004	**45**	0.1105	1.6836	37.0132	405.6528
2011	**45**	0.1629	8.4162	394.8188	155.9944
2012	**46**	0.1532	11.5724	255.6063	132.745
2004	**64**	0.1105	1.6836	37.0116	405.6522
2004	**65**	0.1105	1.6836	37.0136	405.6529
2011	**65**	0.1558	7.6869	510.2783	157.8508
2011	**69**	0.1558	7.6869	510.2781	157.8505
2004	**73**	0.1204	7.0239	64.3059	380.5427
2005	**73**	0.3269	8.5205	293.3619	317.4702
2006	**73**	0.2556	3.4741	1250.798	556.528
2004	**77**	0.1201	5.9138	50.7031	367.2272
2011	**79**	0.1558	7.6869	510.2791	157.8507
2011	**84**	0.1558	7.6869	510.2786	157.8511
2004	**90**	0.1105	1.6836	37.0131	405.6528
2010	**90**	0.2884	2.5572	680.2313	1224.283
2003	**93**	0.0719	4.1253	675.5482	272.7771
2004	**94**	0.1201	5.9138	50.7036	367.2274
2008	**94**	1.0185	6.5753	437.087	98.5519
2011	**94**	0.1558	7.6869	510.2795	157.8507
2012	**94**	0.1248	13.8823	373.5534	107.1672
2005	**95**	0.3269	8.5205	293.3623	317.4702
2006	**95**	0.2556	3.4741	1250.798	556.5285
2011	**96**	0.1688	6.5543	479.8131	170.1547

The above results differ slightly from the all-industries analysis (See Table 4.48). With an unproductive analysis, NCS contribution, appears even smaller. This result should not be surprising if we take into account that in the all-industries one the unproductive were compared to productive ones that by definition tend to use higher amount of fixed capital. Additionally, although basic hour's contribution does not have a specific pattern, paid overtime appears to have even higher compared to the same industries contributions analysed with the all-industries. It makes sense, since in unproductive industries where working time limits ca be easily extended and unregulated paid overtime happens even rarer, implying that it is mainly the unpaid overtime that occurs more frequently. Therefore when and if it happens it needs to be related with an exceptionally high contribution to GVA. However, the below results show that unpaid overtime too appears less frequently, with industry 94 in 2008 acting as an exemption.

Table 4.43 - Comparison between All Industries and Unproductive-Only - Inputs' Contribution to GVA – Full Facet

	YEAR	DMU	v(ncs)/u(gva)	v(basic)/u(gva)	v(paid)/u(gva)	v(unpaid)/u(gva)
ALL	**2004**	**45**	0.2920708	2.820136	13.9587	332.967
UNPRODUCTIVE	**2004**	**45**	0.110495	1.683609	37.01319	405.6528
ALL	**2004**	**64**	0.2920713	2.820138	13.9599	332.9676
UNPRODUCTIVE	**2004**	**64**	0.110495	1.68359	37.01162	405.6522
ALL	**2003**	**93**	0.7412625	2.451275	577.9289	193.5763
UNPRODUCTIVE	**2003**	**93**	0.071885	4.125287	675.5482	272.7771
ALL	**2004**	**94**	0.2920709	2.820138	13.9582	332.967
UNPRODUCTIVE	**2004**	**94**	0.120105	5.913803	50.70361	367.2274
ALL	**2008**	**94**	1.071175	1.721285	4.8361	176.9575
UNPRODUCTIVE	**2008**	**94**	1.018511	6.575286	437.087	98.5519

Contrary to Productive industries only, here we can see that paid and unpaid overtime's contribution is even higher. Especially, for unpaid overtime all industries have a three digit number of £GVA contribution, indicating that it is mainly the unproductive industries that great amount of GVA is strongly associated with unpaid overtime. As explained before, in unproductive industries-only analysis, if they wish to be efficient increasing unpaid overtime by 1 hour, they have to extract as much GVA as possible bigger than in the case of productive industries.

At first glance the results appear odd because as the Table 4.34 shows, basic hours contribute less to output, compared to unpaid and paid overtime. Generally, as we have mentioned earlier the weights that are used have been derived based on some efficient industries that define the production frontier. This means that even the inefficient industries are projected to this frontier sharing similar weights with the efficient industries. For instance, in 2002 industry 19 should be interpreted like this: 'if an industry wishes to reduce 1 basic hour, they will reduce their contribution towards GVA by £4.6', and 'if they wish to reduce their unpaid overtime by 1 hour they will reduce their contribution towards GVA by £290'. In other words, in units of money, a marginal basic hour gives us less than an unpaid overtime one.

As all types of labour are in the same unit (10^7 hours) the contribution per this unit to GVA is comparable across the three types of labour. On the face of it contribution per hour of basic, paid and unpaid rising dramatically in many cases does appear odd. However, we should recall the precise interpretation of these weights. They mean at the margin for an efficient industry a drop of one hour of unpaid labour in many cases will be accompanied by a far bigger drop in GVA than a drop of one hour of basic (paid) labour. This does not mean necessarily that the extra hour of unpaid labour per se contributes more to GVA than a basic hour. Rather, there is greater volatility in GVA as unpaid labour varies across industries than with basic labour. That is we can find industries which have perhaps small levels of unpaid overtime and so can claim it contributes heavily to GVA in order to 'force' into lower efficiency in the comparative analysis those industries that use higher levels of unpaid labour. As labour is a continuum we cannot say whether the extra GVA with low levels of unpaid labour came from those unpaid hours or earlier on from the basic paid hours. All we can say is when unpaid labour is in the mix in many industries its loss will place them in a far lower GVA position. That could be because simply even basic hours would not have been fully productive and hence the lack of need to put in additional unpaid hours. Alternatively these values mean that an industry needs to extract as much GVA as possible from occupying unpaid overtime if they are to be efficient. In other words, if an industry uses unpaid overtime, they have to make it as productive as possible. Therefore, from the full-facet model above, we can conclude that there is an association between unpaid overtime and high GVA, contradicting to the theories claiming that unpaid overtime is not related with production.

Additionally, these results might also be derived from the fact that paid and unpaid overtime experience higher variability than basic hours. Therefore, even the same industry over the years might have extremely high or extremely low contribution of paid and unpaid overtime. In DEA the weights of unpaid hours appear higher because generally unpaid overtime is less than basic working hours. Therefore it appears that unpaid overtime could be more productive to GVA per hour than basic working time does. In other words, for given GVA the smaller the divisor (unpaid hours) the more the GVA per hour. Therefore, these extreme values could be explained by the relatively low amount of unpaid overtime in these industries that make the weight unpaid over basic hours looking quite high.

Another implication of the fact that unpaid overtime hours is a continuation of basic hour, is that if the industry produces a high GVA, it would also tend to need more overtime. So, the DEA model reflects the fact that there is more GVA when we have unpaid overtime. Overtime in general does not go with underemployment. Using extra hours on the top of basic ones is an indicator of an industry with high GVA, and leads to basic hours having ‘exhausted’ their contribution. Alternatively, there has been enough productivity from basic hours. For instance, when we compare two industries, industry A with a high GVA might have more orders compared to industry B with lower GVA. Therefore, employees in industry A will stay longer hours (even performing unpaid overtime) in order to catch up. Consequently, the fact that an industry over-occupies labour, and particularly extends its length, acts immediately as an indicator of a high GVA industry. Combining this fact with what was found in the decomposed outlier analysis that industries during growth rely too much on basic and unpaid overtime (than paid overtime or increasing their capital stock) is confirming that the UK industries opt for increasing s/v (rate of surplus value) instead of g/v (organic composition of capital), according to Marxist terms.

Additionally, unpaid overtime’s high contribution can have a number different interpretations. For instance, in our data part-time workers have not been excluded, consisting more than 25% of British employees. Thus, their overtime does not represent yet any kind of wear and tear of labour, compared to the full-timers. In other words, this high contribution of unpaid overtime to the industries' output can also be partially justified by the long hours provided by the part-time workers. Similar arguments can be applied in the case of paid overtime. Paid overtime appears to have extremely high contributions to GVA for similar reasons although it consists of the 0.25% of total working hours. Therefore in a lot of cases the contribution appears much higher than the case of unpaid overtime. Generally, paid overtime is much less than unpaid, therefore when it is to be used (because it is more expensive compared to unpaid that is free) it definitely needs to be associated with even higher GVA.

This speculation could be correct if we look at the industries that have extremely high contribution of eg paid overtime. For instance, industries 72. R&D and 74. Other professional, scientific, technical and veterinary, are industries that usually do not have a certainly defined working time pattern. Researches, scientists and other professionals can come to the office earlier, can leave later etc until their assigned task finishes. Therefore, when it is to produce high output performing overtime is highly compulsory, especially if they do not have contracts with strictly defined working day. Additionally, although at a first glance this could also act as an indicator of convexities when using labour. It makes sense that as hours pass there can be diminishing returns, or what Marxists describe as 'wear and tear' of labour, where overtime hours seem to contribute more, in fact it is not probably a theoretically/practically sufficient factor. This could be true to an extend for some certain professions, such as a lecturer's output is both teaching research. However, there are also a lot of other administration duties that need to be done. Especially in teaching focused universities, the administration tasks can consume days. Therefore, when the lecturer eventually starts working on their research, the research output produced (publication, conference etc.) is mostly based on unpaid overtime. Generally, high contributions of overtime are expected in industries with this 'flexibility' and in industries that employees are not subjected to a specific production line.

Moreover, convexities would also be possible for certain jobs, that are independent from machinery's and equipment's pace, where there is quite a lot of independence ie. one employee's tasks do not depend immediately on others, it has been detected with morning overtime (see Chapter 2), but cannot represent all industries. In other words, overtime in a lot of cases has been observed to take place before even the 'normal' working day starts. Therefore, working early hours appear extremely productive, but this is a fact restricted to few industries/professions not representing the whole economy.

Three facet Analysis of Decomposed Model Contributions

Table 4.44 - 1 hour of Unpaid Overtime contribution towards £ of GVA – Decomposed Labour Model (All industries)

	CONTRIBUTION	UNPAID_GVA					
DMU	**Description**	**AVERAGE ind**	**Average all**	**Crisis Effects**	**AVERAGE PEERS ind**	**Average peers**	**Crisis Effects Peers**
1	Agriculture	292.904	228.208	264.287		194.547	232.301
5	**Mining**	**236.311**		511.019	**396.491**		170.576
10	Food-Beverages-Tol	242.492					
13	Textiles-Apparel-Le	295.161					
16	Wood	221.679					
17	Paper	309.354					
18	Printing&Reproduct	319.402					
19	**Coke&Petroleum**	**302.810**			**302.810**		
20	Chemicals	333.178					
21	**Pharmaceutical**	**174.676**			**174.676**		
22	Rubber&Plastic	249.671					
23	Non-metalic mineral	310.114					
24	Basic Metals	192.654					
25	Metal Products	220.646					
26	Computer, electroni	246.598					
27	Electrical equipment	287.134					
28	Machinery and equi	217.980					
29	Motor vehicles&Tra	241.955					
30	Transport equipmen	174.865					
31	Furniture - OtherMa	204.751					
35	**Electricity-Gas-Stea**	**383.089**			**383.089**		
37	Sweerage - Waste -I	947.031					
43	**Construction**	**158.790**			**217.862**		
45	**Wholesale&Retail&**	**280.552**			**280.552**		
46	**Wholesale trade**	**202.184**			**226.487**		
47	**Retail**	**214.052**			**214.052**		
49	Land transport & Pi	510.952					
50	**Water transport**	**339.272**			**283.681**		
51	Air transport	352.419					
52	Warehousing and su	301.024					
53	**Postal & Courier**	**140.748**			**140.748**		
55	Accomodation & Foo	266.678					
58	**Publishing Activities**	**231.474**			**95.270**		
61	**Telecommunication**	**118.306**			**136.894**		
62	**Computer programm**	**129.530**			**129.530**		
64	**Financial Services**	**217.645**			**217.645**		
65	**Insurance and Pensi**	**302.307**			**302.307**		
66	**Auxiliary to financing**	**162.776**			**144.972**		
69	**Legal and Accountin**	**112.071**			**112.071**		
71	**Architectural and Er**	**89.087**			**102.164**		
72	**R&D**	**270.723**			**184.477**		
73	**Advertising and Ma**	**221.748**			**221.748**		
74	**Other prof, scientific**	**134.311**			**193.596**		
77	Rental&Leasing	372.866					
78	**Employment Activiti**	**99.948**			**99.948**		
79	**Travel Agencies**	**142.138**			**59.614**		
80	Security and Investi	437.753					
84	**Public Admin and De**	**159.909**			**159.909**		
86	**Human Health**	**101.195**			**143.812**		
87	Residential care & S	159.772					
90	Arts & Libraries &	294.892					
93	Sports	291.278					
94	**Activities of Membe**	**185.121**			**187.900**		
95	**Repair of computers**	**213.483**			**218.690**		
96	**Other personal activ**	**241.016**			**241.160**		

For access to data go to Appendix 22[53]

[53] The industries with bold letters are the peer industries defining the productive frontier.

Based on the group derived from the Unpaid-Basic MRS (See Table 4.31), we regress inputs' target values to real GVA in order to see if an 'average' frontier can be created. In this section we do not focus on the NCS's contribution mainly because this has already been covered in the total labour model where it is more sensible to examine capital composition of each industry. In this part, we focus mainly on the unpaid overtime. Having in mind that 1 unpaid overtime is used every 10, 40, and 100 or even 1000 basic hours depending on the industry groups, and taking into account the previous all-facet analysis of contributions, we can see that unpaid and paid overtime seem to be contributing more to the basic hours. In this part we focus on the different groups of industries that rely more or less unpaid overtime for their production's needs. Table 4.35 show the contribution of unpaid overtime for each industry that performs or would perform in the efficient frontier.

Based on the Table 4.35 all industries seem to belong to one single group, since most of these industries have an average contribution of 1 unpaid overtime hour is contributing between £89 and £383 towards GVA, with an average of £228. There is only one exemption: industry 37. Sewerage seems to have almost £1000. The peer industries also confirm this with a narrower range and a lower average (£194). However, while in the all-industries analysis unpaid overtime's contribution to GVA appears higher than before the outburst of the 2007-8 crisis, in the peers-only analysis it is suggested that there is a drop. This could be because they started using more unpaid overtime after crisis.

Generally, from the Figure 4.24 there is an evident tendency that most industries perform in a lower level than pre crisis. Industries pattern in unpaid overtime contribution to GVA still has its ups and downs, but it is shown that the tendency is slightly lower after the outburst of crisis. This can happen mainly because most industries have shrunk their operations and or used more overtime unpaid. In the previous MRS analysis between unpaid and basic hours it occurred that most industries have started relying on unpaid overtime compared to the basic hours. Here it is also evident that because of this relative increase the productivity per hour appears less after the outburst of crisis. In other words, the picture that we get is that despite the relative drop in industries GVA and despite the absolute drop of total, basic and overtime hours (See Chapter 3 Descriptive Statistics), unpaid overtime is used more compared to basic hours after crisis' outburst demonstrating a smaller contribution to GVA. This is a similar analysis to the previous part where basic hours contribution was appearing much smaller than unpaid overtime’s due to its high quantity as an input in a production process. Now that the relatively ‘rare’ input (unpaid overtime) before crisis becomes more frequent after crisis appears that is productivity is eventually exhausted.

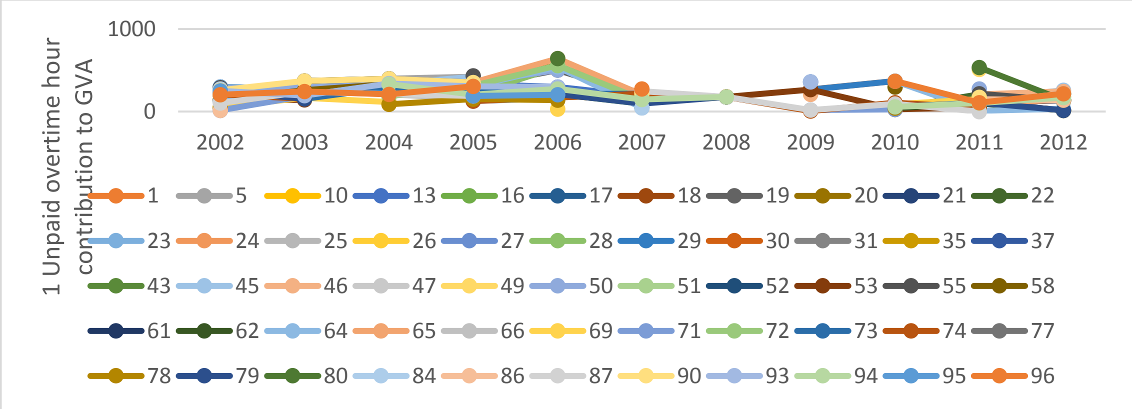


Figure 4.24 – 1 Unpaid Overtime Hour’s contributions towards £ of GVA over the years in one single group – Decomposed Labour Model (All industries)

Table 4.45 - 1 hour of Unpaid Overtime contribution towards £ of GVA –(Three Facet) Decomposed Labour Model (Productive industries)

	CONTRIBUTION	UNPAID_GVA					
DMU	Description	AVERAGE ind	Average all	Crisis Effects	AVERAGE PEERS ind	Average peers	Crisis Effects Peers
85	Education	42.890	76.420	83.130	61.990	55.630	61.990
53	Postal & Courier	61.990		42.890	42.890		42.890
16	Wood	62.780					
59	Motion video tv sou	78.990					
24	Basic Metals	106.340					
52	Warehousing and su	136.890	188.760	61.620		179.170	202.230
13	Textiles-Apparel-Le	139.100		185.380			126.280
27	Electrical equipment	141.110					
30	Transport equipmen	141.370			174.230		
22	Rubber&Plastic	156.760					
35	Electricity-Gas-Stea	157.840			157.840		
23	Non-metalic mineral	162.320					
74	Other prof, scientific	162.550			192.650		
19	Coke&Petroleum	163.810			163.810		
5	Mining	164.040			164.040		
1	Agriculture	168.710					
61	Telecommunication	171.960			171.960		
29	Motor vehicles&Tra	172.970					
50	Water transport	173.910			173.910		
18	Printing&Reproduct	175.420					
28	Machinery and equi	175.420					
26	Computer, electroni	175.820					
62	Computer programm	179.910			179.910		
72	R&D	186.480			108.440		
21	Pharmaceutical	188.540			188.540		
58	Publishing Activities	199.810			181.400		
17	Paper	201.480					
25	Metal Products	211.350					
49	Land transport & Pi	216.170					
43	Construction	216.870			216.870		
86	Human Health	217.580			217.580		
20	Chemicals	228.850			152.860		
10	Food-Beverages-To	231.370					
55	Accomodation & Fo	244.510					
31	Furniture - OtherMa	263.510					
51	Air transport	310.930					
36	Water collection, tre	773.030					

For access to data go to Appendix 22[54]

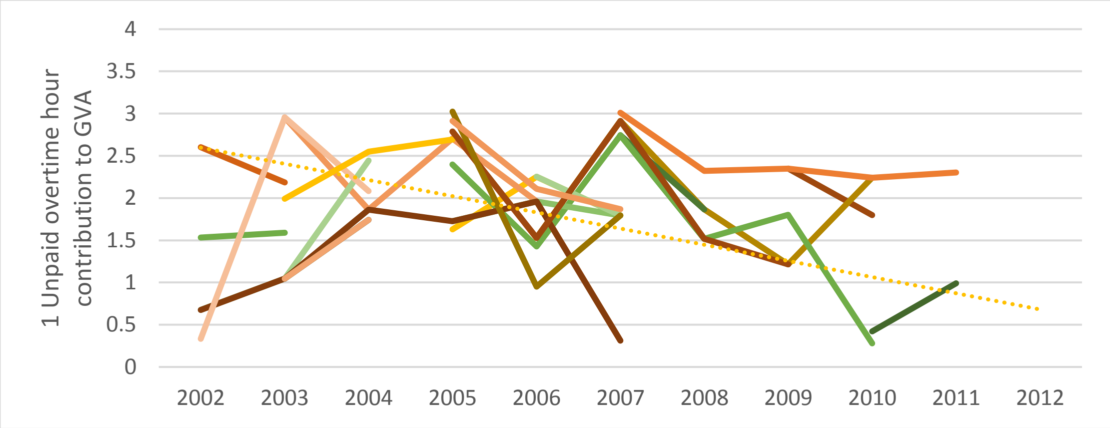


Figure 4.25 – 1 Unpaid Overtime Hour's contributions towards £ of GVA over the years in Medium group of Industries – Decomposed Labour Model (Productive industries)

Contrary to the all-industries analysis where all industries seem to fit within one group, since there was no much variation in GVA contributions, in the productive-only analysis, here there are 4 industries having slightly smaller contribution than in the previous analysis, while the rest that are also similar to the all industry analysis (£228) shows that the average contribution is lower (£188). There is also an evident tendency that most industries perform in a lower level. Therefore, comparing productive with unproductive industries only unpaid overtime is assigned with less GVA. In other words, the relative use of unpaid overtime seems to be higher in productive-only than when they are compared with the unproductive ones. Moreover, contrary to the unproductive only there is bigger stability and less variation on GVA accounted to unpaid overtime. Industries pattern in unpaid overtime contribution to GVA still has its ups and downs, but it is shown that the tendency is slightly lower after the outburst of 2007-8 crisis.

Generally, in a national level the conclusions of an all industry analysis were majorly confirmed by the productive-only one. However, keeping only the productive industries narrows down the range of weights leading to less dispersed results on contributions to GVA across industries. Additionally, there is also a drop of the contribution over the years, as more unpaid overtime is used (see Descriptives and MRSs) making unpaid overtime to be accounted with less GVA.

[54] The industries with bold letters are the peer industries defining the productive frontier.

Table 4.46- 1 hour of Unpaid Overtime contribution towards £ of GVA – Decomposed Labour Model (Unproductive industries)

	CONTRIBUTION	UNPAID_GVA					
DMU	Description	AVERAGE ind	Average all	Crisis Effects	AVERAGE PEERS ind	Average peers	Crisis Effects Peers
45	Wholesale&Retail&	310.846	276.595	286.568	310.846	279.669	310.703
46	Wholesale trade	146.908		263.631	146.908		250.799
47	Retail	103.023			103.023		
64	Financial Services	327.734			327.734		
65	Insurance and Pensi	369.310			369.310		
66	Auxiliary to fiancing	143.034			134.861		
69	Legal and Accountin	130.098			130.098		
71	Architectural and Er	147.590					
73	Advertising and Ma	296.716			336.507		
77	Rental&Leasing	505.167			533.063		
78	Employment Activiti	122.624			122.624		
79	Travel Agencies	247.205			256.967		
80	Security and Investi	184.747					
84	Public Admin and De	159.731			159.731		
90	Arts & Libraries &	489.485					
93	Sports	383.824					
94	Activities of Membe	234.332			200.801		
95	Repair of computers	361.580			361.580		
96	Other personal activ	338.299			362.757		

For access to data go to Appendix 23[55]

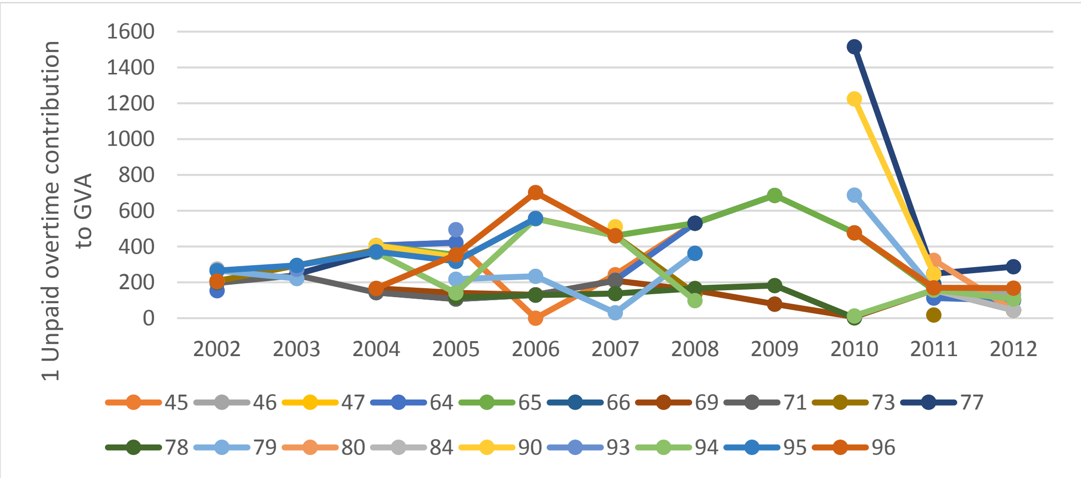


Figure 4.26 – 1 Unpaid Overtime Hour's contributions towards £ of GVA over the years in a single of Industries – Decomposed Labour Model (Unproductive industries)

Again, the Unproductive industries analysis contains even more restricted information for industries with less homogenous characteristics. Like in the all-industries

[55] The industries with bold letters are the peer industries defining the productive frontier.

analysis, in the unproductive industries only all industries seem to fit within one group, since there was no much variation in GVA contributions. Unproductive industries' contribution of unpaid overtime has an average of £276, which is higher not only compared to the all-industries' model but also to the productive ones, acting as another indication that it is the Unproductive industries' GVA is accounted a lot to unpaid overtime (with a range of £103-£505). Apart from some industries that have an extremely high peak (industry 77 and 90), there is no clear tendency of what happens over time. However, both all-industries and the peers-only show a reduction of unpaid overtime contribution after the crisis outburst.

Generally, contrary to the productive industries-only analysis that almost confirmed the patterns of the all-industries one, analysis unproductive industries –only has a lot of deviations and inconsistencies in results. The lack of some relevant homogeneity becomes even bigger problem leading to few full and three facet weights, that are too wide in range, and therefore the MRSs derived are both few and too wide. For this reason, based on the targets derived from the above DEA analysis, we use a regression analysis in an effort to detect some 'average' patterns of contributions to GVA for all industries, productive and unproductive too.

PART III: Clustering industries Before and After Crisis – Dropping Paid Overtime

In this section, we attempt to sort the previous time inconsistencies that appeared in the previous analysis. Therefore, we cluster all industries before and after crisis. In the following section 6 models are run overall: all industries before, all industries after crisis, productive only before, productive only after, unproductive only before and unproductive only after. In other words, this acts as a Pooled DEA analysis, increasing also the probability of being more comparable to the econometric models later on. Repeating the same process as above, we get again Full-Facet models that do not give much information, as the Full-Facet All industries After crisis model is comprised only by 9 observations. Generally, what has been observed earlier, it is the very inclusion of paid overtime that leads to the PIM-DEA not reaching any feasible solution. Despite the treatment that we followed earlier to sort the variables' different scale, it seems that paid overtime that consists almost the 0.25% of the total working hours causes more issues, leading to few industries having feasible solution. By taking paid overtime out of the analysis, Full-Facet

All industries After crisis model data information that we get is comprised by 411 observation, which is a more representative sample.

MRS all industries - Paid overtime is excluded

The results presented above are different from the full facet earlier. For example 19. Coke and petroleum had an average MRS 1 unpaid hour per 60-120 basic in the All-Facet. It is also different from the Three-Facet Decomposed Model. Additionally, 21. Pharmaceutical also displays differences from the PART II analysis. The difference that this model adds is that we achieve smaller variation among the years. However, there are still inconsistencies between the all industry analysis and the Productive only. For instance 1. Agriculture appears with a higher MRS before crisis, but in the Productive only with lower. All the analysis without Paid overtime is displayed in Appendix 24.

Additionally, another thing that is achieved with this clustering is that the general drop in this MRS after crisis is also evident, confirming that industries in total, rely more on unpaid overtime after the outburst of crisis. This pattern is also confirmed by both Productive and Unproductive analysis.

By taking paid overtime out of the analysis, the results, especially in the productive industries change a lot. More specifically, although before crisis more industries appear to have a low MRS between unpaid overtime and basic hours, after the crisis most industries tend to be have extremely high (1 unpaid overtime for 350 basic hours). This is the only part of the analysis that shows a different pattern both from the all industry and the unproductive only. It is also very different from what was demonstrated in PART II analysis. However, there is no clear pattern with unproductive industries. Regarding the Unproductive industries, they display higher consistency among the years and less variation among industries. Therefore, dropping paid overtime leads to higher consistency.

Unpaid Contribution to GVA

The All industry analysis also demonstrates an even higher contribution of unpaid overtime towards industries' GVA. While in PART II, with paid overtime included, the highest value was around £300, here it can go up to £2000, at least for before the crisis.

After crisis this returns to the levels of the PART II analysis. However, when we cluster the industries in productive and unproductive the results we derive are more similar to the PART II analysis. In the productive industries only, the previous analysis is also confirmed. More GVA is accounted for unpaid overtime after the economic crisis than before. Again, for more details go to Appendix 24.

The general conclusion for this analysis still show very similar results with both the ALL facet analysis with all variables included (even paid overtime). By grouping the data into BEFORE and AFTER, we achieve smaller range of values among the years. Additionally, unpaid overtime is still strongly linked to higher GVA. Unpaid overtime also seems to have higher contribution in industries' GVA after the outburst of crisis, as this pattern is also confirmed here.

However, what is more interesting is to compare the full facet analysis of PART II (Tables 4.34-4.38) with this full-facet analysis of PART III. There are only two industries that make this comparison feasible, and these are Industry 74. Other Scientific and professional activities that belongs to the productive ones, and industry 94. Activities of Membership Organisations.

Industries to compare: PART II VS PART III

Regarding Industry 74. Other Scientific and professional activities, the all industry analysis does not provide much detail, especially in comparing the results for before and after crisis, as in the clustered analysis (Before and After crisis)there is only information regarding before the outburst of crisis, and in the non-clustered after. Despite that the clustered ones still offer more consistency among the years, contrary to the non-clustered. Actually, this was the very reason that the clustered analysis takes place.

Table 4.47 - Comparing industry 74. With Clustered and Non-Clustered results – All Industry Analysis

ALL-INDUSTRY	Ind. 74	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CLUSTERED	Unpaid_Basic	4.933	4.933				4.694					
CLUSTERED	Basic_Gva	0.762	0.762		0.828	0.764	0.783	0.764				
CLUSTERED	Unpaid_Gva	3.759	3.759				3.673					
NON-CLUSTERED	Unpaid_Basic								0.559	181.946	22.661	
NON-CLUSTERED	Basic_Gva								9.164	0.584	2.018	
NON-CLUSTERED	Unpaid_Gva								5.120	106.176	45.732	

Table 4.48 - Comparing industry 74. With Clustered and Non-Clustered results – Productive Only Analysis

PRODUCTIVE	Ind. 74	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CLUSTERED	Unpaid_Basic	0.759	0.759		0.759	0.232	4.763	0.477		0.190	0.190	
CLUSTERED	Basic_Gva	1.130	1.130		1.130	1.356	0.581	1.214	1.187		1.067	
CLUSTERED	Unpaid_Gva									0.203	0.203	
NON-CLUSTERED	Unpaid_Basic	16.811		110.803								
NON-CLUSTERED	Basic_Gva	7.741		2.206								
NON-CLUSTERED	Unpaid_Gva	130.127		244.446								

Regarding the productive only analysis, only 2002 would offer comparable results, and still there is no agreement between those. As the peer industries now changed offering a different weighting we have very different results. What is observed tough is that by clustering in before and after crisis more sensible weighting is acquired between basic and unpaid overtime. More specifically, 1 unpaid overtime hour is compensated for 0.75 basic hours before crisis and for 0.19 after. This contrasts to the non-clustered analysis where 1 unpaid overtime is compensated with dozen(s) of basic working hours. This weighting of the two labour hours is also reflected in their contribution, towards GVA (See Table 4.43).

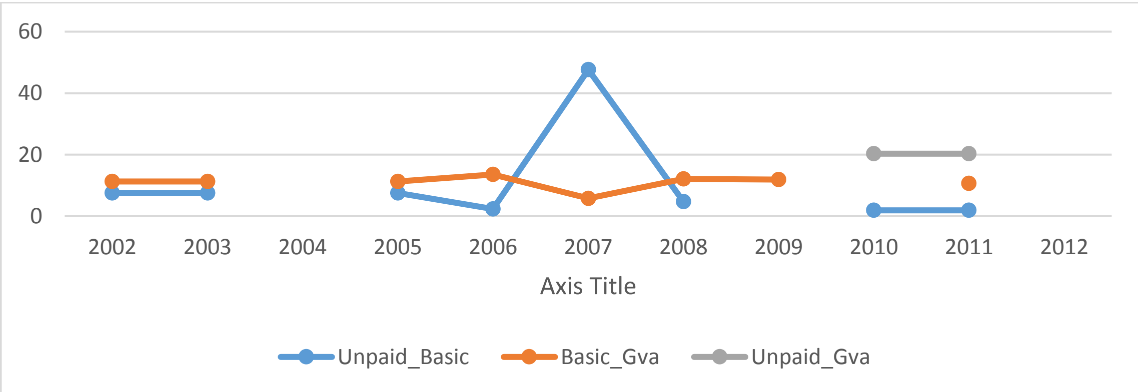


Figure 4.27 – industry 74. With Clustered results – Productive Only Analysis

Generally though, the DEA has been useful regarding the total labour analysis but when it comes to decomposed models an issue arises mainly concerning the scale of which the paid and unpaid overtime vary among industries and over the years. However the pattern of basic and unpaid overtime weight is still very similar to PART II analysis. Particularly, unpaid overtime is used more frequently after the outburst of crisis, compared to the basic working hours.

Table 4.49 - Comparing industry 94. With Clustered and Non-Clustered results – All Industry Analysis

ALL INDUSTRY	Ind. 94	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CLUSTERED	Unpaid_basic	6.576		4.694			4.694					1.779
CLUSTERED	Basic_gva	0.166		0.783	1.147		0.783	1.807				0.500
CLUSTERED	Unpaid_gva	1.090		3.673	0.553	2.400	3.673					
NON-CLUSTERED	Unpaid_basic			118.068				102.806		10.647		
NON-CLUSTERED	Basic_gva			2.820				1.721		5.226		
NON-CLUSTERED	Unpaid_gva			332.967				176.958		55.645		

Table 4.50 - Comparing industry 94. With Clustered and Non-Clustered results – Unproductive Only Analysis

UNPRODUCTIVE	Ind. 94	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CLUSTERED	Unpaid_basic			83.679			83.681					10.668
CLUSTERED	Basic_gva			4.859			4.859			8.506	8.506	5.688
CLUSTERED	Unpaid_gva			406.568			406.567					60.679
NON-CLUSTERED	Unpaid_basic			62.097				14.988			20.535	7.720
NON-CLUSTERED	Basic_gva			5.914				6.575			7.687	13.882
NON-CLUSTERED	Unpaid_gva			367.227				98.552			157.851	107.167

Regarding industry 94. Activities of Membership Organisations, the results in the clustered and non-clustered analysis are more comparable to each other. The patterns are also confirmed when dividing industries into Before and After crisis, as unpaid overtime seems to be used more frequently in this industry too, especially after the outburst of crisis.

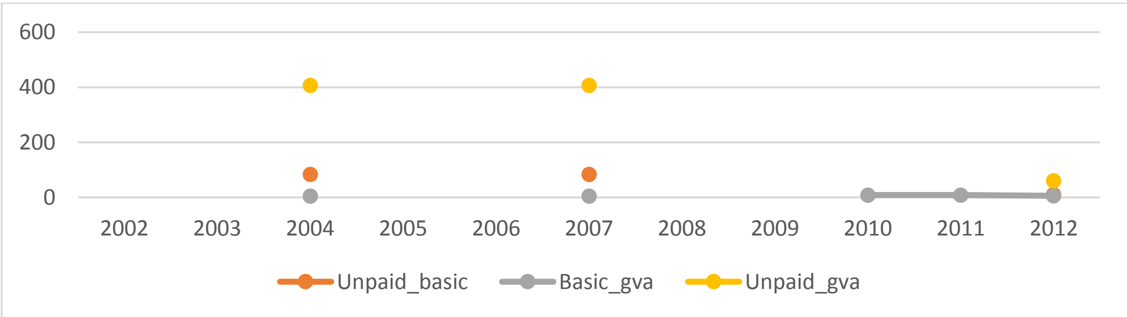


Figure 4.28 – industry 94. With Clustered results – Unproductive Only Analysis

PART IV: Regression Analysis of DEA derived target values: Empirical results

As it has been described, DEA provides results for an efficient frontier. The efficiency targets that DEA provides are based on radial measures of efficiency and derived from the input minimising DEA model. As we saw earlier at the efficient frontier the following equation holds

$$uGVA_{ti} = v_1 EL_{bi} + v_2 EL_{ui} + v_3 EL_{pi} + v_4 ENCS_{ti} \quad (4.35a)$$

Or

$$uGVA_{ti} = \frac{v_1}{u} EL_{bi} + \frac{v_2}{u} EL_{ui} + \frac{v_3}{u} EL_{pi} + \frac{v_4}{u} ENCS_{ti} \quad (4.35b)$$

The input levels preceded by E are efficient as estimated by DEA. We can attempt to estimate through regression analysis the average levels for the coefficient v/u in 4.35b to compare these with the below parametric approach. The model would be as follows:

$$GVA_{ti} = a + b_1 EL_{bi} + b_2 EL_{ui} + b_3 EL_{pi} + b_4 ENCS_{ti} + \varepsilon \quad (4.36)$$

where E indicates the efficient level of the respective input derived using DEA. With this analysis we can get a unique set of contributions to GVA by each input contrary to DEA that can have infinite solutions. We use both a linear form and then a translog to see if the combinations that are suggested should be non-linear. The results give the DEA contributions of each unit of each input at the parametric approximations to the efficient (DEA) frontier we are estimating through (4.36).

Table 4.51 – Regression Analysis of Target values over Real GVA - Pooled OLS – Cobb-Douglas

Pooled OLS	All industries	All ind - YEARS	Productive industries	Productive ind - YEARS	Unproductive industries	Unproductive ind - YEARS	Manufacturing industries	Manufacturing ind - YEARS	Services industries	Services ind - YEARS
Obs	**645**		**525**		**175**		**242**		**349**	
_cons	2.56***	2.215***	2.67***	2.235***	2.474***	2.19***	2.724***	2.2297***	2.6154***	2.235***
lncs_target	0.378***	0.371***	0.373***	0.364***	0.372***	0.362***	0.441***	0.366***	0.3659***	0.361***
lbasic_target	0.187***	0.172***	0.177***	0.114***	0.099*	0.081	0.419***	0.071	0.1234***	0.1243***
lpaid_target	-0.0375***	-0.0324***	- 0.022**	0.003	-0.001	0.006	- 0.2317***	0.002	-0.001	0.005
lunover_target	0.297***	0.331***	0.267	0.346***	0.407***	0.43***	0.153***	0.3935***	0.341***	0.355***
2003	-	0.098**	-	0.0713*	-	0.045		0.063	-	0.074
2004	-	0.16***	-	0.166***	-	0.107		0.196***	-	0.142***
2005	-	0.211***	-	0.228***	-	0.223***		0.184	-	0.2581***
2006	-	0.341***	-	0.363***	-	0.3115***		0.341***	-	0.358***
2007	-	0.34***	-	0.344***	-	0.264***		0.323***	-	0.332***
2008	-	0.504***	-	0.534***	-	0.299***		0.601***	-	0.434***
2009	-	0.554***	-	0.5696***	-	0.449***		0.557***	-	0.5398***
2010	-	0.6***	-	0.675***	-	0.4499***		0.747***	-	0.569***
2011	-	0.431***	-	0.501***	-	0.301***		0.567***	-	0.3856***
2012	-	0.496***	-	0.582***	-	0.402***		0.6484***	-	0.464***
adj.Rsquare	0.912	0.944	0.891	0.95	0.928	0.95	0.884	0.948	0.904	0.945
Diagnostic Tests										
VIF	9.400	4.160	8.060	3.800	5.180	2.930	8.960	4.820	6.810	3.380
hettest (p-value)	0.000	0.000	0.000	0.004	0.017	0.002	0.182	0.802	0.000	0.000
hettest, rhs(p-value)	0.000	0.000	0.000	0.000	0.000	0.001	0.301	0.000	0.000	0.000
estat imtest, white(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ovtest(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.002	0.002	0.000
	*p<.1	**p<.05	***p<.01							

1

Table 4.52– Regression Analysis of Target values over Real GVA - GLS for Panel – Cobb-Douglas

GLS - Heterosk & AR(1)	All industries	Productive industries	Unproductive industries	Manufacturing industries	Services industries
Obs	645	525	175	242	349
_cons	2.890***	3.016***	2.811***	2.932***	2.99***
lncs_target	0.335***	0.33***	0.36***	0.356***	0.344***
lbasic_target	0.189***	0.182***	0.2028***	0.279***	0.1883***
lpaid_target	-0.001	-0.0017	0.00114	- 0.087***	0.00034
lunover_target	0.178***	0.131***	0.1934***	0.096**	0.152***
*p<.1	*p<.05	*p<.01			

The above input and output variables have been transformed into their natural logarithm. In other words, the above coefficients are interpreted like the below example of the GLS analysis on Manufacturing industries only:

For NCS, 1% increase of the £10^9 it leads to 0.35577% £10^8 GVA, or 1% increase in £NCS leads to 0.035577% increase in GVA.

For basic hours, 1% increase of the 10^7 hours leads to 0.278845% £10^8 GVA, or 1% increase in basic hours leads to 2.78845% increase in GVA.

For paid overtime, 1% increase of the 10^5 hours leads to -0.087088% £10^8 GVA, or 1% increase in basic hours leads to a decrease by 87.1% increase in GVA.

For unpaid overtime, 1% increase of the 10^6 hours leads to 0.096455% £10^8 GVA, or 1% increase in basic hours leads to 9.6455% increase in GVA.

Regressing the targets provided by the DEA analysis confirm the previously shown results, where unpaid overtime (either when paid overtime is included or not) has higher effect on GVA than a basic hour, if the industries wish to be efficient. Again this does not imply that overtime is more efficient, but that high GVA is associated with unpaid overtime, causing an average 10% increase, contrary to ¼ of it caused by basic hours.

Most models experience multicollinearity. As it is explained in Chapter 5, there is multicollinearity mainly between basic hours and unpaid overtime. When we control for the different years, we get reduced multicollinearity (below 5). Heteroscedasticity is also present in most models for reasons that are also explained in Chapter 5. Allowing for heteroscedasticity we get narrower range of coefficients among the different models that are tested.

The models that are tested include all industries, Productive-only, Unproductive-

Only, Manufacturing-only and Services-only. Although we have previously presented the industries belonging in Productive and Unproductive industries, we have not shown which ones belong to the traditional categories of Manufacturing and Services. In the Manufacturing industries 5 to 43 are included (with sequential order), while in Services industries from 45 to 96 (See Chapter 3 for industries SIC code).

To begin with, following an Ordinary Least Squares (OLS) analysis, the Pooled model shows that NCS contributes from 0.036% to 0.044% towards GVA. The Manufacturing industries (only) model has the biggest coefficient for NCS, which makes sense if we take into account the nature of industries. Basic working hours contribute from 0.7% to 4.1%, with both extreme values in the Manufacturing industries; the former with years included and the latter without.

Unproductive industries experience the least multicollinearity levels, showing that basic working hour and paid overtime are not statistically important. Although this would make sense for the case of paid overtime, it does not for the case of basic hours. However, unreasonable results in Unproductive industries only would not be surprising because of the small number of observations (17 industries over 11 years).

Paid overtime has negative values in most of the models and/or is statistically insignificant. On the contrary, unpaid overtime is not only statistically significant in most models, but also appears having quite high contribution (15% to 43%). In all models the R-square values are very high (84% to 95%) showing that the variation of the variables used explain the variations in GVA in an exceptionally high degree.

Allowing for heteroscedasticity (Robust OLS) the results do not change much. Allowing for Panel-specific heteroscedasticity and autocorrelation (See Table 4.51) and Chapter 5 for more details), the range of variables' contribution is narrowed within the different models. For NCS, the coefficients are between 0.0325% and 0/036%, basic working hours between 1.7% to 2.7%, with manufacturing having the highest. Paid overtime is either negative or infinitesimal, and insignificant in every Generalised Least Square (GLS) model. Only in Manufacturing industries paid overtime seems statistically significant but negative, implying that 1% increase in paid overtime reduces GVA by 87%. This means that when industries use paid overtime an additional hour reduces the marginal product. Therefore, we can say that in Manufacturing paid overtime is linked with diminishing returns.

The above tendency is not happening with unpaid overtime though. In the GLS models too, it is not only statistically significant, but also seeming to contribute between 9% to 19% towards GVA, with Manufacturing industries only having the lowest. In other words, an increase of few hours (unpaid overtime is less than basic) leads to the almost the same increase in GVA s an increased caused by more hours (basic). This results of the above statistical analysis is similar to the conclusion of DEA analysis, leading in the below interpretation: ‘at efficient levels an industry extracts more GVA from unpaid overtime than from basic hours’, or ‘high GVA increase is linked with high unpaid overtime levels’. This is also linked with the speculations that we made earlier in the DEA weights, indicating that basic hours are ‘exhausting’ their efficiency, exactly because they are a lot and the tend not to vary as much as unpaid overtime hours, which are even more strongly linked with increased production levels.

Although we correct for multicollinearity and allow for heteroscedasticity and panel specific autocorrelation, the regression diagnostics still show the existence of omitted variables. Therefore, we also proceed in the below translog analysis to see if a non-linear combination of our variables describes the output variations better.

Table 4.53 - Regression Analysis of Target values over Real GVA - Pooled OLS – Translog

Pooled OLS	All industries	All ind - YEARS	Productive industries	Productive ind - YEARS	Unproductive industries	Unproductive ind - YEARS	Manufacturing industries	Manufacturing ind - YEARS	Services industries	Services ind - YEARS
Obs	612		525		175		241		349	
_cons	2.331***	1.886***	2.32***	1.838***	2.024***	1.759***	2.4233***	1.855***	2.2483***	1.947***
lncs_target	0.7997***	0.7534***	0.816***	0.779***	0.86***	0.8208***	0.650***	0.725***	0.858***	0.804***
lbasic_target	0.582***	0.414***	0.568***	0.388***	0.645***	0.535***	0.618***	0.361***	0.573***	0.442***
lpaid_target	- 0.135***	- 0.046*	- 0.132***	-0.037	- 0.122**	-0.076	-0.093	-0.083	- 0.076*	-0.030
lunover_target	- 0.241***	-0.0346416	- 0.248***	-0.029	-0.150	-0.033	- 0.225**	0.078	-0.286***	- 0.14**
ncs_target_2	- 0.119***	- 0.134***	- 0.108***	- 0.147***	- 0.149***	- 0.135***	- 0.135**	- 0.179***	- 0.141***	- 0.136***
unover_target_2	0.084***	0.055***	0.097***	0.0635***	0.027	0.026	0.085	0.022	0.089***	0.083***
paidover_target_2	0.0133***	0.003**	0.015***	0.003	0.0099***	0.004	- 0.092**	-0.007	0.009***	0.002
ncsbasic_target	- 0.214***	- 0.224***	- 0.159**	- 0.18***	- 0.297***	- 0.314***	- 0.23*	- 0.264***	- 0.222***	- 0.227***
ncsunover_target	0.234***	0.195***	0.192***	0.155***	0.29***	0.246***	0.258*	0.251**	0.243***	0.1808***
ncspaid_target	- 0.0456**	0.029*	- 0.081***	0.024	0.003	0.051*	0.107	0.109**	- 0.05**	0.021
2003		0.056*		0.061*		0.022		0.065		0.048
2004		0.1599***		0.167***		0.1174**		0.211***		0.132***
2005		0.226***		0.226***		0.214***		0.215***		0.238***
2006		0.352***		0.365***		0.291***		0.373***		0.336***
2007		0.316***		0.334***		0.241***		0.354***		0.294***
2008		0.473***		0.519***		0.2596***		0.631***		0.382***
2009		0.519***		0.549***		0.400***		0.574***		0.489***
2010		0.602***		0.639***		0.4230***		0.76***		0.505***
2011		0.462***		0.508***		0.311***		0.614***		0.377***
2012		0.518***		0.561***		0.364***		0.695***		0.429***
adj.Rsquare	0.9318	0.9658	0.9248	0.9643	0.9573	0.9747	0.8937	0.9577	0.9379	0.9658
Diagnostic Tests										
VIF	114.270	60.370	106.730	56.860	143.580	76.000	163.870	90.150	113.270	59.940
hettest	0.000	0.000	0.000	0.000	0.415	0.885	0.003	0.012	0.018	0.000
hettest, rhs	0.000	0.000	0.000	0.000	0.003	0.152	0.087	0.000	0.000	0.000
estat imtest, white	0.000	0.000	0.000	0.000	0.000	0.201	0.000	0.001	0.000	0.000
ovtest(p	0.052	0.000	0.172	0.000	0.001	0.000	0.317	0.133	0.006	0.001

*p<.1 *p<.05 *p<.01

Table 4.54 –Regression Analysis of Target values over Real GVA - GLS for Panel– Translog

GLS - Heterosk & AR(1)	All industries	Productive industries	Unproductive industries	Manufacturing industries	Services industries
Obs	**612**	**525**	**175**	**241**	**349**
_cons	2.727***	2.73***	1.87***	2.913***	2.500***
lncs_target	0.652***	0.676***	0.916***	0.416***	0.852***
lbasic_target	0.499***	0.488***	0.604***	0.508***	0.454***
lpaid_target	-0.030489	- 0.051**	-0.0127958	-0.0072015	-0.008
lunover_target	- 0.327***	- 0.337***	-0.1129677	- 0.348***	- 0.269***
ncs_target_2	- 0.098***	- 0.087***	- 0.15***	-0.0748182	- 0.157***
unover_target_2	0.09***	0.109***	0.0094108	0.0803992	0.088***
paidover_target_2	0.005***	0.007***	0.0017623	- 0.057**	0.003*
ncsbasic_target	- 0.29***	- 0.253***	- 0.353***	- 0.315***	- 0.239***
ncsunover_target	0.34***	0.293***	0.32***	0.406***	0.252***
ncspaid_target	- 0.043***	- 0.055***	-0.0092824	0.0644509	- 0.038**
	*p<.1	*p<.05	*p<.01		

The Translog analysis suggests that in the All-industries, the Productive and the Manufacturing analysis there are not omitted variables for the efficient industries. Although we use exactly the same variables like the previous Cobb-Douglas model, it is their non-linear combination that describe better GVA'S variations. In the models mentioned above unpaid overtime variables are statistically significant. In some models it is suggested that its contribution has convex effects towards GVA contribution (Illustration 4,1 and 4.2).

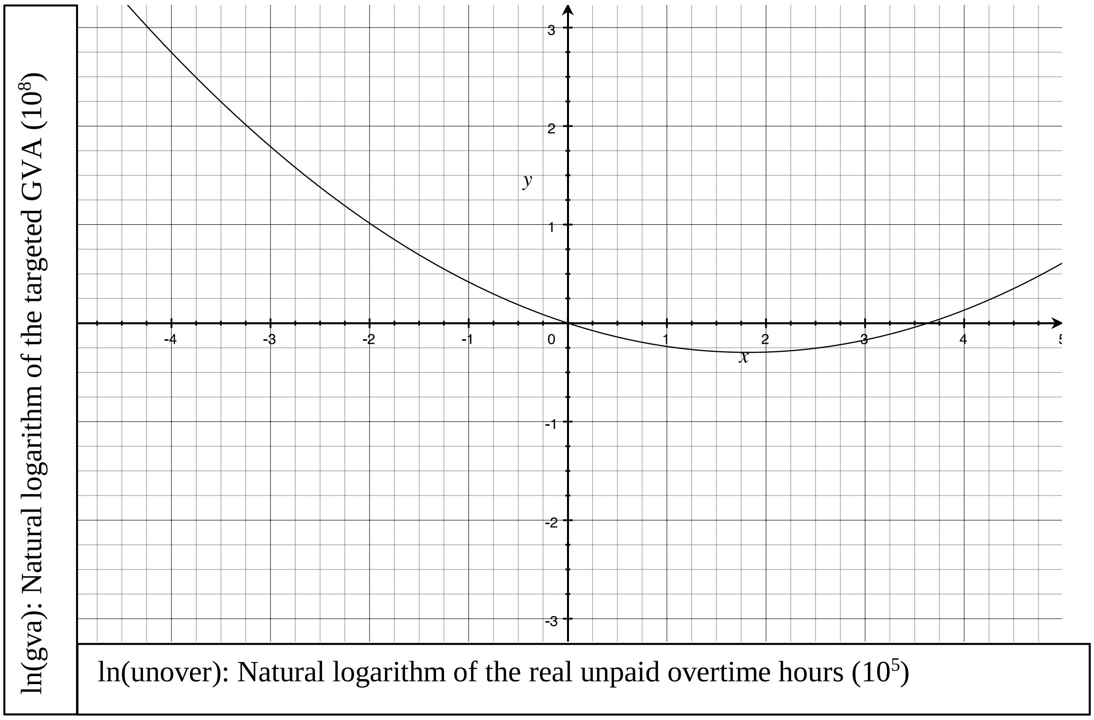


Figure 4.29 – Visualisation of unpaid overtime contribution without the interaction term with NCS

The figure above shows the partial derivative of GVA with respect to unpaid overtime without the interaction term with NCS. It shows that an industry needs to have a unpaid overtime' natural logarithm above 3.5 (or in actual number 33.11 or 33,110,000 hours) in order to have convex effects on GVA contribution. In fact, the average natural logarithm for unpaid overtime is 3.05 (21.11 or 21,110,000 hours) (See Chapter 3 Descriptive Statistics, the mean and the median almost coincide), with minimum -2.25 (0.105 or 105,000 hours) and maximum 6.27 (528.5 or 528,500,000 hours) . In other words, for industries to be efficient if they occupy less than lunover=3.5, unpaid overtime seems to have negative effect (diminishing returns), but if they use more than 3.5 it has positive and more specifically convex. The Figure 4.30 show a similar pattern, if the interaction term of unpaid overtime with NCS is taken into account.

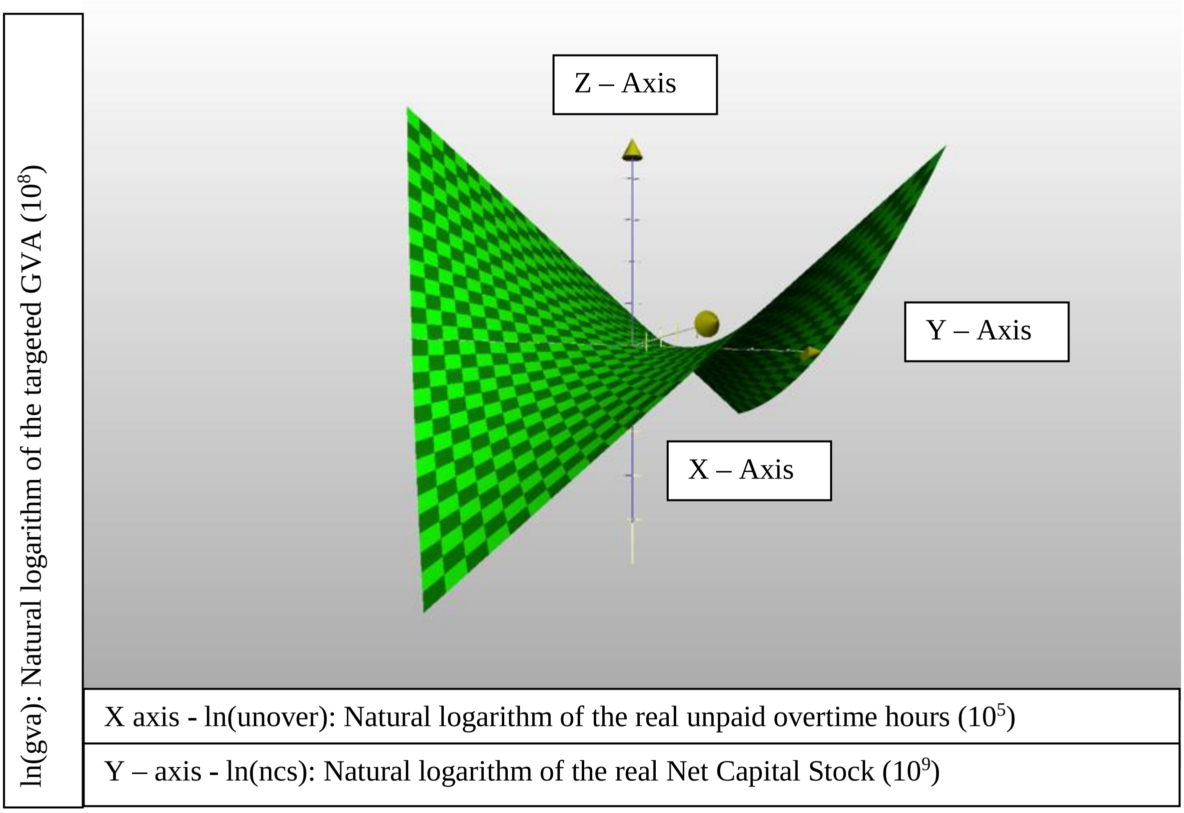


Figure 4.30 – Visualisation of unpaid overtime contribution with the interaction term with NCS

However, the coefficients of the translog production function are not necessarily trustworthy, because of the extremely high multicollinearity. Additionally, the only model that does not suffer from any kind of heteroscedasticity is the Unproductive industries one. But it is the least trusted one, especially in its Translog version, where 17 industries are analysed by 10 variables. In other words, the extremely low degrees of freedom allow little space for interpreting anything in this model.

Generally, R-squares increase further (89% - 97%), showing that this model specification is even closer to describe GVA's variation. Heteroscedasticity is still present. Again, allowing for panel-specific heteroscedasticity and autocorrelation we get slightly different results, especially for the Manufacturing industries only, where the above demonstrated convex effect of labour disappears showing a negative marginal contribution to GVA. In other words, the translog specification in Manufacturing displays diminishing returns, like paid overtime. In other words, the more additional overtime we add the higher the increase in the marginal product.

However, the translog specification causes/increases the multicollinearity issues due to the way it is constructed. Thus, although we can trust the model's statistics we cannot fully trust the variables coefficients. Therefore, the main conclusion form the translog analysis is that for the All-industries and Manufacturing model there are no omitted variables. It is only their non-linear combination that was missing from the Cobb-Douglas model.

Consequently, regressing the target value of the decomposed labour model as derived from the DEA, we find the average contributions across the industries by removing the inefficiencies from all industries. In most models we have heteroscedasticity and multicollinearity. Allowing for heteroscedasticity we still get similar results for variables' coefficients, and in models where multicollinearity is reduced coefficients are still similar. They show that in most models unpaid overtime is related to production, not just positively, but also with high elasticity, with an indication of convex effects, while paid overtime in almost every case is related with diminishing returns. This outcome contradicts theories that claim that unpaid overtime is not related to production, instead they suggest that unpaid overtime is used for non-productive purposes like signalling or gift exchange between employees and employers. It is evident that unpaid overtime is particularly linked with increasing production, more than basic hours do. Combining the results with the previously presented total-labour analysis that shows that working time is remunerated with much less than it contributes, we could conclude that unpaid overtime acts either as a way to expand GVA or as a way to reduce the 'normally' paid hours of working day when the production is not necessarily expanded. Therefore to expand national income by reducing labour share. This is a mainstream way to express what the Marxist analysis describes as a means of extracting absolute surplus value. And these conclusions are based on data expressing the efficient levels of production, or how the industries would perform if they were all equally efficient.

Chapter 5: Statistical Analysis of Unpaid overtime in UK industries

Table 5.1 - Regression Analysis – Chapter Outline

CHAPTER 5	Statistical Analysis	MODEL SPECIFICATION
Descriptives & Outliers	*Descriptive Statistics and Outlier Analysis*	
Regression Methods	*Regression Analysis: Pooled OLS, Robust Pooled, Panel and GLS in panel*	*Pooled OLS and Pooled with Year Dummy* *Generalised Least Squares (GLS) Analysis of Panel Data Set*
Regression Results of real values	*Regression Analysis of real values: Empirical results*	*Heteroscedasticity and Multicollinearity of labour variables* *Empirically valid decomposition of labour between paid and unpaid hours* *Time Effects, Crisis' effects and low technological change* *Productive-Unproductive OR Manufacturing-Services industries differences regarding unpaid labour*

The regression analysis in Chapter 4 has shown how the target inputs would contribute to industries' real GVA, or how would the average contribution of each input look like if all industries were efficient. In this Chapter the regression analysis is showing how the real input values contribute towards GVA with their inefficiencies, comparing how 'real' world looks like and also to compare with the 'ideal' situation proposed by DEA.

As it was presented above we use two model specifications, one with Cobb-Douglas and the other we translog as in Chapter 4. The reasons behind that is that Cobb-Douglas on its own would not provide full information. In fact it has some theoretical and practical deficiencies. Moreover, the DEA results from the earlier regression analysis suggest that probably there is no a mere linear relationship among the variables. Therefore, both Cobb-Douglas and translog production function are specified describing both the whole economy or for different industry groups. Consequently, in this chapter, the following steps are followed: i) general translog model to test for model specification and then ii) a Cobb-Douglas for an attempt of minimising multicollinearity to test the significance of coefficients.

5.1 Descriptive Statistics and Outlier Analysis

Using Data Envelopment Analysis output is useful for the current Statistical analysis too. There are two basic ways where it can be used. Firstly, from the very beginning DEA has already provided an outlier analysis to identify supper efficient industries. These outliers also coincide with those that simple descriptive statistics do. Therefore there is an agreement regarding the industries that need to be dropped from the regression analysis. Taking on board the DEA outlier analysis together with some basic descriptive statistics, some outlier industries are completely dropped. These industries coincide in both ways of detecting outliers. More specifically, industry 2. Aquaculture and Fishing, 3. Forestry, 47. Retail Trade, 68. Real Estate and 85. Education are the outliers that either 'produce' too high/low GVA or use too much/too low input variables. Using the Stata 13 version for our statistical analysis we get the below outliers.

Interestingly, 68. Real Estate is the 'ultimate' outlier with extreme values both in GVA and in its capital inputs. As it has been already described in DEA, Real Estate contains rental and purchase activities that do not represent some kind of new values' production. It is mainly the demand side that leads to such high market price, leading to a miscalculation of the real value of housing and buildings. Additionally, the concept of capital in Real Estate is indeed problematic. Considering as capital a money-making object that occupies zero labour is not only a theoretical failure but also a distortion of reality. It contravenes the axioms of DEA to get output from zero inputs.

Table 5.2 – Outlier industries over the years

Gross Value Added (GVA)	**Gross Capital Stock (GCS)**	**Gross Fixed Capital Formation (GFCF)**	**Net Capital Stock (NCS)**	**Capital Consumption (Capcons)**	**Total Working Hours (ttuthrs)**	**Basic Working Hours (bushrs)**	**Overtime Hours (over)**	**Unpaid Overtime (unover)**
2(2012)	3(2002)	50(2009)	2(2006)	3(2002)	3(2004)	3(2004)	2(2011)	3(2011)
2(2011)	3(2005)	3(2003)	2(2002)	3(2005)	3(2005)	3(2009)	2(2007)	3(2005)
2(2002)	3(2009)	3(2009)	2(2003)	3(2008)	3(2009)	3(2005)	2(2004)	2(2011)
2(2003)	3(2008)	50(2006)	2(2005)	3(2009)	3(2003)	3(2012)	3(2004)	2(2004)
2(2004)	3(2010)	3(2006)	2(2004)	3(2010)	3(2011)	3(2011)	2(2012)	50(2010)
68(2009)	68(2008)	68(2003)	68(2008)	68(2008)	47(2003)	47(2005)	85(2004)	85(2004)
68(2008)	68(2009)	68(2004)	68(2009)	68(2009)	47(2005)	47(2006)	85(2005)	85(2007)
68(2010)	68(2010)	68(2005)	68(2010)	68(2010)	47(2004)	47(2007)	85(2003)	85(2003)
68(2011)	68(2011)	68(2006)	68(2011)	68(2011)	47(2007)	47(2004)	85(2007)	85(2007)
68(2012)	68(2012)	68(2007)	68(2012)	68(2012)	47(2008)	47(2008)	85(2002)	85(2002)

The peculiarities of industry 2. Fishing and Aquaculture and 85. Education have already been described above. Industry 3. Forestry was not analysed at all in the DEA part because of some missing values in 2008. In this part it seems that there are extreme values regarding labour for some years too. 3. Forestry does not appear either in ONS statistics regarding labour (Table 3.2) Therefore, it is dropped. Regarding industry 47. Retail trade, although it has not been enveloped once in the decomposed labour model, there was no evidence of an outlier behavour. Generally, STATA tends to drop industries that are very big or small in size, without necessarily having any other issues. In Table 3.2 it is evident that 85. Education and 47. Retail Trade are the UK industries with the biggest labour participation compared to any other 8.46% (9.38% ONS) and 15.39% (15.60% ONS) of the total labour force participating respectively. Education is also having extreme records of unpaid overtime too. This leads to some drawback in our regression analysis. Therefore, the outliers that are dropped based on Statistical analysis are industries 2,3,47,68,85. By dropping them we miss out information from the most important is that the most populous industries in UK economy. However, the previous results in DEA (both DEA weights and DEA targets) should give an indication of what is happening in these industries.

Table 5.3 - Descriptive statistics after dropping outliers 2, 3, 47, 68, 85

Variables	Description	Obs	Mean	Std. Dev.	Min	Max
industry07~r	Standard Industrial Classification Code (SIC2007)	616			1	96
YEAR	Year (2002-2012)	616			2002	2012
TTUSHRT_adj	Total Usual Working Hours – Including Overtime	616	719000000	810000000	17900000	3550000000
BUSHRT_adj	Basic Usual Working Hours – Excluding Overtime	616	667000000	757000000	15600000	3320000000
overT_adj	Overtime Hours	616	52200000	55600000	957600	264000000
unoverT_adj	Unpaid Overtime	616	38400000	42200000	352800	172000000
paidover_all	Paidover1+Paidover2 +Paidover3+Paidover4	616	13800000	17000000	0	125000000
GFCF	Gross Fixed Capital Formation	616	2780000000	3370000000	-599000000	24800000000
GVA	Gross Value Added	616	17700000000	18200000000	1330000000	91500000000
GCSb	Gross Capital Stock	616	64200000000	94200000000	1840000000	5.91E+11
NCSb	Net Capital Stock	616	38300000000	57400000000	1090000000	3.61E+11
CAPCONS	Capital Consumption	616	25900000000	37800000000	663000000	2.3E+11
gfcf	GFCF/1000000	616	2780.153	3370.537	-599	24800
gva	GVA/1000000	616	17654.92	18248.81	1330	91500
gcs	GCS/1000000	616	64185.05	94248.53	1840	591000
ncs	NCS/1000000	616	38342.01	57437.61	1090	361000
capcons	CAPCONS/1000000	616	25853.07	37845.25	663	230000
ttuthrs	TTUTHRS/1000000	616	719.3214	810.1154	17.9	3550
bushrs	BUSHRS/1000000	616	667.0865	756.5696	15.6	3320
over	OVER/1000000	616	52.17298	55.57484	0.9576	264
unover	UNOVER/1000000	616	38.41656	42.19112	0.3528	172
lgfcf	Natural logarithm of gfcf	614	7.373985	1.11075	4.369448	10.1186
lgva	Natural logarithm of gva	616	9.368747	0.8960621	7.192934	11.42409
lgcs	Natural logarithm of gcs	616	10.34854	1.223451	7.517521	13.28957
lncs	Natural logarithm of ncs	616	9.809811	1.237042	6.993933	12.79663
lcapcons	Natural logarithm of capcons	616	9.430334	1.238726	6.496775	12.34583
lTTUSHRT	Natural logarithm of ttuthrs	616	6.021031	1.093323	2.884801	8.174703
lBUSHRT	Natural logarithm of bushrs	616	5.94218	1.094866	2.747271	8.10772
loverT	Natural logarithm of over	616	3.409812	1.109333	-0.0433251	5.575949
lunoverT	Natural logarithm of unover	616	3.060414	1.158014	-1.041854	5.147494

After dropping the previously mentioned outliers, there are obviously some changes even on the location and dispersion statistics too. For instance, the ratio of unpaid overtime hours to the total ones is 5.34%. Before dropping outliers (see Chapter 3) the ratio was 5.77%. Therefore, there is a reduction after dropping industry 85. Education with the highest unpaid overtime, but this is not enough to eliminate the phenomenon or reduce it merely to one industry.

Additionally, the average of industries' Gross Value Added reveals the crisis that UK economy subjected after 2008. This dissertation is based on the Chain Volume Measures (CVM) data that are provided by UK's statistical authority. Based on this UK economy appears recovering after 2009. Therefore in the following regressions *crisis* is imported as a dummy variable and it has been assigned for the year 2009 in order to detect any possible effect on the outcome.

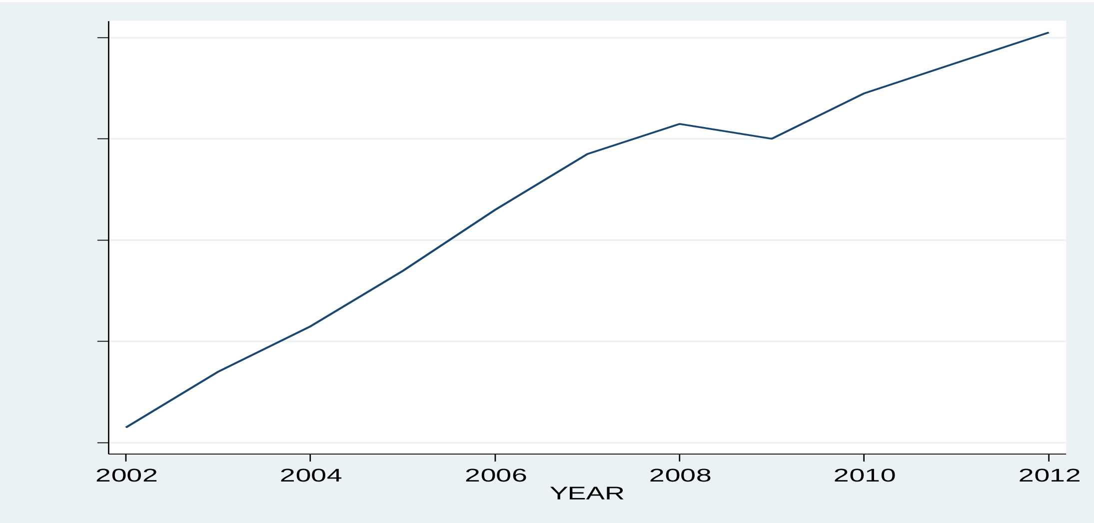
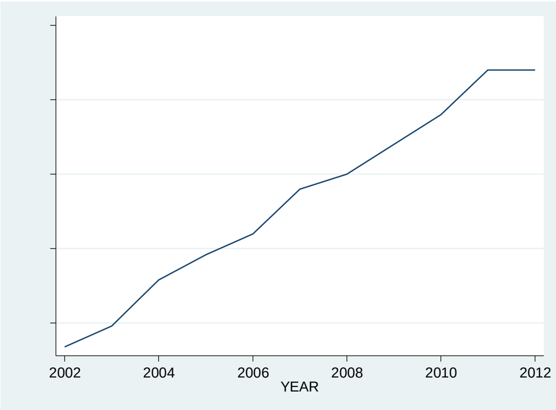
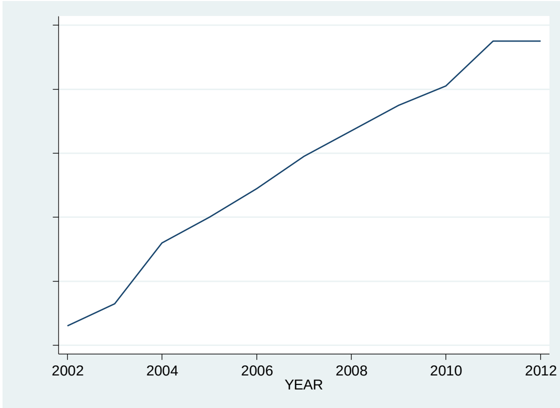


Figure 5.1 – Gross Value Added (GVA) in £ with Chain Volume Measures (CVM) over the years– All Industries' average

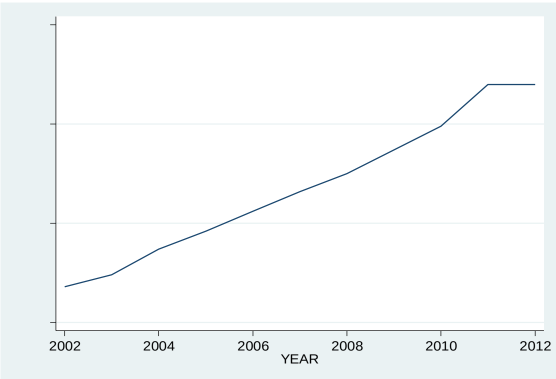
Apart from that, capital measures also reveal a series of interesting events. To begin with, there is a difference in 'reaction' time for capital regarding crisis in 2009. GCS, NCS and Capital Consumption even after 2009 continue growing, and only on 2011 their upward path is interrupted by a stagnation that is not recovering even by the end of 2012. This implies that both stock measures (GCS and NCS) and one flow measure of capital (Capital Consumption) are obviously less responsive. This is not surprising for stock measures of capital, but it does raise questions for the capital consumption as a flow measure. However, if the way of calculating capital consumption/depreciation of capital taken into consideration, it would not be surprising either. More specifically, capital consumption (capcons) is estimated to be a geometrically changing proportion of gross capital, and therefore does not appear to have varying behavior. For more details regarding the choice of capital variable go to Chapter 3.



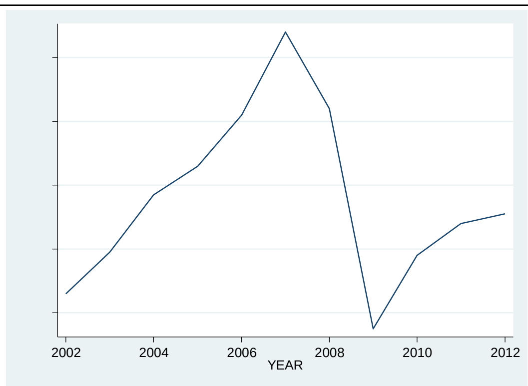
(a) Gross Capital Stock (GCS) in £



(b) **Net Capital Stock (NCS) in £**



(a) **Capital Consumption (CAPCONS) in £**



(b) **Gross Fixed Capital Formation (GFCF) in £**

Figure 5.2 - Capital Measures in £ Chain Volume Measures (CVM) over the years – All Industries' average

The only capital measure that betrays the outburst of economic crisis in 2007 and the free 'air dive' until 2009 is Gross Fixed Capital Formation (GFCF). GFCF is a flow measure showing the new 'value' of capital created or even destroyed, since it can also take negative values. It is actually the amount of investment in a national level and by industry. That is the reason of its volatility. Moreover, looking only at GFCF one could conclude that UK economy has not actually recovered from this crisis and in fact it implies that this crisis is an ongoing one, at least until 2012. A hypothesis here could be that the crisis changed the input mix of the UK economy to a more labour-intensive one – thus the persistent drop in GFCF. In Chapter 4 from the labour-capital MRS analysis we could observe a tendency of their MRS increasing, where we speculated that there is either increased capitalization or a big drop in labour; the latter is more possible from the Descriptive Statistics. However, observing GFCF tendencies (and not only NCS) we see that both labour and capital are dropping with labour experiencing probably the biggest change. In other words, GVA and GDP are not the only measures to critically assess whether an economy is in crisis or not. It does need a combination of economic indicators to evaluate this fact.

Regarding the labour measures, there are numerous interesting observation that one can make. The very first is that total hours are as volatile as GFCF, which is expected. Labour, as the variable part of capital (in Marxist terms) or as the variable part of total costs (in mainstream analysis). These two measures betray the real status of UK economy regarding the ongoing crisis.

Another interesting finding is that total hours reached their peak in 2008 and after that reached their bottom in 2010, confirming aspects of Marxist approach, that a growing economy does not lead to a reduction of working day. On the contrary, it is the capitalistic growth per se that extends the length of working day. In other words, an achieved high output (and therefore profits) does not seem to compensate a highly squeezed labour force through their working day's extension. Therefore, mainstream economics and mainstream economic policy that commands employees to work more in order to make economy achieving a higher output so that to be distributed back to employees, who (after this time investment) work less in the future seems to have no meaning. Increasing the length of working day today does not seem to reduce the working day tomorrow, unless there is crisis/recession and shrinking of production in total. But even in this case, together with the previous DEA findings, it seems that even a reduced 'normal' day is still accompanied by increased unpaid overtime, less in absolute terms, but more in relative terms and comparison to the basic hours or overtime in total.

Regarding the neoclassical argument claiming that it is *income effects*: the more you work, the more you get, and then the more you want to work, would be invalid in this case. Although *income* and *substitution effects* are an individual preferences concept that cannot be detected in aggregate data, taking into account that when approaching the peak of economy (before 2007) employees 'invested' so much unpaid overtime (See Chapter 2, Literature Review) showing that income effects were more dominant for them. However, after the outburst of the 2007-8 crisis the expected returns for this working-time investment did not seem to take place. Businesses eventually reduced their production and the subsequent real wage reduction cannot be the outcome of such an 'investment'. In fact, crises are revealing in how 'in vain' this investment went. Therefore, the pursuit for a higher individual salary might be the excuse, but not the reason for working days' patterns, even based on the available theoretical evidence from the UK. Even in Keynesian terms, where an extremely short working week was 'predicted', reality came to collapse this dream. Even in heterodox analysis, Weberians who claimed that the more productive labour becomes, the shortest the working day will be still is collapsed. It seems that it is the profit maximisation pursuit and the general capital accumulation laws, according to Marxist analysis could be more suitable in explaining the observed working day patterns. One indicator of capital accumulation is related to production level. Although, other pieces of literature can support this hypothesis, this dissertation focuses only in the working time as part of capitalist production, and not as part of capital accumulation.

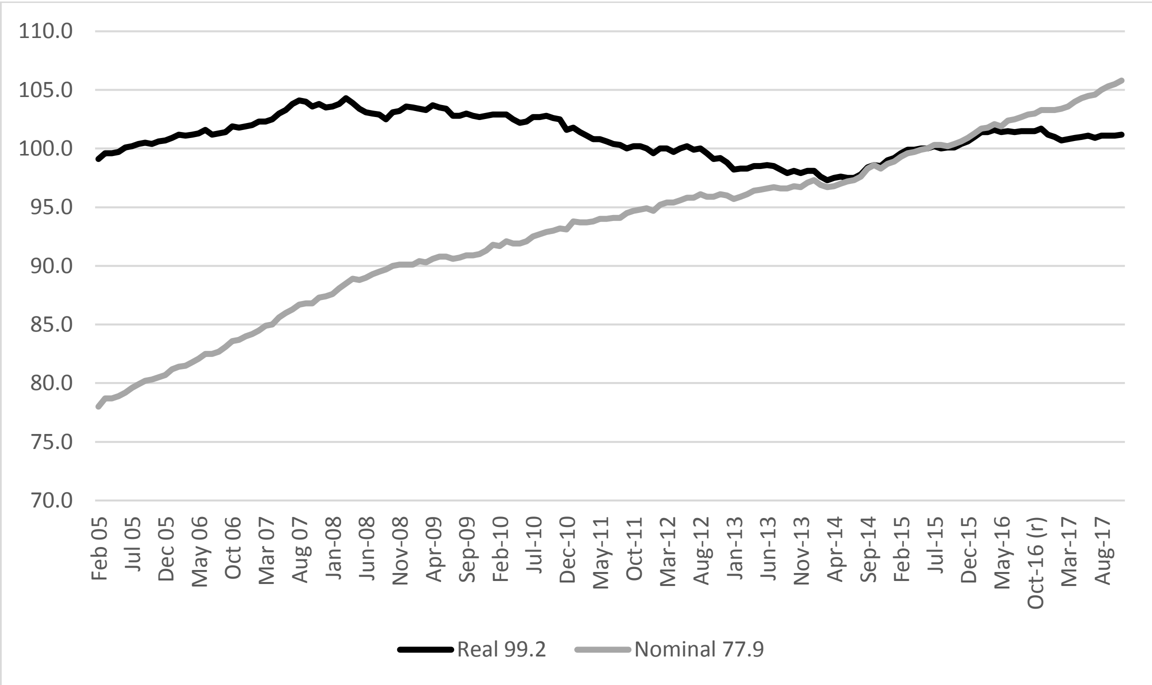
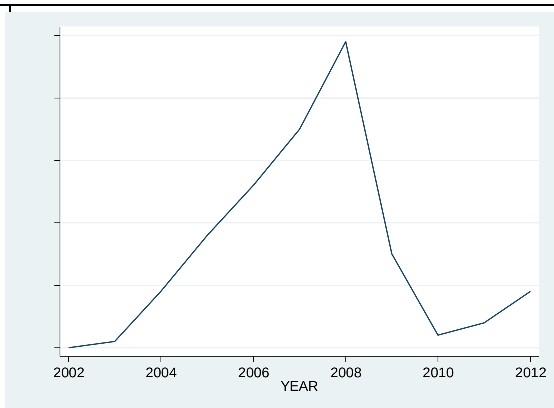


Figure 5.3 - Monthly Wages and Salaries Survey, Office for National Statistics
Source: ONS, Analysis of real earnings: January 2018, Analyses of the average weekly earnings (AWE) figures, adjusted for inflation, which are published in the UK labour market statistical bulletin. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/articles/supplementaryanalysisofaverageweeklyearnings/latest

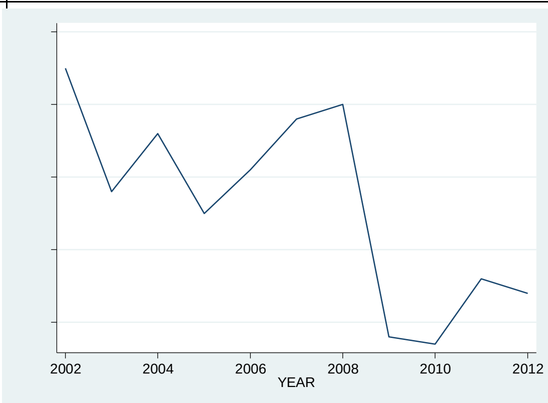
The previously detected and analysed working day patterns go along with the reduction of working hours within the crisis and recession that is according to a Marxist analysis. Contrary to pre-crisis claims that capitalism passes into a new stage where there will be only absolute surplus value extraction (working day extension) (See Mavroudeas and Ioannides, 2003) reality also rejected them showing that crises are completely necessary for capitalism to reproduce and that the relative surplus value extraction (reduction of working day) is as important as the absolute. However, as presented before the absolute reduction in working hours is accompanied by a relative increase in unpaid overtime that so far acted as an indicator of absolute surplus value extraction but now we can claim that acts as a relative one too, since it does not seem to extend the working day in aggregate terms, but reducing the basic working hours.

(a) Total Working Hours (TTUTSHR)



(b) Basic Working Hours (BUSHRS)

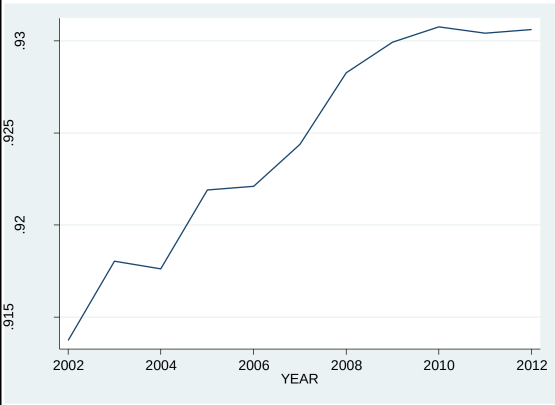
(c) Overtime Hours (OVERTM)



(d) Unpaid Overtime Hours (UNOVER)

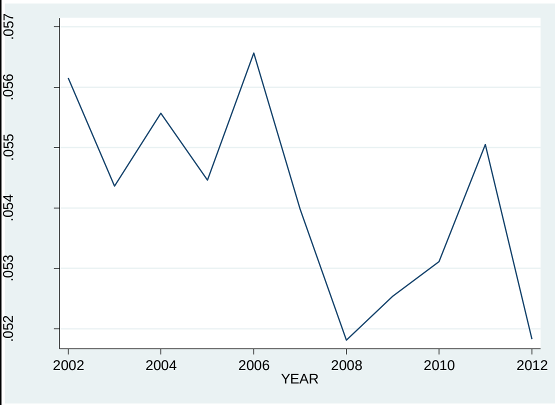
Figure 5.4 - Labour Measures in hours over the years: Average total working hours of all Industries

Another interesting finding is that after the outburst of the economic crisis up to at least until 2012 the total working hours did not even manage to reach not only the 2008, but also the 2003 levels. This can be interpreted either as a productivity increase by substituting labour with capital, which is not justified by our findings so far, or as an evidence of continuous underemployment due to the lack of economic recovery.

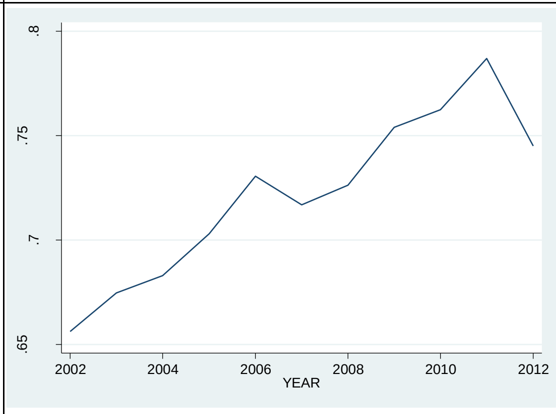


(a) Basic-Total

(b) Overtime –Total



(a) Unpaid Overtime - Total



(b) Unpaid Overtime –Overtime

Figure 5.5 - Labour Ratios over the years – All Industries' average (the above rations cannot be expressed at the same scale since some of them are closer to 0 while others closer to 1)

Correlation Analysis

The next step is to move on to the correlation analysis in order to detect any strong relation among the variables. Not surprisingly all capital variables are highly correlated with each other. The same applies to labour variables too. Regarding the capital variables, the way that they are calculated is primarily responsible for their high correlation. More specifically (see Chapter 3) GFCF is the basis on which gross capital is derived, and therefore net capital. Capital consumption is also expected to be highly correlated with gross and net capital since it is a proportion of the gross. Therefore, the bigger the gross capital the bigger its depreciation. However, a high correlation among the capital variables is not of concern, since only net capital is going to be used in the following regression analysis.

Table 5.4 - Correlation Analysis

	GVA	GCS	NCS	CAPCONS	GFCF	TTUSHR	BUSHRT	overT	unover	paid1	paid2	paid3	paid4
GVA	1.000												
GCS	0.618	1.000											
NCS	0.633	0.993	1.000										
CAPCONS	0.578	0.984	0.956	1.000									
GFCF	0.513	0.439	0.449	0.411	1.000								
TTUSHRT	0.831	0.572	0.599	0.517	0.363	1.000							
BUSHRT	0.828	0.571	0.598	0.516	0.365	1.000	1.000						
over	0.836	0.567	0.591	0.515	0.322	0.965	0.959	1.000					
unover	0.850	0.499	0.523	0.449	0.310	0.951	0.947	0.977	1.000				
Paidover1	0.502	0.468	0.487	0.427	0.147	0.795	0.792	0.793	0.713	1.000			
paidover2	0.590	0.607	0.627	0.562	0.317	0.661	0.654	0.737	0.592	0.590	1.000		
paidover3	0.370	0.196	0.209	0.173	0.121	0.525	0.522	0.540	0.476	0.641	0.422	1.000	
paidover4	0.526	0.478	0.485	0.455	0.183	0.582	0.578	0.620	0.560	0.501	0.575	0.402	1.000

However, a high correlation among the labour variables is also not surprising. More specifically, basic working hours are highly correlated with overtime in general and unpaid overtime. This is explained because the higher the basic working hours, the higher the unpaid overtime; for example if basic working hours are 4 per day, overtime would not be plus 4 hours, but if basic working hours are 8 per day, overtime could be plus 4 hours. Although there are indicative cases with 20 weekly working hours and 60 unpaid overtime, but these are extreme cases. In general, either part time or full time, unpaid overtime seems to consist a 5% of the basic hours (unpaid = 5% basic). Therefore, multicollinearity is expected when the decomposed model is analysed. In this dataset basic and unpaid are correlated with above 0.7, and more specifically with almost 0.95 (See Table 5.4).

However, it is not only the labour variables that are correlated with each other, it is also that they are highly correlated (above 70%) with Gross Value Added. Therefore, any regression model with labour values only would be expected to have a high R-square. From a theoretical point of view, this is not surprising either, since any output to be produced needs labour, and labour as the most variable part of inputs tends to determine production's output in a direct way. Apart from this, there is no evident moderator (between labour-gva and net capital-gva) to explain such a strong relation. In other words, this high correlation is not necessarily problematic, but acts as evident of correct variable selection, especially when examining gross value added, labour and capital are the first determinants one can think.

5.2 Pooled OLS, Robust Pooled and GLS in panel

Generally, methodologies are to facilitate research purposes. Usually, their use has to match with the principles of a specific theoretical analysis. For this reason, together with the theoretical contributions, this dissertation critically reviews the different approaches of measuring the economic activities in relation to their purpose. *Pooled OLS, Panel Data* and *Generalised Least Squares for Panel* are used in order to explore the existence of a uniform pattern that can describe all industries together. This cannot act as a substitute of the previous DEA analysis, but more as a complement, since precious information would be lost. *Pooled Ordinary Least Squares* (*Pooled OLS*) analysis is used as a basis of comparison with the *Panel Analysis* and the *Generalised Least Squares* (*Panel GLS*). Using only Pooled OLS would also restrict the information that occurs with the differences among different periods and different industries. Therefore, Pooled OLS with years as a dummy variable is also tested. However, due to heteroscedasticity and panel specific autocorrelation, Generalised Least Squares is used too.

5.2.1 Pooled OLS, Robust Pooled and Pooled with Year Dummy

Using the Pooled OLS analysis has a series of advantages. It facilitates a combined analysis of cross-sectional data (here industries consist of the sections) and cross-time data (2002-2012). A Pooled model makes it possible to inquire into 'variables' that cannot be easily detected in simple cross-sectional or cross- time analysis. For instance, Net Capital Stock could be considered temporarily invariant across time compared to the labour variables. Therefore, regression analysis of pooled data combining space and time may rely upon higher variability of data in respect of a simple time series or cross-section design research (Hicks 1994, 170-71). Additionally, the Pooled OLS can capture variation of cross-time and cross-sector effects simultaneously.

However, there are some limitations with the use of Pooled OLS. According to Podesta (2002)

> '*the OLS regression estimates, used by social scientists commonly to link potential causes and effects, are likely to be biased, inefficient and/or inconsistent when they are applied to pooled data*'.

Hicks (1994, 171-72) refers to five complications that come from the OLS estimation. First, errors tend to be not independent from a period to the next. In other terms, they might be serially correlated, such that errors in industry i at time t are correlated with errors in industry i at time t+1. The implication of such autocorrelation is the OLS estimators are still linear and unbiased, but they do not have the minimum variance. This is because observations such as that characterise them tend to be interdependent across time. For example, temporally successive values of many national traits (i.e., population size) tend not to be independent over time. Indeed, in the following regressions we detect for autocorrelation. Allowing for panel- specific autocorrelation, we get different results.

Second, by using Pooled OLS the errors tend to be correlated across industries. For instance errors in Industry 20, *Manufacture of chemicals and chemical products* cannot be totally unlinked with errors in industry 21, *Manufacture of basic pharmaceutical products and pharmaceutical preparations*, since the latter's inputs come from the former's output. Instead, we would expect disturbances for such industries to be cross-sectionally correlated. An OLS estimator suffering from heteroscedasticity would still be consistent but it is no longer efficient.

Third, errors tend to be heteroscedastic, such that they may have differing variances across ranges or sub sets of industries. In the following models heteroscedasticity is detected. However, when time is introduced as a dummy variable, the problem is reduced. Therefore, we also suspect panel-specific heteroscedasticity. This may happen because industries with high value of labour like Industry 47, *Retail trade* and Industry 86, *Health* tend to have less restricted and, hence, higher variances on them**.** Although, industry 47 is dropped, industries with similar capital composition still do have this behaviour. Moreover, errors of a Pooled OLS analysis may show heteroscedasticity because the scale of the dependent variable. For instance, the variable GVA differs between industries.

Fourth, as Podesta (2002 p.10) mentions:

> *'errors may contain both temporal and cross-sectional components reflecting cross-sectional effects and temporal effects. Errors tend to conceal unit and period effects. In other words, even if available data are homoscedastic and not auto-correlated, there is a risk of producing a regression with observed heteroscedastic and auto-correlated errors. This is because heteroscedastic and auto-correlation we observe is a function also of model misspecification. The misspecification, that is peculiar of pooled data, is the assumption of homogeneity of level of dependent variable across units and time periods'*.

In particular, if we assume that industries and years are homogeneous in the level, as OLS estimation requires, and they are not, as in our case, according to Stimson (1985, p. 919)

> *'then least squares estimators will be a compromise, unlikely to be a good predictor of the time periods and the cross-sectional units, and the apparent level of heteroscedasticity and auto-correlation will be substantially inflated'.*

Consequently in order to test for model misspecification, we analyse the robust models of the Pooled OLS that take into consideration the existing heteroscedasticity. Under this revised assumption most of our models are improved and give sensible results, as we will see below.

The fifth complication that might occur is that errors might be non-random across spatial and/or temporal units because parameters are heterogeneous across subsets of units. In other words, according to Hicks (1994, p. 172).

> *'since processes linking dependent and independent variables tend to vary across subsets' of industries or/and year, errors 'tend to reflect some causal heterogeneity across space, time, or both'*

In the following models, we approach this complication by taking into account the different subsets like manufacturing vs services and productive vs unproductive industries.

Using the Robust version of Pooled OLS does correct the problems of multicollinearity and heteroscedasticity to a significant degree. Using the robust version of OLS acts as complementary to the classic OLS that still remains a BLUE (Best Linear Unbiased Estimator).

Additionally, Pooled OLS and its robust version, year as a dummy variable is also examined in order to minimise the heteroscedasticity problems that occurs because of time. Indeed most of the models with a year dummy have their heteroscedastic problems reduced and in certain models the issue is completely resolved. Using the year as a dummy variable is also capturing the effect of crisis on the GVA variation.

5.2.2 Panel Data Analysis and Generalised Least Squares (GLS) Analysis of Panel Data Set

Pooled OLS can be complemented by a Panel Data analysis. Panel data analysis examines multi-dimensionally the data over time and over the same sections separately. This analysis provides information about the effects, which take place between the different industries, and how one industry affects the other over time. In a lot of cases, panel data refer to *longitudinal data*.

In economic analysis, panel data have been used in order to examine economies, industries, firms, even specific individuals over different time periods. In the case of unpaid labour, a panel of the 60 industries of the UK are going to be analysed over a period of 11 with annual data.

There are two main techniques in a panel data analysis: *fixed effects* (FE) and *random effects* (RE). Fixed-effects are used whenever we are interested in analysing the impact of variables that vary over time. FE explore the relationship between independent and dependent variables within a sector (country, industry, individual, etc.). Each sector has its own individual characteristics that may or may not influence the independent variables. The Random effects model is used on the other hand when the variation across sectors is assumed to be random and uncorrelated with the dependent or independent variables. According to Green, (2008, p.183)

> *'… (T)he crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the repressors in the model, not whether these effects are stochastic or not'*

In this dissertation, the Hausman (mostly) proposes the fixed effects for most of the models. This makes sense if we take into account that there is no random sample, and all industries in the UK are included with strong links with each other (manufacturing's inputs depend on agriculture product).

Cross-time effects are important to consider, since the 2007-8 economic crisis is expected to change industries GVA. Particularly, unpaid overtime is expected to be more prevalent in the phase of growth rather than during the recession, where industries have registered a shrinkage of their production. On the other hand, there are data which put in doubt that hypothesis.

As described above, the data cover 60 different industries for 11 years (2002-2012). Panel Data analysis can capture simultaneously both the *time effects* and the *industry effects*. According to Baldagi and Song (2006, p.494)

> '*Panel Data benefits are a much larger data set with more variability and less collinearity among the variables than is typical of cross-section or time-series data, their ability to control for individual heterogeneity, they are better able to identify and estimate effects that are simply not detectable in pure cross-sections or pure time-series data*'.

However both theory and the above correlation analysis with the subsequent VIF tests shows that the correlation between the basic and the unpaid working hours is very high (See Table 5.4). This causes serious issues in a Panel Data coefficients leading to inconsistent results. However, contrary to a typical panel analysis that contains hundreds or even thousands of individuals, this dissertation is structured just in a dozen of industries that do not act as a sample of the whole population, but they consst of the whole population. The labour data are derived from randomly selected individuals, but they have been used to construct a totality (industry). Therefore, the data are relatively small (60 industries and 11 years), and the collinearity does not seem to be reduced. To be more specific, there is collinearity between paid and unpaid working hours, and there is not strong individual heterogeneity (low within R-square).

Therefore, apart from Panel Analysis that also has some drawbacks in our analysis, Generalised *Least Squares* (GLS) are also used. Particularly, GLS for panel data, assuming some structure for the distribution of the error terms. In other words, OLS assumption of the constant variance of errors is frequently violated (panel-specific heteroscedasticity, see Empirical Results). Although GLS does not test for the significance of the whole model, it does provide efficient coefficients. Therefore GLS is used complementary to the the Pooled and Panel analysis.

According to STATA (*Comparing xtgls and xtreg,re*), The default situation for GLS is

> '*no correlation across panels, homoscedastic errors and no autocorrelation'*.

However, taking into account the heteroscedasticity findings we assume correlations (cross-sectional) or autocorrelations (time series) in terms of variances. More specifically, a model by Feasible Generalized Least Squares (FGLS) is estimated under the assumption that all aspects of the model are completely specified. Here that includes that the disturbances have different variances for each panel and are constant within panel. Under these assumptions, FGLS is

> '*asymptotically efficient and if iterated will produce maximum likelihood*

estimates of the parameters'[56].

More specifically, with FGLS there are two assumptions that can be made: panel heteroscedasticity and panel specific autocorrelation. Therefore, consistent coefficients can be acquired with the presence of heteroscedasticity and autocorrelation. Assuming either only heteroscedasticity or autocorrelation however, different results are acquired. Autocorrelation takes place when there is correlation between the values of the same variables on related interviewees (of the surveys in this case). It generally exists in data that instead of being randomly selected, is from the same source. Extrapolating the data of Labour force Survey to national industries is expected because eg. if the Manufacturing of Food and Beverages experiences a fall in workforce, these 'resources' will be directed to another. However, it is not necessarily a valid assumption if we take into account that interviewees cannot necessarily move easily from one industry to the other.

Generally, we use Pooled OLS as a basis of comparison with Panel and FGLS. We also use it in order to acquire diagnostics for the model specified. Although, we can trust the model overall, the Pooled and Panel coefficients cannot be trusted mainly due to multicollinearity and heteroscedasticity. Therefore, GLS is used to acquire the efficient variables' coefficients that describe reality better.

Therefore, as it has been outlined above, a general translog model to test for model specification is examined followed by a Cobb-Douglas for an attempt of minimising multicollinearity to test the significance of coefficients.

Consequently, the mathematical expression of the aggregate production functions that are tested below is:

$$VA_i = AK_i^a Lb_i^{b1} Lp_i^{b2} Lu_i^{b3} \quad (5.1)$$

$$VA_{it} = AK_{it}^a Lb_{it}^{b1} Lp_{it}^{b2} Lu_{it}^{b3} \quad (5.2)$$

$a + b1 + b2 + b3 = 1$ or $\neq 1$ (Not necessarily Constant Returns to Scale) (5.3)

Where GVA is Gross Value Added, Lb is basic working hours, Lp is paid overtime hours and Lu is unpaid overtime.

[56] STATA, How does xtgls differ from regression clustered with robust standard errors? https://www.stata.com/support/faqs/statistics/xtgls-versus-regress/

Technological change issues

Assuming a fixed technology of production function that attributes the growth in output Y coming from a combination of growth in inputs, K and L, and changes in A, technology over time can be wrong. Generally, technology in a specified production function is normally attributed to technical change and productivity increase. However, '*what is assumed as a technical change in fact is a residual of a growth expected by inputs alone*' (Fine, 2016). In other words, Total Factor Productivity (TFP) measures not only shifts in the production function (A) but also all deviations from the assumptions that TFP (to be equal with factors' prices) is based on (ie. Perfect Competition, Full Employment, Single Sector). It is expected that in the following empirical analysis, the component A in the model might not necessarily represent technological change alone.

However, the issue of technological change is tackled in this thesis with two different ways. The first is a Data Envelopment Analysis that does not require an a priori assumption on an aggregate production function; on the contrary it does 'reveal' the most realistic relationship between inputs and outputs, that can also be changing over time. In other words, there is no assumption over a production function based on certain neoclassical assumptions regarding Perfect Competition etc. Therefore, technological change can be detected by DEA without the need of this assumption, while a Cobb-Douglas analysis would need it for theorising the distribution outcome of production. The second step is to use statistical analysis based on the DEA results, not equating an industry with another, but for detecting any possible general patterns.

Cobb-Douglas Models

$$VA_i = \text{const} + \beta_1 Lb_i + \beta_2 Lp_i + \beta_3 Lu_i + c_1 K_i \tag{5.4}$$

$$VA_i = \text{const} + \beta_1 Lb_i + \beta_2 Lp_i + \beta_3 Lu_i + c_1 K_i + Year \tag{5.5}$$

$$VA_{it} = \text{const} + \beta_1 Lb_{it} + \beta_2 Lp_{it} + \beta_3 Lu_{it} + c_1 K_{it} \tag{5.6}$$

Translog Models

$$VA_i = \text{const} + \alpha_1 Lb_i + \beta_1 Lp_i + \gamma_1 Lu_i + \delta_1 K_i + \alpha_2 \tfrac{1}{2} Lb_i^2 + \beta_2 \tfrac{1}{2} Lp_i^2 + \gamma_2 \tfrac{1}{2} Lu_i^2 + \delta_2 \tfrac{1}{2} K_i^2 + \alpha_3 Lb_i K_i + \beta_3 Lp_i K_i + \gamma_3 Lu_i K_i + \alpha_4 Lb_i Lp_i + \alpha_5 Lb_i Lu_i + \gamma_3 Lu_i Lp_i \tag{5.7}$$

$$VA_i = \text{const} + \alpha_1 Lb_i + \beta_1 Lp_i + \gamma_1 Lu_i + \delta_1 K_i + \alpha_2 \tfrac{1}{2} Lb_i^2 + \beta_2 \tfrac{1}{2} Lp_i^2 + \gamma_2 \tfrac{1}{2} Lu_i^2 + \delta_2 \tfrac{1}{2} K_i^2 + \alpha_3 Lb_i K_i + \beta_3 Lp_i K_i + \gamma_3 Lu_i K_i + \alpha_4 Lb_i Lp_i + \alpha_5 Lb_i Lu_i + \gamma_3 Lu_i Lp_i + \text{Year} \tag{5.8}$$

$$VA_i = \text{const} + \alpha_{1t} Lb_{it} + \beta_{1t} Lp_{it} + \gamma_1 Lu_{it} + \delta_1 K_{it} + \alpha_2 \tfrac{1}{2} Lb_{it}^2 + \beta_2 \tfrac{1}{2} Lp_{it}^2 + \gamma_2 \tfrac{1}{2} Lu_{it}^2 + \delta_2 \tfrac{1}{2} K_{it}^2 + \alpha_3 Lb_{it} K_{it} + \beta_3 Lp_{it} K_{it} + \gamma_3 Lu_{it} K_{it} + \alpha_4 Lb_{it} Lp_{it} + \alpha_5 Lb_{it} Lu_{it} + \gamma_3 Lu_{it} Lp_{it} \tag{5.9}$$

where, VA_i is Value Added per Industry at a specific year, Lp_i is Paid Labour per industry at a specific year, Lu_i is unpaid labour and K_i is Net Capital Stock, *Year* is a dummy variable for the separate years and *Crisis* a another dummy variable that is attributed to data after 2008 where economic retardation starts.

Every group of industries is examined with Pooled OLS, Robust OLS, Panel and GLS. In the Cobb Douglas model we also use a year dummy and an economic crisis dummy.

Table 5.5 – Models that are examined: All industries, Manufacturing, Services, Productive and Unproductive industries

MODEL SPECIFICATION	MODEL VARIATION	Pooled OLS	Robust	Panel	Panel	GLS	GLS	GLS
			Pooled OLS	Fixed Effects	Random Effects	panel heteroskedastic	panel autocorrelation	panel heteroskedastic and panel autocorrelation
Cobb-Douglas	Plain	✓	✓	✓	✓	✓	✓	✓
	i.YEAR	✓	✓	✓	✓	✓	✓	✓
	Crisis	✓	✓	✗	✗	✗	✗	✗
Translog	Plain	✓	✓	✗	✗	✗	✗	✓
	i.YEAR	✓	✓	✗	✗	✗	✗	✗
	Crisis	✗	✗	✗	✗	✗	✗	✗

5.3 Empirical results

Generally, there is no single regression that is adopted because of a series of issues that our data have: multicollinearity, heteroscedasticity etc. Therefore, we approach the topic with different statistical methods to approach reality, because capturing a single effect of unpaid overtime without interacting terms is difficult.

5.3.1 TRANSLOG model specification

The translog model below is the one that the GLS analysis has shown as the one with all variables statistically significant, after running various combinations.

Table 5.6 – Regression Analysis of Real values over Real GVA - Pooled OLS – Translog

Pooled OLS	All industries	All ind - YEARS	Productive industries	Productive ind - YEARS	Unproductive industries	Unproductive ind - YEARS	Manufacturing industries	Manufacturing ind - YEARS	Services industries	Services ind - YEARS
Obs	609		524		172		242		345	
_cons	- 3.385**	- 3.124**	-0.2771334	0.049854	- 12.216***	- 11.83***	-2.787311	-2.927405	- 5.667***	- 5.275***
lncs	1.109***	1.083***	0.636**	0.61**	3.625***	3.474***	1.87***	1.89***	1.954**	1.906***
lBUSHRT	2.709***	2.61***	2.005***	1.88***	2.103***	2.084***	0.4417837	0.5200044	2.386***	2.199***
lunoverT	- 1.955***	- 1.867***	- 1.231**	- 1.134**	- 1.869***	- 1.665***	-0.9574563	-1.033676	- 2.186***	- 1.976***
lpaidover_all	- 0.441**	- 0.382*	-0.3572475	-0.29003	- 1.96***	- 1.749***	-0.4089742	-0.3519953	- 0.547*	-0.438
ncs2	0.0214144	0.021925	0.046*	0.046*	- 0.258***	- 0.242***	- 0.164***	- 0.162***	- 0.088***	- 0.088***
paidover_all2	-0.0299125	-0.0182	-0.0031293	0.004649	- 0.244***	- 0.198***	0.0492145	0.0873704	-0.031619	-0.02492
ncsbus	- 0.564***	- 0.556***	- 0.396***	- 0.382***	- 0.532***	- 0.528***	-0.0648667	-0.110417	- 0.53***	- 0.495***
ncsunover	0.4103651	0.401***	0.237**	0.223**	0.489***	0.469***	0.2130236	0.26*	0.458***	0.418***
Busunover	0.133**	0.132**	0.124*	0.126**	0.0332771	0.004239	0.1025377	0.0851371	0.157**	0.147*
Buspaidall	0.1027881	0.083068	0.0622646	0.041163	0.863***	0.767***	0.1576338	0.1549996	0.214	0.155556
Unoverpaidall	0.0124023	0.025148	0.0234366	0.038472	- 0.3*	-0.24641	-0.1779446	-0.1975335	-0.1128907	-0.04889
2003		0.046264		0.055624		0.000722		0.066569		0.046212
2004	-	0.070241	-	0.066815	-	0.070633	-	0.0934264	-	0.089962
2005	-	0.114858	-	0.099528	-	0.126637	-	0.128247	-	0.16*
2006	-	0.136*	-	0.132404	-	0.162**	-	0.169*	-	0.174*
2007	-	0.171**	-	0.167**	-	0.18**	-	0.205**	-	0.219**
2008	-	0.1991**	-	0.201**	-	0.189**	-	0.275***	-	0.202**
2009	-	0.171**	-	0.16*	-	0.22**	-	0.233**	-	0.227**
2010	-	0.204**	-	0.2**	-	0.267***	-	0.273***	-	0.252**
2011	-	0.195**	-	0.191**	-	0.29***	-	0.269***	-	0.247**
2012	-	0.244***	-	0.251***	-	0.317***	-	0.289***	-	0.301***
crisis	-	-	-	-	-	-	-	-	-	-
adj.Rsquare	0.8063	0.8085	0.7879	0.7896	0.9351	0.9413	0.8418	0.8455	0.813	0.8166
Diagnostic Tests										
VIF	811.87	432	844.64	454.46	846.43	456.44	1133.48	615.23	801.49	429.71
hettest (p-value)	0.8504	0.9461	0.7636	0.6775	0.0011	0.000	0.0434	0.033	0.2244	0.057
hettest, rhs(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0001
estat imtest, white(p-value)	0.000	0.0675	0.000	0.0097	0.000	0.4641	0.000	0.0083	0.000	0.2933
ovtest(p-value)	0.3245	0.5158	0.0062	0.0103	0.0182	0.0283	0.0729	0.1531	0.0001	0.0006

*p<.1 *p<.05 *p<.01

The results in Translog analysis are quite different from the previous translog analysis of target values (See Chapter 4). In the model here unpaid overtime seems to have negative contribution to GVA (-0.53 for all industries GLS), and there is no evidence for convex effect as in the targeted model. However, as stated before, the translog models suffer from extreme multicollinearity and therefore, their coefficients are not trustworthy.

One useful thing that we get from this analysis is that in the All-Industries and the Manufacturing industries-only, there are no omitted variables. This is useful because in the following Cobb-Douglas analysis, every model has omitted variables. Therefore, at least for these two groups of industries, it is not that we miss any variable, but it is their non-linear combination that is not taken into account with the Cobb-Douglas model. Consequently, being reassured that we do not miss any important variable, we move on to the Cobb-Douglas analysis of our data that offers simpler results with fewer problems in diagnostics.

5.3.2 COBB-DOUGLAS model specification

Table 5.7 – Regression Analysis of Real values over Real GVA - Pooled OLS – Cobb-Douglas

Pooled OLS	All industries	All ind - YEARS	All ind - Crisis	Productive industries	Productive ind - YEARS	Productive ind - Crisis	Unproductive industries	Unproductive ind - YEARS	Unproductive ind - Crisis	Manufacturing industries	Manufacturing ind - YEARS	Manufacturing ind - Crisis	Services industries	Services ind - YEARS	Services ind - Crisis
Obs		**609**			**525**			**172**			**242**			**345**	
_cons	6.591***	6.264***	6.588***	3.774***	3.97***	3.774***	4.075***	4.465***	4.08***	5.131***	4.664***	5.127***	6.755***	6.355***	6.748***
lncs	0.272***	0.261***	0.272***	0.282***	0.271***	0.282***	0.252***	0.239***	0.252***	0.372***	0.359***	0.372***	0.205***	0.195***	0.204***
lBUSHRT	0.386***	0.309***	0.387***	0.424***	0.349***	0.424***	0.377***	0.231**	0.374***	0.348***	0.224***	0.347***	0.412***	0.318***	0.41***
lpaidover_all	- 0..197***	- 0.159***	- 0.1964***	- 0.17***	- 0.133***	- 0.17***	- 0.181***	- 0.106**	- 0.179***	- 0.15***	- 0.089**	- 0.149***	- 0.169***	- 0.124***	- 0.168***
lunoverT	0.297***	0.348***	0.297***	0.191***	0.24***	0.191***	0.338***	0.4268***	0.341***	0.247***	0.323***	0.248***	0.28***	0.333***	0.28***
2003	-	0.056	-	-	0.054	-	-	0.03	-	-	0.047	-	-	0.069	
2004	-	0.083	-	-	0.072	-	-	0.092	-	-	0.067	-	-	0.106	-
2005	-	0.113	-	-	0.091	-	-	0.176	-	-	0.077	-	-	0.165	-
2006	-	0.121	-	-	0.116	-	-	0.164	-	-	0.116	-	-	0.165	-
2007	-	0.182**	-	-	0.162*	-	-	0.254*	-	-	0.153	-	-	0.242**	-
2008	-	0.214***	-	-	0.197**	-	-	0.246*	-	-	0.235**	-	-	0.234**	-
2009	-	0.162**	-	-	0.141	-	-	0.31**	-	-	0.167	-	-	0.219**	-
2010	-	0.202**	-	-	0.186**	-	-	0.339**	-	-	0.198*	-	-	0.266**	-
2011	-	0.182**	-	-	0.171*	-	-	0.318**	-	-	0.207*	-	-	0.237**	-
2012	-	0.259***	-	-	0.250***	-	-	0.432***	-	-	0.264**	-	-	0.323***	-
crisis	-	-	0.012	-	-	0.002	-	-	0.095	-	-	0.009	-	-	0.032
adj.Rsquare	0.779	0.781	0.778	0.766	0.767	0.765	0.844	0.851	0.843	0.815	0.815	0.814	0.777	0.78	0.777
Diagnostic Tests															
VIF	8.670	4.080	7.160	8.570	4.070	7.090	6.920	3.550	5.750	7.990	4.140	6.670	8.060	3.840	6.660
hettest (p-value)	0.137	0.158	0.135	0.410	0.472	0.410	0.000	0.000	0.000	0.000	0.000	0.000	0.661	0.909	0.640
hettest, rhs(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.070	0.528	0.117
estat imtest, white(p-value)	0.000	0.031	0.000	0.000	0.239	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.028	0.984	0.126
ovtest(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.013	0.006
	*p<.1	**p<.05	***p<.01												

Table 5.8 – Regression Analysis of Real values over Real GVA - GLS for Panel – Cobb-Douglas

GLS - Heterosk & AR(1)	All industries		Productive industries		Manufacturing industries		Unproductive industries		Services industries	
Obs	**609**		**525**		**242**		**172**		**345**	
_cons	4.572***	4.46%***	4.41***	4.33***	2.716***	2.399***	4.176***	3.713***	5.209***	4.513***
lncs	0.196***	0.1896***	0.201***	0.193***	0.408***	0.374***	0.255***	0.261***	0.181***	0.207***
lBUSHRT	0.49***	0.4733***	0.512***	0.495***	0.404***	0.478***	0.468***	0.482***	0.418***	0.449***
lpaidover_all	- 0.049***	- 0.0222***	- 0.0417***	-0.0081	- 0.025**	-0.0059	- 0.0435***	-0.0143	- 0.026***	0.00164
lunoverT	0.022	0.0353***	-0.002	0.00884	-0.0038	0.039*	0.05052	0.078***	0.005	0.02047
YEAR										
2003		0.054***		0.057***		0.036**		0.056***		0.066***
2004		0.0795***		0.078***		0.045**		0.097***		0.097***
2005		0.122***		0.121***		0.094***		0.136***		0.136***
2006		0.16***		0.155***		0.139***		0.179***		0.176***
2007		0.196***		0.183***		0.162***		0.215***		0.217***
2008		0.218***		0.211***		0.215***		0.247***		0.233***
2009		0.21***		0.192***		0.168***		0.286***		0.243***
2010		0.246***		0.232***		0.223***		0.337***		0.28***
2011		0.254***		0.244***		0.243***		0.349***		0.298***
2012		0.281***		0.275***		0.282***		0.388***		0.327***
	*p<.1	**p<.05	***p<.01							

5.4 General Conclusions from the Statistical Analysis

Multicollinearity of labour variables

Most of the empirical models below suffer from multicollinearity regarding the labour variables. This is due to basic working hours and unpaid overtime. In this case, paid hours have high pairwise correlation with unpaid hours (See Table 5.4). In the regression analysis, there is evidence of correlation, since it is slightly above 10 with the VIF test (Variance Inflation Factors). This is mainly because unpaid overtime was derived by total hours taking out basic working hours. Multicollinearity increases the standard errors of the coefficients making some independent variables to be statistically insignificant when they should not be. However, we would expect that all regression coefficients are significant or none of the correlated variables has a negative regression coefficient.

The most popular solution to multicollinearity is to either i. combine variables (all labour variables together) or ii. eliminate one of the variables (basic hours or unpaid overtime) or, possibly, iii. increase the sample size. However, we cannot follow any of them because we are interested to the decomposed labour's contributions and therefore we cannot add them or eliminate one of them. Additionally, increasing the sample is just impossible since the data are secondary, and we do not have any control.

An alternative step that can be followed is stepwise regression in order to eliminate the problem and select the best predictor variable to enter when other independent variables are present. One of the stepwise regression processes is the LASSO analysis (Least Absolute Shrinkage and Selection Operator). This produces a table showing which variable we could 'get rid off' first. In the Figure 5.6 with the LASSO analysis, it is evident that the last variable that is in excess is unpaid overtime[57]. In other words, variations of unpaid overtime can explain more the variations in GVA than any other variable (capital or basic hours).

Additionally, the fact than when we control for time variable, we get reduced overall multicollinearity (below 5). Therefore, the OLS results give us an indication of how the coefficients should be.

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[57] The LASSO Table is read from the right to the left; the first variable whose curve 'touches' the 0 in the horizontal axis is the first to be dropped. Here it is paid overtime. And the last whose curve touches the horizontal 0 is the unpaid overtime.

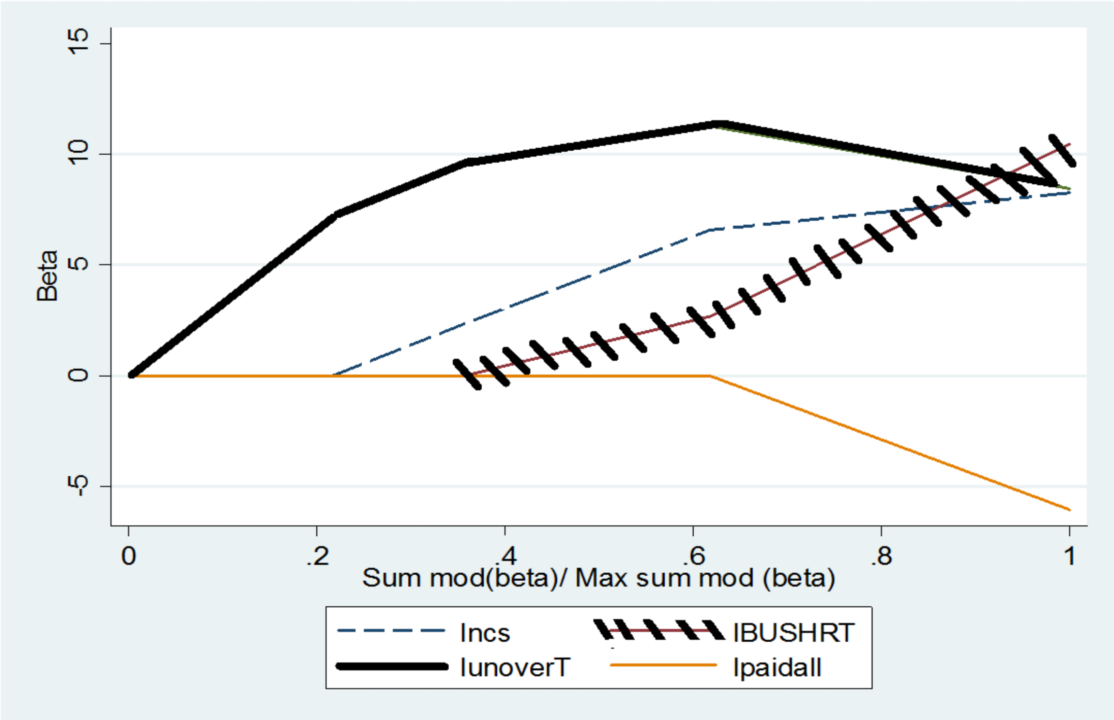

Figure 5.6 - Least Absolute Shrinkage and Selection Operator (LASSO) Test

Heteroscedasticity

Regarding the heteroscedasticity issues, this could be attributed initially to the division of our data into industries. Generally, there are different sub-populations, ie different group of industries (manufacturing vs services) or different groups of years (before and after crisis) that is possible to have different variabilities. However, heteroscedasticity does not occur in every model specification. Only when labour is inserted as an additional explanatory variable the issue appears; in the simple output-capital model there is not evidence of heteroscedasticity (See Appendix 25).

Generally, the occurrence of heteroscedasticity is not unlinked with the nature of labour as variable. There is both a theoretical and empirical justification for the heteroskedastic nature of labour, at least at an industrial analysis level. The kind of labour that is occupied in Agriculture, Manufacturing and Services is completely different from each other; Computer programming has more skilled labour compared to Agriculture. Apart from this, within the same industry there are also different kinds of labour.

Heteroscedastic labour has also been displayed in previous studies. For instance, in an industrial analysis study about labour productivity in the Wholesales industry of Germany for the period 1979-1985 (Van Dalen et al.1990, p.32), labour appeared to have heteroskedastic behavior even within the same industry. Moreover, another study about the UK manufacturing industries' labour productivity during 70s and 80s (Oulton, 1990, p.78) has also displayed the heteroskedastic nature of labour.

Generally, allowing for heteroscedasticity does not lead to significantly different results. Actually the results are even more reinforced. In other words, heteroscedasticity is not obscuring the real contributions of production factors (See Table 5.11).

Autocorrelation

Assuming that there is panel –specific autocorrelation, the results change, especially when it comes to unpaid overtime. Although regressing the target inputs in Chapter 4 allowing for autocorrelation it shrunk the effect of unpaid overtime over the output of the Manufacturing industries only (0.17%)[58] to be equal to basic working hours (0.18%), in the real data, in the All-industries model allowing for heteroscedasticity and autocorrelation with time variables (See Table 5.9 and 5.10) the effect of unpaid overtime is 0.035% and the basic hours is 0.47%. This is actually the model with the better diagnostics that also gives some sensible results too. This implies that in reality 1% increase of unpaid overtime leads to a 0.035% increase of GVA, but 'ideally' if an industry wishes to be efficient 1% increase in unpaid overtime should lead to 0.17% increase of GVA. However, translating the natural logarithms to real numbers we have the results demonstrated at Table 5.10. What we actually observe is that the previous DEA analysis is in agreement with the econometric analysis, where 1 unpaid overtime contributes hundreds of times more than the basic working hours. However, when we allow for autocorrelation, the result shrinks to having maximum 3 times higher effect than the basic hours. Only in the all industry analysis, we observe a slight diminishing effect of the extra unpaid hour (See Table 5.10).

[58] In Chapter 4, for Manufacturing, we saw that:
For NCS, 1% increase of the £10^9 it leads to 0.35577% £10^8 GVA, or 1% increase in £NCS leads to 0.035577% increase in GVA.
For basic hours, 1% increase of the 10^7 hours leads to 0.278845% £10^8 GVA, or 1% increase in basic hours leads to 2.78845% increase in GVA.
For paid overtime, 1% increase of the 10^5 hours leads to -0.087088% £10^8 GVA, or 1% increase in basic hours leads to a decrease by 87.1% increase in GVA.
For unpaid overtime, 1% increase of the 10^6 hours leads to 0.096455% £10^8 GVA, or 1% increase in basic hours leads to 9.6455% increase in GVA.

Table 5.9 – Comparing Hourly contributions of Basic Hours with Unpaid in OLS and GLS (allowing for Heteroscedasticity and Panel Specific Autocorrelation)

			OLS			XTGLS HETEROSC - AUTOCORR		
CLUSTER		Overall Proportion of Hours	Coefficient	£100 of GVA	Hourly Contribution	Coefficient	£100 of GVA	Hourly Contribution
ALL INDUSTRIES	BASIC	0.95	0.309	£30.90	£32.53	0.49	£49.00	***£51.58***
	UNPAID	0.05	0.348	£34.80	£696.00	0.022	£2.20	***£44.00***
MANUFACTURING INDUSTRIES	BASIC	0.95	0.224	£22.40	£23.58	0.478	£47.80	£50.32
	UNPAID	0.05	0.323	£32.30	£646.00	0.039	£3.90	£78.00
UNPRODUCTIVE INDUSTRIES	BASIC	0.95	0.231	£23.10	£24.32	0.482	£48.20	£50.74
	UNPAID	0.05	0.427	£42.68	£853.60	0.078	£7.80	£156.00

Relying on the All-Industry analysis, as both in the Translog Pooled OLS and the Cobb-Douglas Pooled OLS demonstrated the best diagnostics, and choosing the GLS allowing for heteroscedasticity and autocorrelation we end up with capturing the specific effect of basic working hours and unpaid overtime, where on average, the industries' 1 basic hour appears to contribute £51.58, while unpaid overtime £44.00.

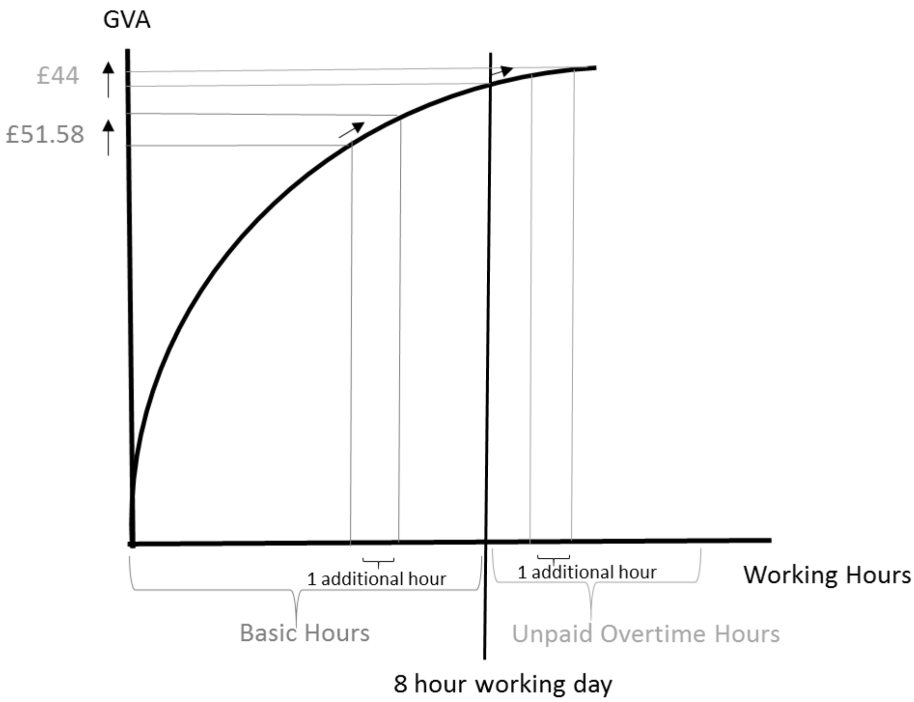

Figure 5.7 ALL Industries Cobb-Douglas (Year Dummy variable) – Allowing for

Heteroscedasticity -Autocorrelation) – See Table 5.9 for labour coefficients

Convex vs Concave effects of unpaid overtime hours in industries' output?

After having controlled issues with collinearity, heteroscedasticity and autocorrelation, using the All-Industries GLS with year dummy we can see that labour probably displays some kind of diminishing returns after a certain time, as the basic hours on average have slightly higher contribution towards GVA (£51.58), compared to unpaid overtime (£44.00). More specifically, the 'wear and tear' of labour steps in, showing that what is evident in past research. Indeed, adding an extra hour of unpaid overtime does reduce the contribution towards GVA, but this does not necessarily mean that tiredness steps in only after the 8th hour. This diminishing effect usually kicks off earlier but a further decomposition of the basic hours would complicate the results even more.

These results have significant theoretical and policy implications. The first theoretical implication is that although a lower contribution of unpaid overtime, it is still captured with a positive sign, contrary to paid overtime that is mainly negative. Unpaid overtime is still contributing to relatively high GVA, challenging all these mainstream theories claiming that unpaid overtime is an individual's choice and not used for production, but eg. for signalling. Firstly, unpaid overtime is a general tendency captured in all industries. Both the descriptive statistics and the DEA analysis show a relatively increased use of unpaid overtime by industries, even after the outburst of crisis. Despite the reduction in total working hours, the unpaid overtime appears to be relatively higher. This cast even more doubts on the approaches that analyse unpaid overtime as an individual choice. Additionally, this challenges the methodologically individualistic approaches that could not find any relation between unpaid overtime with the output (Anger 2008). Therefore, the general concept of neoclassical economics that every factor of production is paid is once again challenged. This is also in agreement with the findings of the DEA analysis in the total labour analysis, where it is evident that labour is not paid what it produces.

Additionally, contrary to the DEA that unpaid overtime seemed to have higher contribution than basic working hours, testing for the best model specification led us to the above result. Although DEA proved very useful when total labour was analysed without being decomposed, it was not as precise as the GLS analysis. Moreover, although the OLS demonstrated the Cobb-Douglas All industries model with the best diagnostics, both in its translog version, and its Cobb-Douglas one, it was the GLS analysis of All industries that provided more efficient coefficients.

Is paid overtime related with positive GVA?

Every model that has been analysed where paid overtime is statistically significant has negative contribution to GVA. Depending on the groups of industries that we examine and this varies from -0.02% to -0.2%. In the GLS (Panel-specific heteroscedasticity & Autocorrelation) with Year dummy variables, it appears to have one of the statistically significant smallest effects (-0.02%) implying that paid overtime reduces GVA by 0.02%. In the previous chapter, paid overtime's contribution was infinitesimal, with only the Manufacturing sector being statistically significant, reducing GVA by 8.7%.

However, concluding that an extra input would reduce our output would be naive and methodologically incorrect. Taking into account that paid overtime is a continuation of basic working hours, it means that at the point that an industry starts using paid overtime, this is linked with diminishing GVA. Especially, if we take into account that paid overtime is very small amount of labour, smaller than unpaid hours, the diminishing effect should not be that damaging.

Time Effects, Crisis' effects

Importing a year dummy in our models, we see that in most cases there is a change in GVA in year 2008 or 2009. More specifically for the model that we adopt (All-Industries GLS Years) we can see that while in 2008 the output was by 0.218% higher than in 2002 (base year), during 2009 this drops to 0.21% (with 2002 as the base year). In other words, the outburst of crisis in 2007 did not have an immediate response in 2008, but it was slightly delayed expressing itself with a drop in the output during 2009. When crisis is expressed as a dummy variable, it is not statistically significant. Generally, in the regression analysis, crisis is not well captured regarding the effect on working time. It is mainly the descriptive statistics and part of the DEA analysis that show an increased contribution of unpaid overtime through the years.

Generally, using different methods in regression analysis (Pooled OLS, Robust, GLS) can give us a better picture of the labour contribution (total or decomposed) towards UK industries' GVA. Although our labour (mainly) data cause issues of multicollinearity and heteroscedasticity, allowing for these OLS assumptions' violations, we can still detect that unpaid overtime, contrary to paid overtime, is not only statistically significant but also strongly linked with the GVA. Crisis is also captured as a factor that impacts on GVA, but we cannot have as precious information for it compared to the DEA analysis. Generally though, the results are very similar to the previous DEA analysis. For more detailed discussion see Chapter 6.

Chapter 6: Discussion and Conclusion

6.1 The most important results

As the 95% of total working hours are comprised by basically 'paid' hours and 5% is the unpaid overtime, the most important result is that in both methods show a strong link between unpaid overtime and its 'productive' use, towards GVA. However, only in statistical analysis -allowing for heteroscedasticity and panel specific autocorrelation- we get a more precise contribution of unpaid overtime and basic hours to GVA, with basic hours contributing on average to £51.8 of GVA per hour and the unpaid £44 (Figure 5.7). Although this could be interpreted as diminishing returns of labour, it is not the case that an additional worker slows down the production, but the additional hour of the same worker has lower contribution. In fact it is capturing the wear and tear of labour that takes place after an extended working day. This confirms a series of empirical analysis that demonstrate this from a psychological or medical point of view. Additionally, this confirms the Marxist approach regarding the extension of working day in favour of the capitalist, as workers stay at work, producing something that they are not going to get any reward from. This acts as a massive challenge to all these mainstream approaches that analysed unpaid overtime as an individual's choice, leading to their subsequent failure to discover links of unpaid overtime to the output produced. This has also massive implications to the neoclassical approach claiming that all inputs of production are paid according to their marginal contribution, failing once more to explain how one can input -acting almost as productively as the basic working hours - not being paid at all.

Another important finding that comes from DEA is that when the working day is not decomposed in basic hours, paid and unpaid overtime, but instead is analysed as a totality, shows that even in terms of mainstream indicators of productivity, labour is indeed assigned with much higher GVA than the average wage (Table 420 compared to Figure 4.11). More specifically, it is found that 1 hour of working time contributes to £30 - £100, while the average hourly payment is £8-£13.5. This finding can come as a confirmation of previous scholars' work who highlighted that labour productivity is increasing, but labour remuneration is decreasing. This finding together with the above finding challenges the neoclassical approach even more. If workers are not paid what they have produced (deducting the 'product' o capital) then where does this generated income go.

The above findings imply also that unpaid overtime acts as a form of absolute surplus value extraction. The fact that there is part of the extended working day, which even in conventional terms, is not paid, reinforces the Marxist analysis that claims that the extension of working day acts in favour of capitalist. Generally, working hours are a more flexible tool to extend than creating new jobs, and this is a pattern also detected in our descriptive statistics (Figure 3.2). These patterns respond both to approaches that considered that the working day can only decrease (mostly in the 20th century) and to Marxist approaches that thought that the pre-crisis capitalism passes into a new stage where there will be only absolute surplus value extraction (working day extension)

Additionally, after crisis there is evidence that although total working hours have dropped there is a relevant extension of the use of unpaid overtime (stable or reduced working day, but with its unpaid part increased – See Figure 3.3). Moreover, the pattern that is observed both in the descriptive statistics and the DEA analysis is industries' GVA due to unpaid overtime is higher after the outburst of economic crisis. Although unpaid overtime is just part of the unpaid working day, it could imply that it can be used as an indicator of relative surplus value extraction. However, supporting such a statement would need further theoretical justification.

Furthermore, it is found that industries rely more on labour than capital after the outburst of crisis betraying the fact that the UK capitalists rely more on extracting higher surplus value than increasing the organic composition of capital in their inter-industrial competition. Generally, most industries seem to experience a slow-down in their capitalisation after the outburst of crisis in 2007. Some of them manage to increase it in levels higher than pre-crisis, but the majority, although have increasing pattern, they do not seem to reach the pre-crisis levels. This implies that up until 2012 the UK economy still experiences crisis, at least as expressed in the capital composition, as a growing economy or industry would be expected with much higher rates. Analysing the Productive industries only, similar patterns are observed, however without the inconsistencies of the all industries model. However, the unproductive industries did not demonstrate a clear pattern.

Generally, using working time as a measure of abstract labour is possible for a quantitative analysis. The homogeneity that was facilitated by the concept of abstract labour enabled a within an industry. However, there has been a heterogeneity of labour regarding its productive use or not. Grouping the 2 digit industries into productive and unproductive, according to Marxist terms, led to useful conclusions in DEA at least for the MRS between capital and labour, revealing the 'stagnant' organic composition of capital. Generally, with DEA was clearer to observe the above-mentioned patterns over the years, as DEA can work with smaller number of units, but with the econometric analysis this was not as easy as we had only a 2-digit industry observation (not 3 or 4) reducing the amount of observations. Therefore, the econometric analysis captures the whole economy in an instance and not the particular groupings.

Moreover, the results for paid overtime do not agree DEA and econometric analysis, as in the first case it is assigned with very high GVA and in the econometric analysis it is either negatively associated with GVA or with extremely high contribution. Paid overtime consist of the 0.25% of total working hours and therefore it is omitted at some point in DEA, as it does not lead to feasible solutions in DEA.

Generally, DEA was very enlightening in the total labour-capital model as provided MRS, labour's contributions to GVA and their patterns over the years that were quite descriptive of the reality. DEA enabled this dissertation to conduct this inter-industry comparison. However, only in the statistical analysis of the decomposed model the specific contribution of unpaid overtime compared to basic working hours was captured.

6.2 Weaknesses of the above results

One of the most challenging issues of this dissertation was the theory examined in comparison to the existing UK data. The fact that Marxist theory defines unpaid labour differently from mainstream schools of thought, and particularly the neoclassical analysis, made the materialisation of this thesis difficult and time-consuming. The never-ending debate regarding the use of orthodox statistics to be interpreted in a heterodox way was hard to avoid. As it was explained several time within this thesis, according to Dunne's (1991) the possible approaches towards the use of data could be *'(i) researchers can attempt to measure Marxian categories directly, (ii) orthodox data could be adjusted to make it closer to the required Marxist categories and/or (iii) we can use Marxist theory to attempt to explain the movement in the orthodox statistics*'. In this dissertation we used the last approach.

Another difficulty was the definition of unpaid labour based on neoclassical and

Marxist analysis. The former simply do not recognise the existence of such a concept, but the latter acknowledge that unpaid labour is the default situation in capitalist production. More specifically measuring the amount of unpaid labour with the Marxist definition would be equal to measuring the amount of profits (as a form of surplus value) in a national economy. A proper Marxist analysis would require the construction of new variables with the use of variables that do exist, and this would include income distribution categories (i.e. wages and profits).

Although the production process in a Marxist analysis is not seen as a field of peaceful encountering between capital (both as material and relation) and labour (both as an input and as a class), this dissertation does not attempt to explore the power relations developed. We do acknowledge that there are social relations not only within every industry, but also within every firm or production unit that determine wages and working hours. Therefore what appears in DEA as 'input' (ie. working time) of the '*Decision*' Making Unit (DMU) in fact it is the outcome of social relations, bargaining, struggle depicted in national and also industrial level. Of course this outcome is not subtracted by its material basis, which is the needs of the capitalist production.

Another issue that was challenging was the combination of different databases: LFS and ONS on the basis of industry codes (SIC). This has a series of assumptions, especially regarding extrapolation of LFS to national level statistics. Additionally, using purely technical data for approaching labour (i.e working hours) with market 'distorted' ones for output and capital (i.e £ GVA and £ NCS) leads to a model with 'hybrid' variables. In other words, it is not purely technical or purely market-value model. This was mainly linked with issues in measuring capital and even issues in measuring national output. This was a difficulty that also restricted our analysis being completely consistent with a Marxist analysis.

Additionally, when decomposing the working day into basic hours, paid overtime and unpaid overtime, the DEA does not seem to attribute sensible weights to the variables with the biggest variability. The fact that capital and basic hours do not vary as much as paid and unpaid overtime over the years are attributed with less GVA. This was only possible to be tested and corrected only in the econometric analysis, allowing for heteroscedasticity and panel-specific autocorrelation.

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APPENDICES

Appendix 1 – Temporary labour as percentage of Total Labour – ONS

Period	Total as % of all employees	Period	Total as % of all employees	Period	Total as % of all employees
Nov-Jan 2002	6.5	Nov-Jan 2006	5.7	Nov-Jan 2010	5.8
Dec-Feb 2002	6.5	Dec-Feb 2006	5.8	Dec-Feb 2010	5.9
Jan-Mar 2002	6.5	Jan-Mar 2006	5.9	Jan-Mar 2010	6
Feb-Apr 2002	6.4	Feb-Apr 2006	5.9	Feb-Apr 2010	6
Mar-May 2002	6.5	Mar-May 2006	5.9	Mar-May 2010	6.2
Apr-Jun 2002	6.5	Apr-Jun 2006	5.8	Apr-Jun 2010	6.3
May-Jul 2002	6.5	May-Jul 2006	5.7	May-Jul 2010	6.3
Jun-Aug 2002	6.5	Jun-Aug 2006	5.8	Jun-Aug 2010	6.3
Jul-Sep 2002	6.5	Jul-Sep 2006	5.8	Jul-Sep 2010	6.3
Aug-Oct 2002	6.6	Aug-Oct 2006	5.9	Aug-Oct 2010	6.4
Sep-Nov 2002	6.5	Sep-Nov 2006	5.9	Sep-Nov 2010	6.3
Oct-Dec 2002	6.5	Oct-Dec 2006	6	Oct-Dec 2010	6.2
Nov-Jan 2003	6.3	Nov-Jan 2007	6.1	Nov-Jan 2011	6.2
Dec-Feb 2003	6.3	Dec-Feb 2007	6	Dec-Feb 2011	6.3
Jan-Mar 2003	6.2	Jan-Mar 2007	6.1	Jan-Mar 2011	6.3
Feb-Apr 2003	6.2	Feb-Apr 2007	6	Feb-Apr 2011	6.3
Mar-May 2003	6.2	Mar-May 2007	6	Mar-May 2011	6.4
Apr-Jun 2003	6.1	Apr-Jun 2007	6	Apr-Jun 2011	6.4
May-Jul 2003	6.1	May-Jul 2007	5.9	May-Jul 2011	6.2
Jun-Aug 2003	6	Jun-Aug 2007	5.9	Jun-Aug 2011	6.1
Jul-Sep 2003	6.2	Jul-Sep 2007	5.9	Jul-Sep 2011	6.1
Aug-Oct 2003	6.4	Aug-Oct 2007	5.8	Aug-Oct 2011	6.2
Sep-Nov 2003	6.3	Sep-Nov 2007	5.8	Sep-Nov 2011	6.2
Oct-Dec 2003	6.3	Oct-Dec 2007	5.9	Oct-Dec 2011	6.2
Nov-Jan 2004	6.2	Nov-Jan 2008	5.8	Nov-Jan 2012	6.2
Dec-Feb 2004	6.2	Dec-Feb 2008	5.7	Dec-Feb 2012	6.3
Jan-Mar 2004	6.1	Jan-Mar 2008	5.6	Jan-Mar 2012	6.3
Feb-Apr 2004	6.1	Feb-Apr 2008	5.6	Feb-Apr 2012	6.2
Mar-May 2004	6	Mar-May 2008	5.5	Mar-May 2012	6.3
Apr-Jun 2004	6.1	Apr-Jun 2008	5.4	Apr-Jun 2012	6.4
May-Jul 2004	6.1	May-Jul 2008	5.4	May-Jul 2012	6.6
Jun-Aug 2004	6.2	Jun-Aug 2008	5.4	Jun-Aug 2012	6.5
Jul-Sep 2004	6.1	Jul-Sep 2008	5.4	Jul-Sep 2012	6.4
Aug-Oct 2004	6.1	Aug-Oct 2008	5.4	Aug-Oct 2012	6.5
Sep-Nov 2004	6	Sep-Nov 2008	5.5	Sep-Nov 2012	6.5
Oct-Dec 2004	6.1	Oct-Dec 2008	5.5	Oct-Dec 2012	6.5
Nov-Jan 2005	6	Nov-Jan 2009	5.6		
Dec-Feb 2005	6	Dec-Feb 2009	5.6		
Jan-Mar 2005	5.9	Jan-Mar 2009	5.6		
Feb-Apr 2005	5.8	Feb-Apr 2009	5.6		
Mar-May 2005	5.8	Mar-May 2009	5.6		
Apr-Jun 2005	5.8	Apr-Jun 2009	5.7		
May-Jul 2005	5.9	May-Jul 2009	5.7		
Jun-Aug 2005	5.9	Jun-Aug 2009	5.7		
Jul-Sep 2005	5.9	Jul-Sep 2009	5.8		
Aug-Oct 2005	5.7	Aug-Oct 2009	5.7		
Sep-Nov 2005	5.7	Sep-Nov 2009	5.7		
Oct-Dec 2005	5.6	Oct-Dec 2009	5.8		

Appendix 2 – Dissertation's code based on SIC2007

Dissertation industry code	SIC07	Description
1	**1**	Crop and animal production, hunting and related service activities
2	**2**	Forestry and logging
3	**3**	Fishing and aquaculture
5	**5**	Mining of coal and lignite
	6	Extraction of crude petroleum and natural gas
	7	Mining of metal ores
	8	Other mining and quarrying
	9	Mining support service activities
10	**10**	Manufacture of food products
	11	Manufacture of beverages
	12	Manufacture of tobacco products
13	**13**	Manufacture of textiles
	14	Manufacture of wearing apparel
	15	Manufacture of leather and related products
16	**16**	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
17	**17**	Manufacture of paper and paper products
18	**18**	Printing and reproduction of recorded media
19	**19**	Manufacture of coke and refined petroleum products
20	**20**	Manufacture of chemicals and chemical products
21	**21**	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	**22**	Manufacture of rubber and plastic products
23	**23**	Manufacture of other non-metallic mineral products
24	**24**	Manufacture of basic metals
25	**25**	Manufacture of fabricated metal products, except machinery and equipment
26	**26**	Manufacture of computer, electronic and optical products
27	**27**	Manufacture of electrical equipment
28	**28**	Manufacture of machinery and equipment n.e.c.
29	**29**	Manufacture of motor vehicles, trailers and semi-trailers
30	**30**	Manufacture of other transport equipment
31	**31**	Manufacture of furniture
	32	Other manufacturing
	33	Repair and installation of machinery and equipment
35	**35**	Electricity, gas, steam and air conditioning supply
36	**36**	Water collection, treatment and supply
37	**37**	Sewerage
	38	Waste collection, treatment and disposal activities; materials recovery
	39	Remediation activities and other waste management services.
43	**41**	Construction of buildings
	42	Civil engineering
	43	Specialised construction activities
45	**45**	Wholesale and retail trade and repair of motor vehicles and motorcycles
46	**46**	Wholesale trade, except of motor vehicles and motorcycles
47	**47**	Retail trade, except of motor vehicles and motorcycles
49	**49**	Land transport and transport via pipelines
50	**50**	Water transport
51	**51**	Air transport
52	**52**	Warehousing and support activities for transportation
53	**53**	Postal and courier activities
55	**55**	Accommodation
	56	Food and beverage service activities
58	**58**	Publishing activities
59	**59**	Motion picture, video and television programme production, sound recording and music publishing activities
	60	Programming and broadcasting activities
61	**61**	Telecommunications
62	**62**	Computer programming, consultancy and related activities
	63	Information service activities
64	**64**	Financial service activities, except insurance and pension funding
65	**65**	Insurance, reinsurance and pension funding, except compulsory social security
66	**66**	Activities auxiliary to financial services and insurance activities
68	**68**	Real estate activities
69	**69**	Legal and accounting activities
	70	Activities of head offices; management consultancy activities
71	**71**	Architectural and engineering activities; technical testing and analysis
72	**72**	Scientific research and development
73	**73**	Advertising and market research
74	**74**	Other professional, scientific and technical activities
	75	Veterinary activities
77	**77**	Rental and leasing activities
78	**78**	Employment activities
79	**79**	Travel agency, tour operator and other reservation service and related activities
80	**80**	Security and investigation activities
	81	Services to buildings and landscape activities
	82	Office administrative, office support and other business support activities
84	**84**	Public administration and defence; compulsory social security
85	**85**	Education
86	**86**	Human health activities
87	**87**	Residential care activities
	88	Social work activities without accommodation
90	**90**	Creative, arts and entertainment activities
	91	Libraries, archives, museums and other cultural activities
	92	Gambling and betting activities
93	**93**	Sports activities and amusement and recreation activities
94	**94**	Activities of membership organisations
95	**95**	Repair of computers and personal and household goods
96	**96**	Other personal service activities

Appendix 3 – Mapping SIC92 with SIC03 and SIC07

SIC 1992	SIC 2003 (4 digits)	SIC 2003 (2 digits)	SIC2007	FINALLY MAPPED
Value = -8	Label = Does not apply		-8	
Value = 1	Label = 01.11:Growing cereals, other crops	1	1	
Value = 2	Label = 01.12:Growing veg,horticulture,nursery		1	
Value = 3	Label = 01.13:Grwg.fruit,nut,beverge,spice crop		1	
Value = 4	Label = 01.21:Farming cattle,dairy		1	
Value = 5	Label = 01.22:Farming sheep,goats,horses etc		1	
Value = 6	Label = 01.23:Farming pigs		1	
Value = 7	Label = 01.24:Farming poultry		1	
Value = 8	Label = 01.25:Farming other animals		1	
Value = 9	Label = 01.30:Mixed farming (crops & animals)		1	
Value = 10	Label = 01.41:Agricultural services:		1	
Value = 11	Label = 01.42:Animal husbdry service (not vet)		1	
Value = 12	Label = 01.50:Hunting,trapping,game etc		1	
Value = 13	Label = 02.01:Forestry,logging	2	2	
Value = 14	Label = 02.02:Forestry,logging services		2	
Value = 15	Label = 05.01:Fishing	5	3	
Value = 16	Label = 05.02:Fish hatcheries,farms		3	
Value = 17	Label = 10.101:Deep coal mines	10	5	
Value = 18	Label = 10.102:Opencast coal working		5	
Value = 19	Label = 10.103:Solid fuel manufacture		5	
Value = 20	Label = 10.20:Lignite mining,agglomeration		5	
Value = 21	Label = 10.30:Peat extraction,agglomeration		8	
Value = 22	Label = 11.10:Crude oil,gas extraction	11	6	
Value = 23	Label = 11.20:Oil,gas services (not surveying)		9	
Value = 24	Label = 12.00:Uranium,thorium ore mining	12	7	
Value = 25	Label = 13.10:Iron ore mining	13	7	
Value = 26	Label = 13.20:Non-ferrous mine.(not Uran,Thor)		7	
Value = 27	Label = 14.11:Quarrying construction stone	14	8	
Value = 28	Label = 14.12:Limestone,gypsum,chalk quarrying		8	
Value = 29	Label = 14.13:Slate quarrying		8	
Value = 30	Label = 14.21:Gravel,sand pits		8	
Value = 31	Label = 14.22:Clay,kaolin mining		8	
Value = 32	Label = 14.30:Chemical,fertiliser mining		8	
Value = 33	Label = 14.40:Salt production		8	
Value = 34	Label = 14.50:Other mining,quarrying		8	
Value = 35	Label = 15.111:Slaught'ng (not poultry,rabbit)	15	10	
Value = 36	Label = 15.112:Animal by-product processing		10	
Value = 37	Label = 15.113:Fellmongery		10	
Value = 38	Label = 15.12:Poultry production,preserving		10	
Value = 39	Label = 15.13:Meat,poultry products		10	
Value = 40	Label = 15.20:Fish,fish products,preserving		10	
Value = 41	Label = 15.31:Potato products,preserving		10	
Value = 42	Label = 15.32:Fruit,vegetable juice processing		10	
Value = 43	Label = 15.33:Other fruit,veg processing		10	
Value = 44	Label = 15.41:Crude oils,fats manufacture		10	
Value = 45	Label = 15.42:Refined oils,fats manufacture		10	
Value = 46	Label = 15.43:Margarine,edible fat manufacture		10	
Value = 47	Label = 15.51:Dairies,cheese making		10	
Value = 48	Label = 15.52:Ice cream manufacture		10	
Value = 49	Label = 15.61:Grain,mill products		10	
Value = 50	Label = 15.62:Starches,starch products		10	
Value = 51	Label = 15.71:Farm animal feed manufacture		10	
Value = 52	Label = 15.72:Pet food manufacture		10	
Value = 53	Label = 15.81:Bread,fresh pastry,cakes manufact.		10	
Value = 54	Label = 15.82:Biscuits,rusks,preserved pastries		10	
Value = 55	Label = 15.83:Sugar manufacture		10	
Value = 56	Label = 15.84:Chocolate,cocoa,sugar confect'y		10	
Value = 57	Label = 15.85:Macaroni,noodles,couscous etc		10	
Value = 58	Label = 15.86:Tea,coffee manufacture		10	
Value = 59	Label = 15.87:Condiment,seasoning manufacture		10	
Value = 60	Label = 15.88:Homogenised,dietetic food products		10	
Value = 61	Label = 15.89:Other food products manufacture		10	
Value = 62	Label = 15.91:Distilled alcoholic drinks		11	
Value = 63	Label = 15.92:Ethyl alcohol from fermentation		11	
Value = 64	Label = 15.93:Wine production		11	
Value = 65	Label = 15.94:Cider,other fruit wine production		11	
Value = 66	Label = 15.95:Non-distilled fermented drinks		11	
Value = 67	Label = 15.96:Beer production		11	
Value = 68	Label = 15.97:Malt production		11	
Value = 69	Label = 15.98:Mineral water,soft drink prodctn.		11	

SIC 1992	SIC 2003	SIC 2003 (2 digits)	SIC2007	FINALLY MAPPED
Value = 70	Label = 16.00:Tobacco products	16	12	
Value = 71	Label = 17.11:Cotton fibre preparation	17	13	
Value = 72	Label = 17.12:Wool fibre preparation		13	
Value = 73	Label = 17.13:Worsted fibre preparation		13	
Value = 74	Label = 17.14:Flax fibre preparation		13	
Value = 75	Label = 17.15:Silk,synthetic preparation		13	
Value = 76	Label = 17.16:Sewing thread manufacture		13	
Value = 77	Label = 17.17:Other textile preparation		13	
Value = 78	Label = 17.21:Cotton weaving		13	
Value = 79	Label = 17.22:Woollen weaving		13	
Value = 80	Label = 17.23:Worsted weaving		13	
Value = 81	Label = 17.24:Silk weaving		13	
Value = 82	Label = 17.25:Other textile weaving		13	
Value = 83	Label = 17.30:Textile finishing		13	
Value = 84	Label = 17.401:Soft furnishing manufacture		13	
Value = 85	Label = 17.402:Canvas,sacks etc manufacture		13	
Value = 86	Label = 17.403:Household textiles manufacture		13	
Value = 87	Label = 17.511-2:Woven,tufted carpets,rugs manu.		13	
Value = 88	Label = 17.513:Other carpets,rugs manufacture		13	
Value = 89	Label = 17.52:Cordage,rope,twine manufacture		13	
Value = 90	Label = 17.53:Non-woven articles (not clothing)		13	
Value = 91	Label = 17.541:Lace manufacture		13	
Value = 92	Label = 17.542:Narrow fabrics manufacture		13	
Value = 93	Label = 17.543:Other textiles manufacture		13	
Value = 94	Label = 17.60:Knitted,crocheted fabric manuf.		13	
Value = 95	Label = 17.71:Knitted,crocheted hosiery manuf.		14	
Value = 96	Label = 17.72:Knitted,crocheted clothing		14	
Value = 97	Label = 18.10:Leather clothing manufacture	18	14	
Value = 98	Label = 18.21:Workwear manufacture		14	
Value = 99	Label = 18.221:Other mens outerwear manufacture		14	
Value = 100	Label = 18.222:Other womens outerwear manuf.		14	
Value = 101	Label = 18.231:Mens underwear manufacture		14	
Value = 102	Label = 18.232:Womens underwear manufacture		14	
Value = 103	Label = 18.241:Hat manufacture		14	
Value = 104	Label = 18.242:Other apparel,accessories manuf.		14	
Value = 105	Label = 18.30:Fur processing		14	
Value = 106	Label = 19.10:Leather tanning,dressing	19	15	
Value = 107	Label = 19.20:Luggage,handbags,saddlery manuf.		15	
Value = 108	Label = 19.30:Footwear manufacture		15	
Value = 109	Label = 20.10:Wood sawmill,planing,impregnation	20	16	
Value = 110	Label = 20.20:Wood veneer,plywood,etc production		16	
Value = 111	Label = 20.30:Builders carpentry,joinery		16	
Value = 112	Label = 20.40:Wooded containers manufacture		16	
Value = 113	Label = 20.51:Other wood products manufacture		16	
Value = 114	Label = 20.52:Cork,straw,etc manufacture		16	
Value = 115	Label = 21.11:Pulp manufacture	21	17	
Value = 116	Label = 21.12:Paper,card manufacture		17	
Value = 117	Label = 21.211:Paper board,sacks,bags manuf.		17	
Value = 118	Label = 21.212:Cartons,boxes,etc manufacture		17	
Value = 119	Label = 21.22:Sanitary,toilet requis. production		17	
Value = 120	Label = 21.23:Paper stationary manufacture		17	
Value = 121	Label = 21.24:Wallpaper manufacture		17	
Value = 122	Label = 21.25:Other paper articles manufacture		17	
Value = 123	Label = 22.11:Book publishing	22	58	
Value = 124	Label = 22.12:Newspaper publishing		58	
Value = 125	Label = 22.13:Journal,periodical publishing		58	
Value = 126	Label = 22.14:Sound recording publishing		58	
Value = 127	Label = 22.15:Other publishing		58	
Value = 128	Label = 22.21:Newspaper printing		18	
Value = 129	Label = 22.22:Other printing		18	
Value = 130	Label = 22.23:Bookbinding,finishing		18	
Value = 131	Label = 22.24:Composition,plate-making		18	
Value = 132	Label = 22.25:Other printing activities		18	
Value = 133	Label = 22.31:Reproduction of sound recording		18	
Value = 134	Label = 22.32:Reproduction of video recording		18	
Value = 135	Label = 22.33:Reproduction of computer media		18	
Value = 136	Label = 23.10:Coke oven products manufacture	23	19	
Value = 137	Label = 23.201:Mineral oil refining		19	
Value = 138	Label = 23.202:Other treatment petrol products		19	
Value = 139	Label = 23.30:Nuclear fuel processing		24	
Value = 140	Label = 24.11:Industrial gas manufacture	24	20	
Value = 141	Label = 24.12:Dye,pigment manufacture		20	
Value = 142	Label = 24.13:Inorganic chemical manufacture		20	

SIC 1992	SIC 2003	SIC 2003 (2 digits)	SIC2007	FINALLY MAPPED
Value = 143	Label = 24.14:Organic chemical manufacture		20	
Value = 144	Label = 24.15:Fertilizer,etc manufacture		20	
Value = 145	Label = 24.16:Primary plastics manufacture		20	
Value = 146	Label = 24.17:Primary synthetic rubber		20	
Value = 147	Label = 24.20:Pesticides,etc manufacture		20	
Value = 148	Label = 24.301&3:Paint,varnsh,mastic,sealnt man		20	
Value = 149	Label = 24.302:Printing ink manufacture		20	
Value = 150	Label = 24.41:Basic pharmaceutical manufacture		21	
Value = 151	Label = 24.42:Pharmaceutical preparations man.		21	
Value = 152	Label = 24.511:Soap,detergent manufacture		20	
Value = 153	Label = 24.512:Cleaning,polishing agent man.		20	
Value = 154	Label = 24.52:Perfumes,etc manufacture		20	
Value = 155	Label = 24.61:Explosives manufacture		20	
Value = 156	Label = 24.62:Glues,etc manufacture		20	
Value = 157	Label = 24.63:Essential oils manufacture		20	
Value = 158	Label = 24.64:Photographic chemicals man.		20	
Value = 159	Label = 24.65:Recording media manufacture		20	
Value = 160	Label = 24.66:Other chemical products man.		20	
Value = 161	Label = 24.70:Man-made fibres manufacture		20	
Value = 162	Label = 25.11:Rubber tyres,etc manufacture	25	22	
Value = 163	Label = 25.12:Rubber tyres retreading etc		22	
Value = 164	Label = 25.13:Other rubber products manufacture		22	
Value = 165	Label = 25.21:Plastic sheets,tubes,etc man.		22	
Value = 166	Label = 25.22:Plastic packing manufacture		22	
Value = 167	Label = 25.231:Plastic flooring manufacture		22	
Value = 168	Label = 25.232:Other plastic builders ware		22	
Value = 169	Label = 25.24:Other plastic products		22	
Value = 170	Label = 26.11:Flat glass manufacture	26	23	
Value = 171	Label = 26.12:Flat glass shaping,processing		23	
Value = 172	Label = 26.13:Hollow glass manufacture		23	
Value = 173	Label = 26.14:Glass fibre manufacture		23	
Value = 174	Label = 26.15:Other glass proc,manufacture		23	
Value = 175	Label = 26.21:Ceramic hhld,ornamental man.		23	
Value = 176	Label = 26.22:Ceramic sanitary fixtures man.		23	
Value = 177	Label = 26.23:Ceramic insulators etc man.		23	
Value = 178	Label = 26.24:Other technical ceramic man.		23	
Value = 179	Label = 26.25:Other ceramic manufacture		23	
Value = 180	Label = 26.26:Refractory ceramic manufacture		23	
Value = 181	Label = 26.30:Ceramic tile,flags manufacture		23	
Value = 182	Label = 26.40:Bricks,tiles etc manufacture		23	
Value = 183	Label = 26.51:Cement manufacture		23	
Value = 184	Label = 26.52:Lime manufacture		23	
Value = 185	Label = 26.53:Plaster manufacture		23	
Value = 186	Label = 26.61:Concrete prods(construction)man.		23	
Value = 187	Label = 26.62:Plaster products(construction)man.		23	
Value = 188	Label = 26.63:Ready-mixed concrete manufacture		23	
Value = 189	Label = 26.64:Mortars manufacture		23	
Value = 190	Label = 26.65:Fibre cement manufacture		23	
Value = 191	Label = 26.66:Other concrete,plaster,etc man.		23	
Value = 192	Label = 26.70:Stone cutting,shaping		23	
Value = 193	Label = 26.81:Abrasive products manufacture		23	
Value = 194	Label = 26.821:Asbestos manufacture		23	
Value = 195	Label = 26.822:Oath non-metal mineral prod man.		23	
Value = 196	Label = 27.10:Basic iron,steel,ferro-alloys man.	27	24	
Value = 197	Label = 27.21:Cast iron tubes manufacture		24	
Value = 198	Label = 27.22:Steel tubes manufacture		24	
Value = 199	Label = 27.31:Cold drawing		24	
Value = 200	Label = 27.32:Cold rolling(narrow strip)		24	
Value = 201	Label = 27.33:Cold forming,folding		24	
Value = 202	Label = 27.34:Wire drawing		24	
Value = 203	Label = 27.35:Other 1st proc iron,steel		24	
Value = 204	Label = 27.41:Precious metals production		24	
Value = 205	Label = 27.42:Aluminium production		24	
Value = 206	Label = 27.43:Lead,zinc,tin production		24	
Value = 207	Label = 27.44:Copper production		24	
Value = 208	Label = 27.45:Other non-metal production		24	
Value = 209	Label = 27.51:Iron casting		24	
Value = 210	Label = 27.52:Steel casting		24	
Value = 211	Label = 27.53:Light metals casting		24	
Value = 212	Label = 27.54:Other non-ferrous casting		24	
Value = 213	Label = 28.11:Metal structures etc manufacture	28	25	
Value = 214	Label = 28.12:Builders metal work		25	
Value = 215	Label = 28.21:Metal containers manufacture		25	

SIC 1992	SIC 2003	SIC 2003 (2 digits)	SIC2007	FINALLY MAPPED
Value = 216	Label = 28.22:Radiators,boilers manufacture		25	
Value = 217	Label = 28.30:Steam generators manufacture		25	
Value = 218	Label = 28.40:Forging,pressing etc		25	
Value = 219	Label = 28.51:Treatment,coating of metals		25	
Value = 220	Label = 28.52:General mech engineering		25	
Value = 221	Label = 28.61:Cutlery manufacture		25	
Value = 222	Label = 28.62:Tools manufacture		25	
Value = 223	Label = 28.63:Locks,hinges etc manufacture		25	
Value = 224	Label = 28.71:Steel drums etc manufacture		25	
Value = 225	Label = 28.72:Light metal packaging manufacture		25	
Value = 226	Label = 28.73:Wire products manufacture		25	
Value = 227	Label = 28.74:Fasteners,chains etc manufacture		25	
Value = 228	Label = 28.75:Other metal products manufacture		25	
Value = 229	Label = 29.11:Engines,turbines (not aircraft)	29	28	
Value = 230	Label = 29.121:Pumps manufacture		28	
Value = 231	Label = 29.122:Compressors manufacture		28	
Value = 232	Label = 29.13:Taps,valves manufacture		28	
Value = 233	Label = 29.14:Bearings,gears etc manufacture		28	
Value = 234	Label = 29.21:Furnace manufacture		28	
Value = 235	Label = 29.22:Lifting,handling eqt manufacture		28	
Value = 236	Label = 29.23:Cool.,ventilat eqt(not domestic)		28	
Value = 237	Label = 29.24:Other gen purpose mach manufacture		28	
Value = 238	Label = 29.31:Agricultural tractors manufacture		28	
Value = 239	Label = 29.32:Other agric.,forestry mach. man.		28	
Value = 240	Label = 29.40:Machine tool manufacture		28	
Value = 241	Label = 29.51:Metallurgy mach manufacture		28	
Value = 242	Label = 29.521+3:Concrete,mining,roadwk mch man.		28	
Value = 243	Label = 29.522:Earthmoving eqt		28	
Value = 244	Label = 29.53:Food,tobacco proc mach		28	
Value = 245	Label = 29.54:Textile etc ,leather mach man.		28	
Value = 246	Label = 29.55:Paper etc prod mach manufacture		28	
Value = 247	Label = 29.56:Other special purpose mach man.		28	
Value = 248	Label = 29.60:Weapons,ammunition manufacture		25	
Value = 249	Label = 29.71:Elec domestic appliances man.		27	
Value = 250	Label = 29.72:Non elec domestic appliances man.		27	
Value = 251	Label = 30.01:Office mach manufacture	30	26	
Value = 252	Label = 30.02:Computers, IT eqt manufacture		26	
Value = 253	Label = 31.10:Elec motors,gentors,trans man.	31	27	
Value = 254	Label = 31.20:Elec distribution, control man.		27	
Value = 255	Label = 31.30:Insulated cable manufacture		27	
Value = 256	Label = 31.40:Electric battery manufacture		27	
Value = 257	Label = 31.50:Lighting eqt manufacture		27	
Value = 258	Label = 31.61:Other elec eqt (engines/veh) man.		27	
Value = 259	Label = 31.62:Other elec eqt manufacture		27	
Value = 260	Label = 32.10:Electronic components etc man.	32	26	
Value = 261	Label = 32.201:Telegraph,telephone eqt man.		26	
Value = 262	Label = 32.202:Radio,electronic goods manuf.		26	
Value = 263	Label = 32.30:TV,radio,HiFi etc eqt manufacture		26	
Value = 264	Label = 33.10:Medical eqt,appliances manufacture	33	26	
Value = 265	Label = 33.20:Testing,navigating etc eqt man.		26	
Value = 266	Label = 33.30:Industrial proc control eqt man.		26	
Value = 267	Label = 33.401:Spectacles,lens manufacture		26	
Value = 268	Label = 33.402:Optical precision eqt manufacture		26	
Value = 269	Label = 33.403:Photographic,cinema eqt man.		26	
Value = 270	Label = 33.50:Watches,clock manufacture		26	
Value = 271	Label = 34.10:Motor veh manufacture	34	29	
Value = 272	Label = 34.201:Motor veh bodywork manufacture:		29	
Value = 273	Label = 34.202:Trailers manufacture		29	
Value = 274	Label = 34.203:Caravan manufacture		29	
Value = 275	Label = 34.30:Motor veh parts etc manufacture		29	
Value = 276	Label = 35.11:Ship building,repairing	35	30	33
Value = 277	Label = 35.12:Boat building,repairing		30	33
Value = 278	Label = 35.20:Rail,tram rolling stk etc man.		30	
Value = 279	Label = 35.30:Aircraft,spacecraft manufacture		30	
Value = 280	Label = 35.41:Motorcycle manufacture		30	
Value = 281	Label = 35.42:Bicycle manufacture		30	
Value = 282	Label = 35.43:Invalid carriage manufacture		30	
Value = 283	Label = 35.50:Other transport eqt manufacture		30	
Value = 284	Label = 36.11:Chairs etc manufacture	36	31	
Value = 285	Label = 36.12:Other office,shop furniture man.		31	
Value = 286	Label = 36.13:Other kitchen furniture man.		31	
Value = 287	Label = 36.14:Other furniture manufacture		31	
Value = 288	Label = 36.15:Mattresses manufacture		31	

SIC 1992	SIC 2003	SIC 2003 (2 digits)	SIC2007	FINALLY MAPPED
Value = 289	Label = 36.21:Coins,medal manufacture		32	
Value = 290	Label = 36.22:Jewellery etc manufacture		32	
Value = 291	Label = 36.30:Musical instruments manufacture		32	
Value = 292	Label = 36.40:Sports goods manufacture		32	
Value = 293	Label = 36.501:Arcade games etc manufacture		32	
Value = 294	Label = 36.502:Other games,toys etc manufacture		32	
Value = 295	Label = 36.61:Imitation jewellery manufacture		32	
Value = 296	Label = 36.62:Brooms,brushes etc manufacture		32	
Value = 297	Label = 36.631:Stationers goods manufacture		32	
Value = 298	Label = 36.632:Other manufacture		32	
Value = 299	Label = 37.10:Metal scrap recycling	37	38	
Value = 300	Label = 37.20:Non-metal scrap recycling		38	
Value = 301	Label = 40.10:Elec generation,supply	40	35	
Value = 302	Label = 40.20:Gas production supply		35	
Value = 303	Label = 40.30:Steam,hot water supply		35	
Value = 304	Label = 41.00:Water supply etc	41	36	
Value = 305	Label = 45.11-45.50:Building demol.,earth moving	45	43	41
Value = 306	Label = 50.10+50.30+50.50:Sales motors,parts,etc	50	45	
Value = 307	Label = 50.20:Motor veh repair		45	
Value = 308	Label = 50.40:Motorcycle sale,repair etc		45	
Value = 309	Label = 51.11-51.19:Wsale on fee,contract basis	51	46	
Value = 310	Label = 51.21-51.70:Wholesale		46	
Value = 311	Label = 51.57:Wsale waste,scrap		46	
Value = 312	Label = 52.11-52.63:Retail trade	52	47	
Value = 313	Label = 52.71:Repair leather articles		95	
Value = 314	Label = 52.72:Repair elec hhld goods		95	
Value = 315	Label = 52.73:Repair watches,clocks etc		95	
Value = 316	Label = 52.74:Other repair		95	
Value = 317	Label = 55.11:Hotels,motels with restaurant	55	55	
Value = 318	Label = 55.12:Hotels,motels without restaurant		55	
Value = 319	Label = 55.21:Youth hostel,mountain refuge		55	
Value = 320	Label = 55.22:Camping,caravan sites		55	
Value = 321	Label = 55.23:Other provision of lodgings		56	
Value = 322	Label = 55.301-2:Licenced,unlicenced restaurants		56	
Value = 323	Label = 55.303:Take-away food shops		56	
Value = 324	Label = 55.401:Licenced clubs with entertainment		56	
Value = 325	Label = 55.402:Public houses,bars		56	
Value = 326	Label = 55.51:Canteens		56	
Value = 327	Label = 55.52:Catering		56	
Value = 328	Label = 60.10:Transport via railway	60	49	
Value = 329	Label = 60.21:Other scheduled land transport		49	
Value = 330	Label = 60.22:Taxi		49	
Value = 331	Label = 60.23:Other passenger land transport		49	
Value = 332	Label = 60.24:Freight transport by road		49	
Value = 333	Label = 60.30:Transport via pipelines		49	
Value = 334	Label = 61.10:Sea,coastal water transport	61	50	
Value = 335	Label = 61.20:Inland water transport		50	
Value = 336	Label = 62.10:Scheduled air transport	62	51	
Value = 337	Label = 62.20:Non-scheduled air transport		51	
Value = 338	Label = 62.30:Space transport		51	
Value = 339	Label = 63.11:Cargo handling	63	52	
Value = 340	Label = 63.12:Storage,warehousing		52	
Value = 341	Label = 63.21:Other land transport activities		52	
Value = 342	Label = 63.22:Other water transport activities		52	
Value = 343	Label = 63.23:Other air transport activities		52	
Value = 344	Label = 63.301-3:Travel agenc.,organisers,guides		79	
Value = 345	Label = 63.304:Other tourist assistance		79	
Value = 346	Label = 63.40:Other transport agencies		79	
Value = 347	Label = 64.11:National post activities	64	53	
Value = 348	Label = 64.12:Courier activ. (not natnl. Post)		53	
Value = 349	Label = 64.20:Telecommunications		61	
Value = 350	Label = 65.11:Central banking	65	64	
Value = 351	Label = 65.121:Banks		64	
Value = 352	Label = 65.122:Building societies		64	
Value = 353	Label = 65.21:Financial leasing		64	
Value = 354	Label = 65.22:Other credit granting		64	
Value = 355	Label = 65.231-6:Unit,inv trusts,hlding co etc		64	
Value = 356	Label = 65.233:Securities dealing for self		64	
Value = 357	Label = 66.01:Life insurance	66	65	
Value = 358	Label = 66.02:Pension funding		65	
Value = 359	Label = 66.03:Non-life insurance		65	
Value = 360	Label = 67.11:Financial market administration	67	66	
Value = 361	Label = 67.12:Securities,fund management		66	

SIC 1992	SIC 2003	SIC 2003 (2 digits)	SIC2007	FINALLY MAPPED
Value = 362	Label = 67.13:Other financial intermed. activ.		66	
Value = 363	Label = 67.20:Other insurance activities		66	
Value = 364	Label = 70.11:Development,sale of real estate	70	68	
Value = 365	Label = 70.12:Buying,selling real estate,self		68	
Value = 366	Label = 70.20:Letting own property		68	
Value = 367	Label = 70.31:Real estate agency		68	
Value = 368	Label = 70.32:Management of real estate		68	
Value = 369	Label = 71.10:Car rental	71	77	
Value = 370	Label = 71.21:Other land transport rental		77	
Value = 371	Label = 71.22:Water transport eqt rental		77	
Value = 372	Label = 71.23:Air transport eqt rental		77	
Value = 373	Label = 71.31:Agricultural mach,eqt rental		77	
Value = 374	Label = 71.32:Construction mach,eqt rental		77	
Value = 375	Label = 71.33:Office mach,eqt rental		77	
Value = 376	Label = 71.34:Other mach,eqt rental		77	
Value = 377	Label = 71.40:Person,hhld eqt rental		77	
Value = 378	Label = 72.10:Computer hardware consultancy	72	62	
Value = 379	Label = 72.20:Computer software consultancy		62	
Value = 380	Label = 72.30:Data processing		63	
Value = 381	Label = 72.40:Data base activities		63	
Value = 382	Label = 72.50:Repair of office,computer eqt		95	
Value = 383	Label = 72.60:Other computer activities		62	
Value = 384	Label = 73.10:Research,natural sciences,engin.	73	72	
Value = 385	Label = 73.20:Res.,social sciences,humanities		72	
Value = 386	Label = 74.11:Legal activities	74	69	
Value = 387	Label = 74.12:Accountng,auditng,tax consultancy		69	
Value = 388	Label = 74.13:Market,opinion research		73	
Value = 389	Label = 74.14:Business,management consultancy		70	
Value = 390	Label = 74.15:Managemnt activities,holding comps		70	
Value = 391	Label = 74.20:Archit.,engineering,etc consultncy		71	
Value = 392	Label = 74.30:Technical testing,analysis		71	
Value = 393	Label = 74.40:Advertising		71	
Value = 394	Label = 74.50:Labour,personnel recruitment		78	
Value = 395	Label = 74.60:Investigation,security services		80	
Value = 396	Label = 74.70:Industrial cleaning		81	
Value = 397	Label = 74.81:Photographic activities		74	
Value = 398	Label = 74.82:Packaging activities		82	
Value = 399	Label = 74.83:Secretarial,translation		74	
Value = 400	Label = 74.84:Other business activities		82	
Value = 401	Label = 75.11:General public service activities	75	84	
Value = 402	Label = 75.12:Reguln Govt agency (not Soc Sec)		84	
Value = 403	Label = 75.13:Development of Govt agencies		84	
Value = 404	Label = 75.14:Support of Govt as a whole		84	
Value = 405	Label = 75.21:Foreign affairs		84	
Value = 406	Label = 75.22:Defence		84	
Value = 407	Label = 75.23:Justice and judicial activities		84	
Value = 408	Label = 75.24:Public security,law and order etc		84	
Value = 409	Label = 75.25:Fire service		84	
Value = 410	Label = 75.30:Compulsory Social Security activ.		84	
Value = 411	Label = 80.10:Primary educ,state,maintained	80	85	
Value = 412	Label = 80.10:Primary educ,priv.,non-maintained		85	
Value = 413	Label = 80.21:Gen. 2ndry educ,state,maintained		85	
Value = 414	Label = 80.21:Gen. 2ndry educ,private,non-main.		85	
Value = 415	Label = 80.22:Tech,vocational 2nd-ary educ		85	
Value = 416	Label = Special educ,state,maintained		85	
Value = 417	Label = Special educ,private non-maintained		85	
Value = 418	Label = 80.301:Sub-degree level educ		85	
Value = 419	Label = 80.302+3:First & post degree level educ.		85	
Value = 420	Label = 80.41:Driving school activities		85	
Value = 421	Label = 80.42:Adult,other educ		85	
Value = 422	Label = 85.11:Hospital activities	85	86	
Value = 423	Label = 85.12:Medical practice activities		86	
Value = 424	Label = 85.13:Dental practice activities		86	
Value = 425	Label = 85.14:Other human health activities		86	
Value = 426	Label = 85.20:Veterinary activities		75	
Value = 427	Label = 85.31:Social work with accom		87	
Value = 428	Label = 85.32:Social work without accom		88	
Value = 429	Label = 90.00:Sewage,refuse disposal etc	90	37	
Value = 430	Label = 91.11:Business,employers organisations	91	94	
Value = 431	Label = 91.12:Professional organisations		94	
Value = 432	Label = 91.20:Trade unions		94	
Value = 433	Label = 91.31:Religious organisations		94	
Value = 434	Label = 91.32:Political organisations		94	

SIC 1992	SIC 2003	SIC 2003 (2 digits)	SIC2007	FINALLY MAPPED
Value = 435	Label = 91.33:Other membership organisations		94	
Value = 436	Label = 92.11:Motion picture,video production	92	59	
Value = 437	Label = 92.12:Motion picture,video distribution		59	
Value = 438	Label = 92.13:Motion picture projection		59	
Value = 439	Label = 92.20:Radio,TV activities		60	
Value = 440	Label = 92.31:Artistic,literary creation etc		90	
Value = 441	Label = 92.32:Arts facilities		90	
Value = 442	Label = 92.33:Fair,amusement park activities		93	
Value = 443	Label = 92.34:Other entertainment activities		93	
Value = 444	Label = 92.40:News agency activities		63	
Value = 445	Label = 92.51:Library,archive activities		91	
Value = 446	Label = 92.52:Museum activities		91	
Value = 447	Label = 92.53:Botanical,zoological gardens etc		91	
Value = 448	Label = 92.61:Operation of sports arenas,stadia		93	
Value = 449	Label = 92.62:Other sporting activities		93	
Value = 450	Label = 92.71:Gambling,betting activities		92	
Value = 451	Label = 92.72:Other recreational activities		92	
Value = 452	Label = 93.01:Washing,dry cleaning textiles,furs	93	96	
Value = 453	Label = 93.02:Hairdressing,oth beauty treatment		96	
Value = 454	Label = 93.03:Funeral etc		96	
Value = 455	Label = 93.04:Physical well-being activities		96	
Value = 456	Label = 93.05:Other service activities		96	
Value = 457	Label = 95.00:Priv. hhlds with emplyed persons	95	97	98
Value = 458	Label = 99.00:Extra-territorial organisations	99	99	
Value = 459	Label = Inadequate description,No reply			
Value = 461	Label = Workplace outside UK			

Appendix 4 – Individuals with dropped professions – based on variable inecac05 of the Labour Force Survey (See LFS User Guide – Variables)

Individuals with dropped professions
drop if inecac05 == 3
drop if inecac05 == 4
drop if inecac05 == 5
drop if inecac05 == 6
drop if inecac05 == 7
drop if inecac05 == 8
drop if inecac05 == 9
drop if inecac05 == 10
drop if inecac05 == 11
drop if inecac05 == 12
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drop if inecac05 == 27
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drop if inecac05 == 29
drop if inecac05 == 30
drop if inecac05 == 31
drop if inecac05 == 22
drop if inecac05 == 33
drop if inecac05 == 34

Appendix 5 - Table 4.14 – Marginal Rate of Substitution (MRS) between Total Labour and Net Capital Stock (NCS) – All industries – 1 total working hour compensated wit £ of NCS

DEA All industries					Regression Targets		DEA Peer industries		
MRS TOT-NCS	DMU	Description	Average MRS	Crisis Effects	TOTAL_T COEFF	NCS COEFF	TOT_NCS PEERS	Average PEERS	Crisis Effects PEERS
Lowest: 231 OBS	13	Textiles-Apparel-Leather	£12.6 (0.126)	£4,9 (0.0497)	0.955	4.692	Lowest	£9.7 (0.097)	£6 (0.06)
£1.7 -20 (0.017-0.2)	16	Wood	£6 (0.06)	£6.80 -0.0686	*0*	*0*	£2.2 -£16	£5.90 -0.060	£5.87 (0.0587)
	17	Paper		INCREASE			0.022 -0.16		DECREASE
	27	Electrical equipment			Adj R-squared	0.859			
	45	Wholesale&Retail &Repair of Motorvehicles							
	46	Wholesale trade							
	53	Postal & Courier							
	66	Auxiliary to fiancing							
	69	Legal and Accounting							
	71	Architectural and Engineering							
	73	Advertising and Market Rsearch							
	74	Other prof, scientific, technical & Veterinary							
	78	Employment Activities							
	79	Travel Agencies					Low: £11-£51 (0.11 -0.51)	£25.7 (0.257)	DECREASE: £29 (0.290991017) - £17 (0.173897971)
	85	Education							
	87	Residential care & Social Work							
	93	Sports							
	94	Activities of Memberships Organisations							
	95	Repair of computers and personal household goods							
	96	Other personal activities							
Low: 88 OBS	22	Rubber&Plastic	£25.6 (0.256)	£29 (0.291)	1.772	9.294	Low: £11 -£51 0.11 -0.51	£25.7 (0.257)	
£11 -£51	23	Non-metalic mineral	£19.3 (0.1932)	£13.5 (0.1356)	*0*	*0*		£20.20 -0.2025	
	25	Metal Products		DECREASE					DECREASE: £29 (0.290991017) - £17 (0.173897971)
0.11 -0.51	28	Machinery and equipment			Adj R-squared	0.9524			
	31	Furniture - OtherManf - Repair&Installation							
	50	Water transport							
	55	Accomodation & Food & Beverages							
	62	Computer programming and consultancy							
Medium: 275 OBS	1	Agriculture	£132 (1.324823213)	£113 - 1.138088422	1.921	2.906	Medium	£168 (1.68)	DECREASE
	5	Mining	£120 (1.204599259)	£132 (1.32127961)	*0*	*0*	£67.4-£260	£143 (1.43)	£148 (1.479)
£64.7 - £333	10	Food-Beverages-Tobacco		INCREASE			0.674 - 2.6		£142 (1.418)
(0.674 - 3.3)	19	Coke&Petroleum			Adj R-squared	0.8007			
	20	Chemicals							
	21	Pharmaceutical							
	26	Computer, electronic and opticals							
	29	Motor vehicles&Tralers							
	30	Transport equipment							
	37	Sweerage - Waste -Remediation							
	49	Land transport & Pipelines							
	51	Air transport							
	52	Warehousing and supporting transport							
	58	Publishing Activities							
	59	Motion video tv sound & Broadcasting							
	61	Telecommunication							
	65	Insurance and Pension							
	72	R&D							
	77	Rental&Leasing							
	80	Security and Investigation - Services to Buildings and Landscape & Other Admin							
	84	Public Admin and Defence & Social Security							
	90	Arts & Libraries & Gambling							
High: 22 OBS £100- £780	24	Basic Metals	£469 (4.692)	£308 (3.08)	2.950169	-0.3100209	High: £100-£780	£780 (7.785)	-
1- 7.8	35	Electricity-Gas-Steam-Air-conditioning	£320 (3.204)	£410 (4.10)	*0*	*0.548*	1- 7.8		
	43	Construction		INCREASE	Adj R-squared	0.899			
Inconsistent	2	Forestry							
	18	Printing&Reproduction of recorded media							
	64	Financial Services							
	86	Human Health							

Appendix 6 - Marginal Rate of Substitution (MRS) between Total Labour and Net Capital Stock (NCS) – All industries – 1 total working hour compensated wit £ of NCS – DETAILS

Level	DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Lowest	13	Textiles-Apparel-Leather	1.056	0.648	0.039	0.033	0.106	0.106	0.057	0.039	0.052	0.069	0.047
0.017 -0.2	16	Wood	0.220	0.044	0.024	0.033	0.044	0.044	0.057	0.039	0.054	0.133	0.127
	17	Paper	1.056	0.648	0.039	0.033	0.044	0.044	1.965	0.061	0.054	0.133	0.127
	27	Electrical equipment	1.056	1.007	0.335	0.045	0.120	0.120	0.184	0.061	0.052	0.069	0.047
	45	Wholesale&Retail&Repair of Motorvehicles	0.030	0.419	0.123	0.045	0.106	0.106	0.119	0.061	0.111	0.171	0.200
	46	Wholesale trade	0.128	0.022		0.032	0.049	0.049	0.074	0.040	0.059	0.134	0.094
	53	Postal & Courier	0.023	0.026	0.024	0.034	0.032	0.032	0.034	0.061	0.064	0.045	0.033
	66	Auxiliary to fiancing	0.509	0.419	0.123	0.045	0.106	0.106	0.119	0.061	0.064	0.045	0.034
	69	Legal and Accounting	0.376	0.162			0.021	0.021	0.017	0.040	0.034	0.069	0.025
	71	Architectural and Engineering	0.509	0.034	0.030	0.036	0.039	0.039	0.041	0.054	0.064	0.069	0.034
	73	Advertising and Market Rsearch	0.509	0.648	0.123	0.045	0.106	0.106	0.119	0.061	0.064	0.045	0.033
	74	Other prof, scientific, technical & Veterinary	1.056	0.034	0.030	0.036	0.039	0.039	0.041	0.061	0.064	0.045	0.034
	78	Employment Activities	0.030	0.034	0.030	0.036	0.039	0.039	0.041	0.052	0.045	0.040	0.034
	79	Travel Agencies	0.022	0.026	0.024	0.034	0.044	0.044	0.057	0.061	0.064	0.171	0.200
	85	Education	0.128	0.022									
	87	Residential care & Social Work	0.509	0.419	0.335	0.243	0.106	0.106	0.119	0.054	0.064	0.069	0.034
	93	Sports	1.056	0.044	0.039	0.033	0.044	0.044	0.057	0.061	0.052	0.069	0.047
	94	Activities of Memberships Organisations	0.030	0.034	0.030	0.036	0.106	0.106	0.119	0.061	0.064	0.045	0.034
	95	Repair of computers and personal household goods	0.022	0.026	0.024	0.033	0.032	0.032	0.034	0.039	0.054	0.133	0.127
	96	Other personal activities	0.030	0.034	0.030	0.036	0.039	0.039	0.041	0.061	0.064	0.045	0.034
Low	22	Rubber&Plastic	1.056	0.648	0.335	0.243	0.120	0.120	0.184	0.061	0.111	0.069	0.228
0.11 -0.51	23	Non-metalic mineral	1.056	0.648	0.335	0.243	0.120	0.120	0.184	0.061	0.052	0.069	0.127
	25	Metal Products	0.509	0.648	0.335	0.243	0.120	0.120	0.184	0.061	0.111	0.171	0.200
	28	Machinery and equipment	0.864	0.648	0.335	0.243	0.120	0.120	0.184	0.061	0.111	0.171	0.200
	31	Furniture - OtherManf - Repair&Installation	0.509	0.419	0.335	0.243	0.120	0.120	0.184	0.061	0.111	0.171	0.034
	50	Water transport	1.056	0.648	0.335	0.243	0.120	0.120	0.184	0.061	0.111	0.234	0.228
	55	Accomodation & Food & Beverages	0.509	0.419	0.335	0.243	0.120	0.120	0.184	0.061	0.111	0.171	0.200
	62	Computer programming and consultancy	0.509	0.419	0.335	0.243	0.120	0.120	0.184	0.054	0.111	0.171	0.200
Medium	1	Agriculture	1.056	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.850	1.700
0.674 - 1.7	5	Mining	0.864	1.007	1.268	1.095	1.140	1.140	0.709	2.448	1.549	1.246	3.449
	10	Food-Beverages-Tobacco	0.864	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.234	0.228
	19	Coke&Petroleum	1.036	2.590	1.991	2.331	1.641	1.641	1.965	2.495	1.501	4.616	
	20	Chemicals	1.056	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.850	1.700
	21	Pharmaceutical	1.056	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.850	1.700
	26	Computer, electronic and opticals	0.864	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.111	0.234	0.228
	29	Motor vehicles&Tralers	1.056	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.850	1.700
	30	Transport equipment	1.056	1.007	1.268	1.095	1.140	1.140	0.709	0.061	0.111	0.234	0.228
	37	Sweerage - Waste - Remediation	1.056	1.007	1.268	1.095	1.140	1.140	0.709	13.996	0.674	0.850	1.700
	49	Land transport & Pipelines	0.864	1.007	1.268	1.095	1.140	1.140	0.709	2.448	1.549	1.246	1.700
	51	Air transport	1.056	1.007	1.268	1.095	1.140	1.140	2.449	2.495	1.501	3.087	
	52	Warehousing and supporting transport	1.056	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.850	1.700
	58	Publishing Activities	0.864	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.234	0.228
	59	Motion video tv sound & Broadcasting	1.056	1.007	1.268	1.095	1.140	1.140	0.709	13.996	7.671	3.087	1.700
	61	Telecommunication	0.864	1.007	1.268	1.095	1.140	1.140	0.709	2.448	1.549	1.246	1.700
	65	Insurance and Pension	1.056	1.007	1.268	1.095	1.140	1.140	0.709	2.448	1.549	1.246	1.700
	72	R&D	1.056	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.234	0.228
	77	Rental&Leasing	1.056	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.850	1.700
	80	Security and Investigation - Services to Buildings and Landscape & Other Admin	0.864	1.007	1.268	1.095	1.140	1.140	0.709	2.448	1.549	1.246	1.700
	84	Public Admin and Defence & Social Security	1.291	0.977	0.938	0.906			1.935			3.354	6.702
	90	Arts & Libraries & Gambling	0.864	1.007	1.268	1.095	1.140	1.140	0.709	1.078	0.674	0.850	1.700
High	24	Basic Metals	1.056	4.821	1.991	4.903	2.494	2.494	2.449	2.226		4.616	
1- 7.8	35	Electricity-Gas-Steam-Airconditioning	1.056	1.007	1.268	4.903	2.494	2.494	2.449	2.448	7.671	34.460	3.449
	43	Construction	7.785										
Inconsistent	2	Forestry				2.331			1.965			4.616	0.127
	18	Printing&Reproduction of recorded media	1.056	1.007	1.268	0.243	0.120	0.120	0.184	0.061	0.064	0.069	0.047
	64	Financial Services	0.509	0.648	0.335	0.243	1.140	1.140	0.184	0.061	0.111	0.171	0.200
	86	Human Health	1.291	0.022									

Appendix 7 – Table 4.15 - Marginal Rate of Substitution (MRS) between Total Labour and Net Capital Stock (NCS) – Productive industries – 1 total working hour compensated wit £ of NCS

MRS		Lowest		Low		Medium		High		Highest
TOTAL_NCS										
Range		£2.1- £6.4		£32-£92		£45-£520		£79-£760		£230-£6300
Average wide		£14.65		£64.12		£170.17		£717.42		
Average narrow		£4.23		£62.05		£153.10		£276.30		£2,003.49
Before Crisis		£4.37		£72.48		£116.39		£249.13		£1,952.56
After Crisis		£4.53		£48.38		£208.36		£373.97		£2,079.88
Industries	**13**	**Textiles-Apparel-Leather**	**1**	**Agriculture**	**19**	**Coke&Petroleum**	**24**	**Basic Metals**	**2**	**Fishing & Aquaculture**
	16	**Wood**	**5**	**Mining**	**43**	**Construction**	**35**	**Electricity-Gas-Steam-Airconditioning**		
	17	**Paper**	**10**	**Food-Beverages-Tobacco**	**51**	**Air transport**				
	53	**Postal & Courier**	**18**	**Printing&Reproduction of recorded media**	**55**	**Accomodation & Food & Beverages**				
	71	**Architecture and Civil Engineering**	**20**	**Chemicals**	**59**	**Motion video tv sound & Broadcasting**				
	74	**Other prof, scientific, technical & Veterinary**	**21**	**Pharmaceutical**	**85**	**Education**				
	87	**Residential care and social work**	**22**	**Rubber&Plastic**	**86**	**Human Health**				
			23	**Non-metalic mineral**						
			25	**Metal Products**						
			26	**Computer, electronic and opticals**						
			27	**Electrical equipment**						
			28	**Machinery and equipment**						
			29	**Motor vehicles&Tralers**						
			30	**Transport equipment**						
			31	**Furniture - OtherManf - Repair&Installation**						
			37	**Sweerage - Waste -Remediation**						
			49	**Land transport & Pipelines**						
			50	**Water transport**						
			52	**Warehousing and supporting transport**						
			58	**Publishing Activities**						
			61	**Telecommunication**						
			62	**Computer programming and consultancy**						
			72	**R&D**						
PEERS		**Lowest**		**Low**		**Medium**				**Highest**
Range		£3.1- £6.4		£32-£92		£45-£520				£230-£6300
Average wide		£10.43		£59.48						
Average narrow		£5.60		£60.98		£182.24				£2,003.49
Before Crisis		£4.27		£73.40		£149.12				£1,952.56
After Crisis		£6.42		£48.59		£226.00				£2,079.88
PEERS	**86**	**Human Health**								

Appendix 8 - Table 4.16 - Marginal Rate of Substitution (MRS) between Total Labour and Net Capital Stock (NCS) – Unproductive industries – 10^7 total working hour compensated with 10^9 £ of NCS

MRS							
TOTAL_NCS	**DMU**	**Description**	**Average**	**Crisis Effects**	**TOT_NCS PEERS**	**Average PEERS**	**Crisis Effects PEERS**
Lowest: 0.03-0.15	45	Wholesale&Retail&Repair of Motorvehicles	0.30156822	INCREASE	Lowest: 0.03-0.15	0.408599844	INCREASE
	46	Wholesale trade	0.071663111	0.066590354		0.06128516	0.057184172
	66	Auxiliary to fiancing		0.073636244			0.06367884
	69	Legal and Accounting					
	73	Advertising and Market Rsearch					
	78	Employment Activities					
	94	Activities of Memberships Organisations					
	96	Other personal activities					
Medium:1.15-12.3	64	Financial Services	2.910300443	DECREASE	Medium:1.15-12.3	3.023948662	DECREASE
	65	Insurance and Pension	3.037373889	4.588866772		3.184640595	4.588866772
	77	Rental&Leasing		2.17086664			2.2377517
	80	Security and Investigation - Services to Buildings and Landscape & Other Admin					
	95	Repair of computers and personal household goods					
Inconsistent	79	Travel Agencies			Inconsistent		

Appendix 9 - Table 4.17 - £1 of NCS contributions towards £ of GVA – Total Labour Model (All industries)

CONTRIBUTION										
NCS_GVA		**Lowest**		**Low**		**Medium**		**High**		**Inconsistent**
TARGET										
Average narrow		**£0.02**		**£0.05**		**£0.99**		**£1.44**		
Before Crisis				**£0.06**		**£0.33**		**£1.27**		
After Crisis				**£0.02**		**£0.53**		**£1.64**		
Industries	**43**	**Construction**	84	Public Admin and Defence & Social Security	1	Agriculture	13	Textiles-Apparel-Leather	**86**	**Human Health**
					2	**Forestry**	16	Wood		
					5	**Mining**	17	Paper		
					10	Food-Beverages-Tobacco	18	Printing&Reproduction of recorded media		
					19	**Coke&Petroleum**	22	Rubber&Plastic		
					20	Chemicals	23	Non-metalic mineral		
					21	**Pharmaceutical**	25	Metal Products		
					24	Basic Metals	27	Electrical equipment		
					26	Computer, electronic and opticals	28	Machinery and equipment		
					29	Motor vehicles&Tralers	30	Transport equipment		
					35	Electricity-Gas-Steam-Airconditioning	31	Furniture - OtherManf - Repair&Installation		
					37	Sweerage - Waste - Remediation	45	Wholesale&Retail&Repair of Motorvehicles		
					49	Land transport & Pipelines	46	Wholesale trade		
					51	Air transport	**50**	**Water transport**		
					52	Warehousing and supporting transport	**53**	**Postal & Courier**		
					58	Publishing Activities	55	Accomodation & Food & Beverages		
					59	Motion video tv sound & Broadcasting	**62**	**Computer programming and consultancy**		
					61	Telecommunication	**64**	**Financial Services**		
					65	**Insurance and Pension**	66	Auxiliary to fiancing		
					72	R&D	**69**	**Legal and Accounting**		
					77	Rental&Leasing	71	Architectural and Engineering		
					80	Security and Investigation - Services to Buildings and Landscape & Other Admin	**73**	**Advertising and Market Rsearch**		
					85	**Education**	74	Other prof, scientific, technical & Veterinary		
					90	Arts & Libraries & Gambling	**78**	**Employment Activities**		
							79	**Travel Agencies**		
							87	Residential care & Social Work		
							93	Sports		
							94	Activities of Memberships Organisations		
							95	**Repair of computers and personal household goods**		
							96	Other personal activities		
PEERS		**Lowest**		**Low**		**Medium**		**High**		**Inconsistent**
Average wide						£0.58				
Average narrow						£0.50		£1.31		
Before Crisis						£0.40		£1.06		
After Crisis						£0.49		£1.56		

Appendix 10 – Table 4.18 - £1 of NCS contributions towards £ of GVA – Total Labour Model (Productive industries)

CONTRIBUTION								
NCS_GVA	**Low**		**Medium**		**High**		**Inconsistent**	
Average narrow	**0.070728**		**0.451157**		**1.835162**			
Before Crisis	**0.083148**		**0.31768**		**1.653626**			
After Crisis	**0.055824**		**0.614396**		**2.053006**			
Industries	**43**	**Construction**	1	Agriculture	13	Textiles-Apparel-Leather	27	Electrical equipment
			2	Fishing & Aquaculture	16	Wood		
			5	**Mining**	17	Paper		
			10	Food-Beverages-Tobacco	**53**	**Postal & Courier**		
			18	Printing&Reproduction of recorded media	71	Architecture and Civil Engineering		
			19	Coke&Petroleum	74	Other prof, scientific, technical & Veterinary		
			20	Chemicals	87	Residential care and social work		
			21	**Pharmaceutical**				
			22	Rubber&Plastic				
			23	Non-metalic mineral				
			24	Basic Metals				
			25	Metal Products				
			26	Computer, electronic and opticals				
			28	Machinery and equipment				
			29	Motor vehicles&Tralers				
			30	Transport equipment				
			31	Furniture - OtherManf - Repair&Installation				
			35	Electricity-Gas-Steam-Airconditioning				
			37	Sweerage - Waste -Remediation				
			49	Land transport & Pipelines				
			50	Water transport				
			51	Air transport				
			52	Warehousing and supporting transport				
			55	Accomodation & Food & Beverages				
			58	Publishing Activities				
			59	Motion video tv sound & Broadcasting				
			61	Telecommunication				
			62	**Computer programming and consultancy**				
			72	R&D				
			85	**Education**				
			86	Human Health				

Appendix 11 - Table 4.19 - £1 of NCS contributions towards £ of GVA – Total Labour Model (Unproductive industries)

CONTRIBUTION				
NCS_GVA		Low		Medium
Average narrow		£0.48		£1.31
Before Crisis		£0.71		£1.14
After Crisis		£0.33		£1.51
Industries	47	Retail	45	Wholesale&Retail&Repair of Motorvehicles
	64	Financial Services	46	Wholesale trade
	65	Insurance and Pension	66	Auxiliary to fiancing
	77	Employment Activities	69	Legal and Accounting
	79	Security and Investigation - Services to Buildings and Landscape & Other Admin	71	Advertising and Market Rsearch
	80	Public Admin and Defence & Social Security	73	Rental&Leasing
	95	Other personal activities	78	Travel Agencies
			94	Repair of computers and personal household goods
			96	Other personal activities
PEERS				
Average wide		£0.33		£1.21
Average narrow		£0.38		£1.04
Before Crisis		£0.27		£1.42
After Crisis				

Appendix 12 - Table 4.20 – 1 hour of Total Working Hour's contributions towards £ of GVA – Total Labour Model (All industries)

CONTRIBUTION								
TOT_GVA		**Low**		**Medium**		**High**		**Inconsistent**
Average narrow		**£7.30**		**£27.71**		**£99.15**		
Before Crisis		**£6.49**		**£24.87**		**£87.69**		
After Crisis		**£8.47**		**£31.16**		**£125.99**		
Industries	46	Wholesale trade	1	Agriculture	**19**	**Coke&Petroleum**	**2**	**Forestry**
	53	**Postal & Courier**	**5**	**Mining**	**24**	**Basic Metals**		
	69	**Legal and Accounting**	10	Food-Beverages-Tobacco	**35**	**Electricity-Gas-Steam-Airconditioning**		
	78	**Employment Activities**	13	Textiles-Apparel-Leather				
	84	Public Admin and Defence & Social Security	16	Wood				
	85	**Education**	17	Paper				
	86	Human Health	18	Printing&Reproduction of recorded media				
	94	Activities of Memberships Organisations	20	Chemicals				
	96	Other personal activities	**21**	**Pharmaceutical**				
			22	Rubber&Plastic				
			23	Non-metalic mineral				
			25	Metal Products				
			26	Computer, electronic and opticals				
			27	Electrical equipment				
			28	Machinery and equipment				
			29	Motor vehicles&Tralers				
			30	Transport equipment				
			31	Furniture - OtherManf - Repair&Installation				
			37	Sweerage - Waste -Remediation				
			43	**Construction**				
			45	Wholesale&Retail&Repair of Motorvehicles				
			49	Land transport & Pipelines				
			50	**Water transport**				
			51	Air transport				
			52	Warehousing and supporting transport				
			55	Accomodation & Food & Beverages				
			58	Publishing Activities				
			59	Motion video tv sound & Broadcasting				
			61	Telecommunication				
			62	**Computer programming and consultancy**				
			64	**Financial Services**				
			65	**Insurance and Pension**				
			66	Auxiliary to financing				
			71	Architectural and Engineering				
			72	R&D				
			73	**Advertising and Market Rsearch**				
			74	Other prof, scientific, technical & Veterinary				
			77	Rental&Leasing				
			79	**Travel Agencies**				
			80	Security and Investigation - Services to Buildings and Landscape & Other Admin				
			87	Residential care & Social Work				
			90	Arts & Libraries & Gambling				
			93	Sports				
			95	**Repair of computers and personal household goods**				
PEERS								
Average wide								
Average narrow		**£6.91**		**£25.85**		**£120.18**		
Before Crisis		**£6.09**		**£23.25**		**£118.13**		
After Crisis		**£7.46**		**£28.19**		**£126.39**		

Appendix 13 - 4.22 – 1 hour of Total Working Hour’s contributions towards £ of GVA – Total Labour Model (Productive industries)

CONTRIBUTION								
TOT_GVA		**Lowest**		**Low**		**Medium**		**High**
Average narrow		£8.80		£21.64		£126.08		£264.40
Before Crisis		£8.53		£20.34		£70.35		£188.48
After Crisis		£9.13		£23.26		£191.98		£324.49
Industries	**53**	**Postal & Courier**	1	Agriculture	**19**	**Coke&Petroleum**	2	Fishing & Aquaculture
	71	Architecture and Civil Engineering	**5**	**Mining**	**24**	**Basic Metals**	36	Water collection treatment supply
	74	Other prof, scientific, technical & Veterinary	10	Food-Beverages-Tobacco	35	Electricity-Gas-Steam-Airconditioning		
			13	Textiles-Apparel-Leather	51	Air transport		
			16	Wood				
			17	Paper				
			18	Printing&Reproduction of recorded media				
			20	Chemicals				
			21	**Pharmaceutical**				
			22	Rubber&Plastic				
			23	Non-metalic mineral				
			25	Metal Products				
			26	Computer, electronic and opticals				
			27	Electrical equipment				
			28	Machinery and equipment				
			29	Motor vehicles&Tralers				
			30	Transport equipment				
			31	Furniture - OtherManf - Repair&Installation				
			37	Sweerage - Waste -Remediation				
			43	Construction				
			49	Land transport & Pipelines				
			50	Water transport				
			52	Warehousing and supporting transport				
			55	Accomodation & Food & Beverages				
			58	Publishing Activities				
			59	Motion video tv sound & Broadcasting				
			61	Telecommunication				
			62	**Computer programming and consultancy**				
			72	R&D				
			85	**Education**				
			86	Human Health				
			87	Residential care and social work				
PEERS		**Lowest**		**Low**		**Medium**		**High**
Average narrow		£9.32		£18.86		£184.27		£318.04
Before Crisis		£8.53		£18.81		£118.44		£134.99
After Crisis		£9.13		£18.98		£263.26		£379.06

Appendix 14 –10^7 hour of Total Working Hour's contributions towards £ of 10^8 GVA – Total Labour Model (All industries)

CONTRIBUTION **TOT_GVA**

DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Agriculture	2.694	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	4.210	5.381
2	Forestry				13.499			11.912			48.152	3.977
5	Mining	2.156	2.601	3.245	3.548	4.569	4.569	3.646	6.218	5.257	4.647	7.938
10	Food-Beverages-Tobacco	2.156	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	2.183	2.225
13	Textiles-Apparel-Leather	2.694	2.303	0.928	0.726	1.430	1.430	1.174	0.900	1.040	1.264	1.027
16	Wood	2.234	0.993	0.635	0.726	0.992	0.992	1.174	0.900	1.097	3.561	3.977
17	Paper	2.694	2.303	0.928	0.726	0.992	0.992	11.912	0.995	1.097	3.561	3.977
18	Printing&Reproduction of recorded media	2.694	2.601	3.245	1.960	1.520	1.520	1.864	0.995	1.074	1.264	1.027
19	Coke&Petroleum	4.560	13.765	12.661	13.499	13.197	13.197	11.912	9.674	8.240	48.152	
20	Chemicals	2.694	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	4.210	5.381
21	Pharmaceutical	2.694	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	4.210	5.381
22	Rubber&Plastic	2.694	2.303	1.960	1.960	1.520	1.520	1.864	0.995	1.489	1.264	2.225
23	Non-metalic mineral	2.694	2.303	2.098	1.960	1.520	1.520	1.864	0.995	1.040	1.264	3.977
24	Basic Metals	2.694	8.259	12.661	10.530	8.435	8.435	10.156	19.247		48.152	
25	Metal Products	1.800	2.303	2.098	1.960	1.520	1.520	1.864	0.995	1.489	1.744	2.026
26	Computer, electronic and opticals	2.156	2.601	3.245	3.548	4.569	4.569	3.646	5.501	1.489	2.183	2.225
27	Electrical equipment	2.694	2.601	2.098	0.843	1.520	1.520	1.864	0.995	1.040	1.264	1.027
28	Machinery and equipment	2.156	2.303	2.098	1.960	1.520	1.520	1.864	0.995	1.489	1.744	2.026
29	Motor vehicles&Tralers	2.694	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	4.210	5.381
30	Transport equipment	2.694	2.601	3.245	3.548	4.569	4.569	3.646	0.995	1.489	2.183	2.225
31	Furniture - OtherManf - Repair&Installation	1.800	1.934	2.098	1.960	1.520	1.520	1.864	0.995	1.489	1.744	0.718
35	Electricity-Gas-Steam-Airconditioning	2.694	2.601	3.245	10.530	8.435	8.435	10.156	6.218	15.506	20.731	7.938
37	Sweerage - Waste - Remediation	2.694	2.601	3.245	3.548	4.569	4.569	3.646	15.167	4.358	4.210	5.381
43	Construction	1.482										
45	Wholesale&Retail&Repair of Motorvehicles	0.496	1.934	1.494	0.843	1.430	1.430	1.541	0.995	1.489	1.744	2.026
46	Wholesale trade	0.381	0.090		0.284	0.615	0.615	0.743	0.657	0.777	1.331	0.892
49	Land transport & Pipelines	2.156	2.601	3.245	3.548	4.569	4.569	3.646	6.218	5.257	4.647	5.381
50	Water transport	2.694	2.303	2.098	1.960	1.520	1.520	1.864	0.995	1.489	2.183	2.225
51	Air transport	2.694	2.601	3.245	3.548	4.569	4.569	10.156	9.674	8.240	9.239	
52	Warehousing and supporting transport	2.694	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	4.210	5.381
53	Postal & Courier	0.541	0.652	0.635	0.726	0.779	0.779	0.811	0.995	1.074	0.839	0.738
55	Accomodation & Food & Beverages	1.800	1.934	2.098	1.960	1.520	1.520	1.864	0.995	1.489	1.744	2.026
58	Publishing Activities	2.156	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	2.183	2.225
59	Motion video tv sound & Broadcasting	2.694	2.601	3.245	3.548	4.569	4.569	3.646	15.167	15.506	9.239	5.381
61	Telecommunication	2.156	2.601	3.245	3.548	4.569	4.569	3.646	6.218	5.257	4.647	5.381
62	Computer programming and consultancy	1.800	1.934	2.098	1.960	1.520	1.520	1.864	0.891	1.489	1.744	2.026
64	Financial Services	1.800	2.303	2.098	1.960	4.569	4.569	1.864	0.995	1.489	1.744	2.026
65	Insurance and Pension	2.694	2.601	3.245	3.548	4.569	4.569	3.646	6.218	5.257	4.647	5.381
66	Auxiliary to fiancing	1.800	1.934	1.494	0.843	1.430	1.430	1.541	0.995	1.074	0.839	0.718
69	Legal and Accounting	1.413	0.838			0.380	0.380	0.305	0.657	0.609	1.092	0.503
71	Architectural and Engineering	1.800	0.600	0.599	0.714	0.745	0.745	0.779	0.891	1.074	1.092	0.718
72	R&D	2.694	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	2.183	2.225
73	Advertising and Market Rsearch	1.800	2.303	1.494	0.843	1.430	1.430	1.541	0.995	1.074	0.844	0.738
74	Other prof, scientific, technical & Veterinary	2.694	0.600	0.599	0.714	0.745	0.745	0.779	0.995	1.074	0.839	0.718
77	Rental&Leasing	2.694	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	4.210	5.381
78	Employment Activities	0.496	0.600	0.599	0.714	0.745	0.745	0.779	0.868	0.820	0.780	0.718
79	Travel Agencies	0.562	0.652	0.635	0.726	0.992	0.992	1.174	0.995	1.074	1.744	2.026
80	Security and Investigation - Services to Buildings and Landscape & Other Admin	2.156	2.601	3.245	3.548	4.569	4.569	3.646	6.218	5.257	4.647	5.381
84	Public Admin and Defence & Social Security	0.819	0.710	0.562	0.489			0.661			0.856	0.803
85	Education	0.381	0.090									
86	Human Health	0.819	0.090									
87	Residential care & Social Work	1.800	1.934	2.098	1.960	1.430	1.430	1.541	0.891	1.074	1.092	0.718
90	Arts & Libraries & Gambling	2.156	2.601	3.245	3.548	4.569	4.569	3.646	5.501	4.358	4.210	5.381
93	Sports	2.694	0.993	0.928	0.726	0.992	0.992	1.174	0.995	1.040	1.264	1.027
94	Activities of Memberships Organisations	0.496	0.600	0.599	0.714	1.430	1.430	1.541	0.995	1.074	0.839	0.718
95	Repair of computers and personal household goods	0.562	0.652	0.635	0.726	0.779	0.779	0.811	0.900	1.097	3.561	3.977
96	Other personal activities	0.496	0.600	0.599	0.714	0.745	0.745	0.779	0.995	1.074	0.839	0.718

Appendix 15 - Table 4.23 - 1 hour of Total Working Hour's contributions towards £ of GVA – Total Labour Model (Unproductive industries)

CONTRIBUTION				
TOT_GVA		**Low**		**Medium**
Average narrow		£7.91		£31.04
Before Crisis		£7.16		£26.18
After Crisis		£9.04		£36.69
Industries	**47**	**Retail**	45	Wholesale&Retail&Repair of Motorvehicles
	78	**Travel Agencies**	46	Wholesale trade
	94	**Repair of computers and personal household goods**	**64**	**Financial Services**
	96	**Other personal activities**	**65**	**Insurance and Pension**
			66	Auxiliary to financing
			69	**Legal and Accounting**
			71	Advertising and Market Rsearch
			73	**Rental&Leasing**
			77	**Employment Activities**
			79	**Security and Investigation - Services to Buildings and Landscape & Other Admin**
			80	Public Admin and Defence & Social Security
			84	**Activities of Memberships Organisations**
			95	**Other personal activities**
PEERS		**Low**		**Medium**
Average wide				
Average narrow		£7.56		£37.05
Before Crisis		£6.02		£29.27
After Crisis		£8.65		£47.04

Appendix 16 - Table 4.35 - Marginal Rate of Substitution (MRS) between Unpaid Overtime and Basic Working Hours – All industries – 1 Unpaid overtime hour compensated with Basic Working Hours

MRS		Low		Medium		Medium - High		High		Inconsistent
UNPAID_BASIC										
Range		23 - 379		34 - 1180		188 – 11610		**702.7-1161**		
Average wide		39.05		57.38		268.87		704.6899391		
Average narrow		10.57		39.87		115.69		931.9448333		
Before Crisis		20.5		52.63		119.73		1161.187333		
After Crisis		6.27		28.32		128.42		702.7005889		
Industries	**5**	**Mining**	1	Agriculture	**45**	**Wholesale&Retail&Repair of Motorvehicles**	**35**	**Electricity-Gas-Steam-Airconditioning**	20	Chemicals
	21	**Pharmaceutical**	10	Food-Beverages-Tobacco	**47**	**Retail**	52	Warehousing and supporting transport	**46**	**Wholesale trade**
	61	**Telecommunication**	13	Textiles-Apparel-Leather	49	Land transport & Pipelines	77	Rental&Leasing	**58**	**Publishing Activities**
	80	Security and Investigation - Services to Buildings and Landscape & Other Admin	16	Wood	**50**	**Water transport**			**69**	**Legal and Accounting**
			17	Paper	51	Air transport			**71**	**Architectural and Engineering**
			18	Printing&Reproduction of recorded media	**53**	**Postal & Courier**			**84**	**Public Admin and Defence & Social Security**
			19	**Coke&Petroleum**	87	Residential care & Social Work			**86**	**Human Health**
			22	Rubber&Plastic	90	Arts & Libraries & Gambling				
			23	Non-metalic mineral						
			24	Basic Metals						
			25	Metal Products						
			26	Computer, electronic and opticals						
			27	Electrical equipment						
			28	Machinery and equipment						
			29	Motor vehicles&Tralers						
			30	Transport equipment						
			31	Furniture - OtherManf - Repair&Installation						
			43	**Construction**						
			62	**Computer programming and consultancy**						
			64	**Financial Services**						
			65	**Insurance and Pension**						
			66	Auxiliary to fincancing						
			72	**R&D**						
			73	**Advertising and Market Rsearch**						
			74	**Other prof, scientific, technical & Veterinary**						
			78	**Employment Activities**						
			79	**Travel Agencies**						
			85	Education						
			93	Sports						
			94	**Activities of Memberships Organisations**						
			95	**Repair of computers and personal household goods**						
			96	**Other personal activities**						
PEERS		**Low**		**Medium**		**Medium - High**		**High**		**Inconsistent**
Range				5 -3200		188 – 11610				
Average wide				44.82		389.63				
Average narrow				31.23		528.83				
Before Crisis				42.71		614.94				
After Crisis				33.59		388.92				
REGRESSION										
NCS		2.626932		*0.000*						
BASIC		0.9551313		*0.000*						
UNPAID		0.4889886		*0.000*						
PAID		-3.80E-10		*0.928*						
Adj. R-square		0.8362								

Appendix 17 - MRS between Unpaid Overtime and Basic Working Hours over the years in groups of industries - Total Labour Model (All industries) – 10^6 unpaid overtime hours is exchanged with 10^7 basic hours

MRS

UNPAID_BASIC	DMU	Description	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Zero	59	Motion video tv sound & Broadcasting					0.000				0.000		
Low WIDE:	5	Mining	1.240			27.324						0.633	0.826
0.5 - 2732	21	Pharmaceutical	0.227	1.879	11.807	3.791						0.761	0.052
NARROW:	61	Telecommunication	0.000									0.633	0.794
2.3 - 37.9	80	Security and Investigation - Services to Buildings and Landscape & Other Admin											0.794
Medium	1	Agriculture			9.705	3.791		0.964		0.945	3.470		
WIDE	10	Food-Beverages-Tobacco	9.766		70.270	3.791		7.040				1.286	2.409
0.5 - 702.7	13	Textiles-Apparel-Leather	5.347					1.505			0.000		
NARROW	16	Wood	3.239		17.036	2.202	5.274	0.561					
3.4 - 118	17	Paper	5.347	4.144	17.036	3.070	32.012	0.561					
	18	Printing&Reproduction of recorded media	3.071	4.144	9.705	3.070	32.012	1.882			0.000		
	19	Coke&Petroleum	6.249	1.879	11.807	3.070		1.505					
	22	Rubber&Plastic	3.298	4.144	8.810	3.070	32.012	0.561			0.340		
	23	Non-metalic mineral	5.347	4.144	6.590	3.070	32.012	0.561			0.000		
	24	Basic Metals	3.071					0.964					
	25	Metal Products	3.202	1.732	6.590	2.202	32.012	0.964			0.340	0.761	
	26	Computer, electronic and opticals	2.664	1.879	9.705	3.070	32.012	0.964			0.000		0.052
	27	Electrical equipment	3.071	1.879	17.036	3.070	32.012	0.561			0.000		
	28	Machinery and equipment	3.202	3.420	6.590	2.202	32.012	0.964	7.086		0.340	0.761	2.398
	29	Motor vehicles&Tralers	9.928	1.879	9.705	3.791		0.964		0.945	3.470		0.052
	30	Transport equipment	3.298	1.879	9.705	3.791		0.964			0.340	0.761	0.052
	31	Furniture - OtherManf - Repair&Installation	3.202	3.420	8.810	3.070		2.361			0.340	0.761	2.398
	43	Construction										0.633	2.409
	62	Computer programming and consultancy			7.131		6.997	2.361	7.086		0.340	0.633	0.052
	64	Financial Services	1.240	1.879	11.807	3.070	32.012	0.434			3.470	0.052	0.341
	65	Insurance and Pension				3.791		2.361				0.633	0.826
	66	Auxiliary to fiancing	3.202	0.000	18.883	2.089	6.997	0.000	0.000				
	72	R&D			8.032			0.964			0.000		2.329
	73	Advertising and Market Rsearch		1.221	6.590	4.579	5.274	1.882	8.311			0.000	0.000
	74	Other prof, scientific, technical & Veterinary	3.298	1.221		6.964	10.517	1.882	8.716	0.056	18.195	2.266	
	78	Employment Activities	2.801								0.558		3.592
	79	Travel Agencies	4.644	1.221		2.202	5.274	0.561	8.716		1.065	0.761	0.052
	85	Education										1.903	
	93	Sports	3.239	7.897	17.036	3.070					0.000		0.000
	94	Activities of Memberships Organisations	3.202		11.807			0.964	10.281	0.000	1.065		
	95	Repair of computers and personal household goods	3.239	0.000		3.436	20.136						
	96	Other personal activities	3.202	3.420		3.070					3.470	0.761	2.398
Medium-High	45	Wholesale&Retail&Repair of Motorvehicles			11.807	27.324		7.040				1.286	38.892
WIDE	47	Retail											13.800
2.7- 3844	49	Land transport & Pipelines										33.237	
NARROW	50	Water transport	7.185	4.852	11.807	3.791						16.739	
18.8 – 1161	51	Air transport			9.705	3.791							
	53	Postal & Courier		**6.543**		**19.619**	**20.137**	**1.715**	**8.716**	**28.778**	0.268	**0.865**	
	87	Residential care & Social Work	0.788	**43.174**		**13.804**		**7.040**	**8.716**	**0.215**	**2.973**		
	90	Arts & Libraries & Gambling	**9.928**	**116.117**	**70.270**	**3.791**		1.882					
High	35	Electricity-Gas-Steam-Airconditioning		116.119	70.270								
NARROW:	52	Warehousing and supporting transport		116.121	70.271								0.794
702.7	77	Rental&Leasing		**116.117**	**70.270**	3.791							
Inconsistent	20	Chemicals	22.896			3.791		0.964			0.000		
	46	Wholesale trade	0.184										4.021
	58	Publishing Activities	1.911		11.807							0.000	0.000
	69	Legal and Accounting	0.346	14.638					91.868		2.578	1.912	
	71	Architectural and Engineering	0.075	1.732		6.964				0.215	0.297		0.000
	84	Public Admin and Defence & Social Security	22.896					0.434				0.633	2.409
	86	Human Health	0.184										2.020

Appendix 18 - Table 4.35 - 1 hour of Unpaid Overtime contribution towards £ of GVA – Decomposed Labour Model (All industries)

	CONTRIBUTION	UNPAID_GVA					
DMU	**Description**	**AVERAGE ind**	**Average all**	**Crisis Effects**	**AVERAGE PEERS ind**	**Average peers**	**Crisis Effects Peers**
1	Agriculture	292.904	228.208	264.287		194.547	232.301
5	Mining	236.311		511.019	396.491		170.576
10	Food-Beverages-Tobacco	242.492					
13	Textiles-Apparel-Leather	295.161					
16	Wood	221.679					
17	Paper	309.354					
18	Printing&Reproduction of recorded media	319.402					
19	Coke&Petroleum	302.810			302.810		
20	Chemicals	333.178					
21	Pharmaceutical	174.676			174.676		
22	Rubber&Plastic	249.671					
23	Non-metalic mineral	310.114					
24	Basic Metals	192.654					
25	Metal Products	220.646					
26	Computer, electronic and opticals	246.598					
27	Electrical equipment	287.134					
28	Machinery and equipment	217.980					
29	Motor vehicles&Tralers	241.955					
30	Transport equipment	174.865					
31	Furniture - OtherManf - Repair&Installation	204.751					
35	Electricity-Gas-Steam-Airconditioning	383.089			383.089		
37	Sweerage - Waste - Remediation	947.031					
43	Construction	158.790			217.862		
45	Wholesale&Retail&Repair of Motorvehicles	280.552			280.552		
46	Wholesale trade	202.184			226.487		
47	Retail	214.052			214.052		
49	Land transport & Pipelines	510.952					
50	Water transport	339.272			283.681		
51	Air transport	352.419					
52	Warehousing and supporting transport	301.024					
53	Postal & Courier	140.748			140.748		
55	Accomodation & Food & Beverages	266.678					
58	Publishing Activities	231.474			95.270		
61	Telecommunication	118.306			136.894		
62	Computer programming and consultancy	129.530			129.530		
64	Financial Services	217.645			217.645		
65	Insurance and Pension	302.307			302.307		
66	Auxiliary to fiancing	162.776			144.972		
69	Legal and Accounting	112.071			112.071		
71	Architectural and Engineering	89.087			102.164		
72	R&D	270.723			184.477		
73	Advertising and Market Rsearch	221.748			221.748		
74	Other prof, scientific, technical & Veterinary	134.311			193.596		
77	Rental&Leasing	372.866					
78	Employment Activities	99.948			99.948		
79	Travel Agencies	142.138			59.614		
80	Security and Investigation - Services to Buildings and Landscape & Other Admin	437.753					
84	Public Admin and Defence & Social Security	159.909			159.909		
86	Human Health	101.195			143.812		
87	Residential care & Social Work	159.772					
90	Arts & Libraries & Gambling	294.892					
93	Sports	291.278					
94	Activities of Memberships Organisations	185.121			187.900		
95	Repair of computers and personal household goods	213.483			218.690		
96	Other personal activities	241.016			241.160		

Appendix 19 – Table 4.37 - Marginal Rate of Substitution (MRS) between Unpaid Overtime and Basic Working Hours – Productive industries – 1 Unpaid overtime hour compensated with Basic Working Hours

MRS		Low		Medium		High		Inconsistent
UNPAID_BASIC								
Range		2.6-4.3		7- 96		110-316		
Average wide				34.66				
Average narrow		3.46		31.48		178.88		
Before Crisis				35.47				
After Crisis				25.85				
Industries	22	Rubber& Plastic	1	Agriculture	31	Furniture - OtherManf - Repair&Installation	10	Food-Beverages-Tobacco
			2	**Fishing & Aquaculture**	**74**	**Other prof, scientific, technical & Veterinary**	**16**	**Wood**
			5	**Mining**			**21**	**Pharmaceutical**
			17	Paper			23	Non-metalic mineral
			18	Printing&Reproduction of recorded media			**53**	**Postal & Courier**
			19	**Coke&Petroleum**			**85**	**Education**
			24	Basic Metals				
			25	Metal Products				
			26	Computer, electronic and opticals				
			27	Electrical equipment				
			28	Machinery and equipment				
			29	Motor vehicles&Tralers				
			30	**Transport equipment**				
			35	**Electricity-Gas-Steam-Airconditioning**				
			36	Water collection, treatment and Supply				
			43	**Construction**				
			49	Land transport & Pipelines				
			50	**Water transport**				
			51	Air transport				
			52	Warehousing and supporting transport				
			58	**Publishing Activities**				
			59	Motion video tv sound & Broadcasting				
			61	**Telecommunication**				
			62	**Computer programming and consultancy**				
			72	**R&D**				
			86	**Human Health**				
PEERS		**Low**		**Medium**		**High**		**Inconsistent**
Range				10.3-96		11-31.6		
Average wide				41.62		148.14		
Average narrow				30.92		213.81		
Before Crisis				32.34				
After Crisis				32.86				
PEERS								

Appendix 20 - Table 4.38 - Marginal Rate of Substitution (MRS) between Unpaid Overtime and Basic Working Hours – Unproductive industries – 1 Unpaid overtime hour compensated with Basic Working Hours

MRS		Low		Medium		High		Highest		Inconsistent
UNPAID_BASIC										
Range		2.2		7.7-62		15-308		83-2740		
Average wide				50.09		129.04		439.38		
Average narrow		2.23		23.98		68.72		616.09		
Before Crisis				46.52		100.26		193.53		
After Crisis				16.92		36.64		982.68		
Industries	**80**	**Security and Investigation - Services to Buildings and Landscape & Other Admin**	**46**	**Wholesale trade**	66	Auxiliary to fiancing	**45**	**Wholesale&Retail&Repair of Motorvehicles**	**65**	**Insurance and Pension**
			47	**Retail**	**73**	**Advertising and Market Rsearch**	**64**	**Financial Services**	**69**	**Legal and Accounting**
			94	**Activities of Memberships Organisations**	**77**	**Rental&Leasing**	**78**	**Employment Activities**	**84**	**Public Admin and Defence & Social Security**
					79	**Travel Agencies**				
					95	**Repair of computers and personal household goods**				
					96	**Other personal activities**				
PEERS		**Low**		**Medium**		**High**		**Highest**		**Inconsistent**
Range		2.2		7.7-62		15-308		90-2740		
Average wide				52.21		67.78		295.37		
Average narrow		2.23		22.98		75.2		422.68		
Before Crisis				62.1		104.88		193.53		
After Crisis				16.51		36.64		670.06		
PEERS										

Appendix 21 – Paid overtime analysis

Marginal Rate of Substitution of Basic Hours and Paid Overtime

Table Appendix 21.1 –Marginal Rate of Substitution (MRS) between Paid Overtime and Basic Working Hours – All industries – 1 paid overtime hour compensated with Basic Working Hours

MRS							
PAID-BASIC	**DMU**	**Description**	**Average**	**Crisis Effect**	**Paid-Baic Peers**	**Average Peers**	**Crisis Effect Peers**
Lowest: 0.1161	80	Security and Investigation - Services to Buildings and Landscape & Other Admin	0.001	-			
Low	13	Textiles-Apparel-Leather	0.082	DECREASE	LOW	0.059	-
WIDE:	18	Printing&Reproduction of recorded media	0.066	0.079	4.5 - 12		
0.7 - 47.6	19	Coke&Petroleum		0.044			
NARROW:	21	Pharmaceutical					
1.2 - 12	45	Wholesale&Retail&Repair of Motorvehicles					
	50	Water transport			MEDIUM	1.541	DECREASE
	61	Telecommunication					
	64	Financial Services					
	69	Legal and Accounting					
	71	Architectural and Engineering					
	78	Employment Activities					
	87	Residential care & Social Work					
	94	Activities of Memberships Organisations					
Medium	20	Chemicals	1.437	INCREASE	MEDIUM	1.541	DECREASE
WIDE	23	Non-metalic mineral	1.517	1.481	WIDE		1.754
0.73 - 695	26	Computer, electronic and opticals		2.239	26.8 - 695		0.476
NARROW	27	Electrical equipment			NARROW		
10.9 - 141	66	Auxiliary to fiancing			26.8 - 57.9		
	72	R&D					
	73	Advertising and Market Rsearch					
	79	Travel Agencies					
	93	Sports					
	95	Repair of computers and personal household goods					
High: 894-1125	74	Other prof, scientific, technical & Veterinary	6.7431163-10.0961215	-			
Inconsistent	58	Publishing Activities			MEDIUM	1.541	DECREASE
	59	Motion video tv sound & Broadcasting					

Even with this restricted piece of information it seems that there are industries that use more paid overtime than others. Coke & Petroleum (19), Publishing Activities (58), Financial Services (64) and Architectural and Engineering (71) belong to the former category. In the first category, it seems that 1 hour of paid overtime occurs for every 0.11 basic hours. This probably cannot be a valid result, especially when there is information for only one industry and for only one year. In the second group 1 hour of paid overtime occurs every 6.5 basic working hours. This could be true for some industries. However the fact that we have only 2 years of information for the industries in the group, where most of the industries share the same weights does not provide us with confidence for the results. The Medium group can be the group with weights closer to reality, knowing the situation in the British labour market, where 1 paid overtime occurs in every 150 basic hours, with increasing average after the outburst of crisis. However, most industries in the group have information for one-two years maximum. Therefore, an analysis of paid overtime becomes an extremely difficult task.

Table Appendix 21.2 - Marginal Rate of Substitution (MRS) between Paid Overtime and Unpaid Overtime – All industries – 1 paid overtime hour compensated with Unpaid Overtime Hours

MRS

PAID-UNPAID	DMU	Description	Average	Crisis Effects	PAID-UNPAID-PEERS	Average - PEERS	Crisis Effects - PEERS
Lowest	21	Pharmaceutical	0.004	-	LOW: 0.04 - 1.05	0.032	-
0.04	45	Wholesale&Retail&Repair of Motorvehicles			LOW: 0.04 - 1.06	0.032	-
Low	19	Coke&Petroleum	0.041	INCREASE	LOW: 0.04 - 1.05	0.032	-
018-1.16	46	Wholesale trade	0.051	0.047	0.04 - 1.05	0.715	INCREASE: 0.389328883 - 0.459370281
	50	Water transport		0.065		0.032	-
	65	Insurance and Pension				0.032	-
	78	Employment Activities				0.032	-
	96	Other personal activities					
Medium	13	Textiles-Apparel-Leather	0.786	INCREASE	MEDIUM	0.715	INCREASE: 0.389328883 - 0.459370281
1.46-15.07	20	Chemicals	0.711	0.464	WIDE:	0.456	
	23	Non-metalic mineral		0.867	1.16 - 33		
	37	Sweerage - Waste -Remediation			NARROW:		
	58	Publishing Activities			1.16 - 7.88		
	66	Auxiliary to fiancing					
	69	Legal and Accounting					
	71	Architectural and Engineering					
	72	R&D					
	73	Advertising and Market Rsearch					
	74	Other prof, scientific, technical & Veterinary					
	79	Travel Agencies					
	90	Arts & Libraries & Gambling					
	93	Sports					
	94	Activities of Memberships Organisations					
Inconsistent	22	Rubber&Plastic					
	55	Accomodation & Food & Beverages					
	64	Financial Services			LOW: 0.04 - 1.05	0.032	-
	80	Security and Investigation - Services to Buildings and Landscape & Other Admin					
	87	Residential care & Social Work					

Although the task of getting sensible weights of paid overtime is difficult, it is worth examining the MRS between paid and unpaid overtime. In this part, we have information for only 73 industries for paid-unpaid hour. This part of our analysis shows that there are industries where paid overtime happens more frequently than unpaid and in other industries exactly the opposite.

For instance, in Pharmaceutical, Wholesale and Retail of Motor vehicles there are 25 paid overtime hours every 1 unpaid (1/0.04). However there is only one year of information for both industries. Regarding the second group, there are almost 2 paid overtime hours for every one unpaid hour. In this group most industries act as peers, and there is information for more than a couple of years. In the most populous group (medium) however, we have exactly the opposite tendency. There is 1 hour of paid overtime for every 7 hours of unpaid. This group includes some manufacturing industries (Textile, Chemicals, Non-metalic mineral) and most of what we call services traditionally (Publishing, Financing, Legal and Accounting ect). The latter act as peers as well. The result makes sense since these industries are focused on task-completion and therefore working time extension can happen in an unregulated way. This has also been highlighted in the literature on unpaid overtime in relationship to the *post-Fordism's* time greediness (See Van-Echteltt 2007). Although there are few industries able to be examined in this part, the fact that in some industries (particularly the majority of them) use more unpaid overtime than paid is reflecting reality. Additionally, in this category, it appears that before the 2007-8 crisis we had 1 paid overtime hour for every 4 unpaid with the pattern changed to 1:8. However, in the peers-only analysis, we have a change from 1:3.9 to 1:4.6, which shows that there are no massive changes between the MRS, and if it changes it increases.

Table Appendix 21.3 - Marginal Rate of Substitution (MRS) between Paid Overtime and Basic Working Hours – Productive industries – 1 paid overtime hour compensated with Basic Working Hours

MRS							
PAID-UNPAID	**DMU**	**Description**	**Average**	**Crisis Effects**	**PAID-UNPAID-PEERS**	**Average - PEERS**	**Crisis Effects - PEERS**
Lowest: 0.015-0.052	17	Paper	**0.033**	-	**Lowest: 0.052**		
	50	**Water transport**				0.052	-
Low: 0.19 - 0.34	18	Printing&Reproduction of recorded media	**0.283**	**DECREASE**	**Low: 0.3 - 0.34**		
	26	Computer, electronic and opticals		**0.322**			
	74	**Other prof, scientific, technical & Veterinary**		**0.188**		0.322	-
Medium: 0.47 - 2.48	36	Water collection, treatment and Supply	**1.745**	**INCREASE**	**Medium: 0.47 - 1.97**		
	58	**Publishing Activities**		**1.406**		1.138	-
	59	Motion video tv sound & Broadcasting		**2.191**			
	72	**R&D**					
Inconsistent	**5**	**Mining**					
	27	Electrical equipment					
	61	**Telecommunication**					

Despite the even fewer observations that we have (19 DMUs with at least 3 non-zero weights), the results that we get are not very different from the all industries either. Like in the case of unpaid overtime, the range becomes narrower, showing that when we homogenise our industries we get more consistent results. The only difference with the all-industries analysis is that industry 74 used to have 1 paid overtime every 675 basic hours, but here it is much smaller, every 28basic hours on average, at least these are the frontiers on which the industry was projcted. This group has restricted information, therefore we treat these results with caution.

Contrary to the above that both paid and unpaid overtime appear more frequently compared to basic working hours, regarding the exchange of paid with unpaid overtime, it seems that the results are 'narrower' compared to the all-industries analysis. In other words, analysing productive-only it seems that in most industries paid overtime happens even more frequently compared to unpaid overtime (See low group).

Table Appendix 21.4 - Marginal Rate of Substitution (MRS) between Paid Overtime and Unpaid Overtime – Productive industries – 1 paid overtime hour compensated with Unpaid Overtime Hours

MRS							
PAID-UNPAID	DMU	Description	Average	Crisis Effects	PAID-UNPAID-PEERS	Average - PEERS	Crisis Effects - PEERS
Lowest: 0.016-0.16	10	Food-Beverages-Tobacco	0.483	INCREASE	Lowest: 0.016-0.10	0.202	INCREASE
	17	Paper	0.063	0.056		0.064	0.055
	18	Printing&Reproduction of recorded media		0.094			0.059
	20	Chemicals					
	22	Rubber&Plastic					
	23	Non-metalic mineral					
	25	Metal Products					
	26	Computer, electronic and opticals					
	27	Electrical equipment					
	28	Machinery and equipment					
	29	Motor vehicles&Tralers					
	31	Furniture - OtherManf - Repair&Installation					
	43	Construction					
	50	Water transport					
	55	Accomodation & Food & Beverages					
Low: 0.11-0.5	5	Mining	0.262	INCREASE	Low: 0.11-0.5	0.262	INCREASE
	61	Telecommunication	0.296	0.303		0.296	0.303
	74	Other prof, scientific, technical & Veterinary		0.336			0.336
Medium: 0.95-2.3	21	Pharmaceutical	1.524	INCREASE	Medium: 0.95	0.945	-
	35	Electricity-Gas-Steam-Airconditioning		1.256			
	36	Water collection, treatment and Supply		2.329			
	59	Motion video tv sound & Broadcasting					
Inconsistent	13	Textiles-Apparel-Leather					
	58	Publishing Activities					
	62	Computer programming and consultancy					
	72	R&D					

This contradicts with the reality, where unpaid overtime is higher than paid over time by a factor of 10 for the whole UK economy. This result is also treated with caution, since 54 observations in this category with only 3 peer industries. But still the weights that are derived are shaped with regard to the efficient frontier. Therefore these MRSs are still the exchange rates for the inputs 'when the industry is efficient'.

Generally, the MRS analysis of the decomposed labour model focusing on productive industries only shows similar results, more narrow. However, there are slight alterations of industries' grouping, though the majority of times the result makes sense. MRSs that were derived with fewer observations, we treat the results with some caution.

Again, a more specific analysis with more homogenous features for industries leads to more consistent results.

Table Appendix 21.5 - Marginal Rate of Substitution (MRS) between Paid Overtime and Basic Working Hours – Unproductive industries – 1 paid overtime hour compensated with Basic Working Hours

MRS	Lowest	Low	Medium	Medium-High	Inconsistent
PAID_BASIC					
Range	8.5	22-73	27 - 9	160-450	
Average wide			43.3845		
Average narrow	8.5737	47.369	62.601		
Before Crisis		21.9843	90.638		
After Crisis		43.1813	53.2553		
Industries	**77 Rental& Leasing**	**45 Wholesale&Retail& Repair of Motorvehicles**	**94 Activities of Memberships Organisations**	**78 Employment Activities**	**66 Auxiliary to fiancing**
		46 Wholesale trade			**73 Advertising and Market Rsearch**
		64 Financial Services			**95 Repair of computers and personal household goods**
		65 Insurance and Pension			
		69 Legal and Accounting			
		79 Travel Agencies			
		84 Public Admin and Defence & Social Security			
		96 Other personal activities			
PEERS	**Lowest**	**Low**	**Medium**	**Medium-High**	**Inconsistent**
Range	1.3-8.5	22-73	27 - 66		
Average wide			42.0849		
Average narrow	8.5737	50.1781	66.3831		
Before Crisis		21.9843	90.638		
After Crisis		64.275	53.2553		

For deriving the above MRS, we end up with only 22 DMUs with at least 3 non-zero weights. The results that we get are very different from the all industries. In fact, it is only industry 79 with similar weights. The rest are appearing either up or down compared to the all industries analysis. Generally, the unproductive industries suggest that there is a narrower range of paid overtime compared to all-industries analysis. However, here it is suggested also that the paid overtime is even more infrequent compared to productive industries analysis, which would not be surprising taking into account that these industries are structured based on task-completion and not on strict working day limits.

Table Appendix 21.6 - Marginal Rate of Substitution (MRS) between Paid Overtime and Unpaid Overtime – Unproductive industries – 1 paid overtime hour compensated with Unpaid Overtime Hours

MRS	Lowest	Low	Inconsistent
PAID_UNPAID			
Range	0.1-0.9	1.9-6.4	
Average wide		2.779	
Average narrow	0.547	3.37	
Before Crisis		3.464	
After Crisis		3.121	
Industries	73 Advertising and Market Rsearch	46 Wholesale trade	45 Wholesale&Retail&Repair of Motorvehicles
		65 Insurance and Pension	64 Financial Services
		66 Auxiliary to fiancing	77 Rental&Leasing
		69 Legal and Accounting	95 Repair of computers and personal household goods
		78 Employment Activities	96 Other personal activities
		79 Travel Agencies	
		80 Security and Investigation - Services to Buildings and Landscape & Other Admin	
		84 Public Admin and Defence & Social Security	
		94 Activities of Memberships Organisations	
PEERS	Lowest	Low	Inconsistent
Range	0.1-0.9	0.19-0.64	
Average wide		2.661	
Average narrow	0.395	3.299	
Before Crisis	0.395	2.347	
After Crisis	0.556	3.568	

Contrary to the all-industries and the productive-only, here it appears that only industry 73 has more paid overtime than unpaid. In the majority of industries it appears that there is 1 paid hour every 3 unpaid. In the Productive only, the overwhelming majority appeared to have more paid than unpaid. However, in any case (all-industries, productive, unproductive) the non-zero weights that were derived were few. Therefore, there is no safe conclusion in this case.

Generally, from the comparison between all-industries, Productive and Unproductive we can see that the results are very similar. Only occasionally, the differences are massive. Generally, the more sensible exchange rates are derived from the Productive industries only, showing that it is the Unproductive ones responsible for the big range of weights and probably the lack of some kind of homogeneity.

Appendix 22 - 1 hour of Unpaid Overtime contribution towards £ of GVA – Decomposed Labour Model (Productive industries)

	CONTRIBUTION	UNPAID_GVA					
DMU	Description	AVERAGE ind	Average all	Crisis Effects	AVERAGE PEERS ind	Average peers	Crisis Effects Peers
85	Education	42.89	76.42	83.13	61.99	55.63	61.99
53	Postal & Courier	61.99		42.89	42.89		42.89
16	Wood	62.78					
59	Motion video tv sound & Broadcasting	78.99					
24	Basic Metals	106.34					
52	Warehousing and supporting transport	136.89	188.76	61.62		179.17	202.23
13	Textiles-Apparel-Leather	139.1		185.38			126.28
27	Electrical equipment	141.11					
30	Transport equipment	141.37			174.23		
22	Rubber&Plastic	156.76					
35	Electricity-Gas-Steam-Airconditioning	157.84			157.84		
23	Non-metalic mineral	162.32					
74	Other prof, scientific, technical & Veterinary	162.55			192.65		
19	Coke&Petroleum	163.81			163.81		
5	Mining	164.04			164.04		
1	Agriculture	168.71					
61	Telecommunication	171.96			171.96		
29	Motor vehicles&Tralers	172.97					
50	Water transport	173.91			173.91		
18	Printing&Reproduction of recorded media	175.42					
28	Machinery and equipment	175.42					
26	Computer, electronic and opticals	175.82					
62	Computer programming and consultancy	179.91			179.91		
72	R&D	186.48			108.44		
21	Pharmaceutical	188.54			188.54		
58	Publishing Activities	199.81			181.4		
17	Paper	201.48					
25	Metal Products	211.35					
49	Land transport & Pipelines	216.17					
43	Construction	216.87			216.87		
86	Human Health	217.58			217.58		
20	Chemicals	228.85			152.86		
10	Food-Beverages-Tobacco	231.37					
55	Accomodation & Food & Beverages	244.51					
31	Furniture - OtherManf - Repair&Installation	263.51					
51	Air transport	310.93					
36	Water collection, treatment and Supply	773.03					

Appendix 23 - Table 4.46 - 1 hour of Unpaid Overtime contribution towards £ of GVA – Decomposed Labour Model (Unproductive industries)

	CONTRIBUTION	UNPAID_ GVA					
DMU	Description	AVERAGE ind	Average all	Crisis Effects	AVERAGE PEERS ind	Average peers	Crisis Effects Peers
45	Wholesale&Retail&Repair of Motorvehicles	310.846	276.595	286.568	310.846	279.669	310.703
46	Wholesale trade	146.908		263.631	146.908		250.799
47	Retail	103.023			103.023		
64	Financial Services	327.734			327.734		
65	Insurance and Pension	369.310			369.310		
66	Auxiliary to fiancing	143.034			134.861		
69	Legal and Accounting	130.098			130.098		
71	Architectural and Engineering	147.590					
73	Advertising and Market Rsearch	296.716			336.507		
77	Rental&Leasing	505.167			533.063		
78	Employment Activities	122.624			122.624		
79	Travel Agencies	247.205			256.967		
80	Security and Investigation - Services to Buildings and Landscape & Other Admin	184.747					
84	Public Admin and Defence & Social Security	159.731			159.731		
90	Arts & Libraries & Gambling	489.485					
93	Sports	383.824					
94	Activities of Memberships Organisations	234.332			200.801		
95	Repair of computers and personal household goods	361.580			361.580		
96	Other personal activities	338.299			362.757		

APPENDIX 24 – Details of the Clustered Analysis Before and After Crisis

Table APPENDIX 24.1 – MRS Unpaid-Basic – Before and After Crisis – All Industry Analysis

ALL INDUSTRIES - UNPAID-BASIC

a) BEFORE

MRS		Low		Medium		High		Highest		Inconsistent
UNPAID_BASIC										
AVERAGE		11.83984		40.60128		230.2447		599.9786		
AVERAGE (NARROW)		6.005714		45.98518		234.6533				
	19	**Coke&Petroleum**	13	Textiles-Apparel-Leather	1	Agriculture	96	Other personal activities	16	Wood
	26	Computer, electronic and opticals	17	Paper	**5**	**Mining**			24	Basic Metals
	27	Electrical equipment	18	Printing&Reproduction of recorded media	10	Food-Beverages-Tobacco			72	R&D
	62	**Computer programming and consultancy**	22	Rubber&Plastic	20	Chemicals			73	Advertising and Market Rsearch
	64	**Financial Services**	23	Non-metalic mineral	21	Pharmaceutical			79	Travel Agencies
	71	Architectural and Engineering	25	Metal Products	29	Motor vehicles&Tralers			93	Sports
			28	Machinery and equipment	30	Transport equipment			95	Repair of computers and personal household goods
			31	Furniture - OtherManf - Repair&Installation	51	Air transport				
			50	Water transport	58	Publishing Activities				
			53	**Postal & Courier**	65	Insurance and Pension				
			69	Legal and Accounting	77	Rental&Leasing				
			74	Other prof, scientific, technical & Veterinary	90	Arts & Libraries & Gambling				
			94	Activities of Memberships Organisations						
PEERS										
AVERAGE		2.121983		46.93791				599.9786		
		3.182975		46.93791						

b) AFTER

MRS		Low		Medium		High		Inconsistent
UNPAID_BASIC								
AVERAGE		4.3456		18.68095		66.11891		
	20	Chemicals	1	Agriculture	28	Machinery and equipment	21	Pharmaceutical
			25	Metal Products	45	Wholesale&Retail&Repair of Motorvehicles	22	Rubber&Plastic
			29	Motor vehicles&Tralers	50	Water transport	53	Postal & Courier
			30	Transport equipment	64	Financial Services	66	Auxiliary to fiancing
			31	Furniture - OtherManf - Repair&Installation	87	Residential care & Social Work	71	Architectural and Engineering
			58	Publishing Activities			79	Travel Agencies
			62	Computer programming and consultancy				
			72	R&D				
			78	Employment Activities				
			94	Activities of Memberships Organisations				
			96	Other personal activities				
PEERS								
AVERAGE		4.3456		26.75275		33.78707		

Table APPENDIX 24.2 – MRS Unpaid-Basic – Before and After Crisis – Productive Industry Analysis

a) BEFORE

MRS												
UNPAID_BASIC		Lowest		Low		Medium		High		Highest		Inconsistent
AVERAGE		0.683495		15.48996		19.17292		54.26536		347.8922		
	19	Coke&Petroleum	13	Textiles-Apparel-Leather	1	Agriculture	35	Electricity-Gas-Steam-Air-conditioning	10	Food-Beverages-Tobacco	5	Mining
			17	Paper	18	Printing&Reproduction of recorded media	52	Warehousing and supporting transport	37	Sewerage	21	Pharmaceutical
			23	Non-metalic mineral	20	Chemicals						
			27	Electrical equipment	22	Rubber&Plastic						
			50	Water transport	24	Basic Metals						
			53	Postal & Courier	25	Metal Products						
			62	Computer programming and consultancy	26	Computer, electronic and opticals						
			71	Architecture & civil engineering	28	Machinery and equipment						
			87	Residential care and social work	29	Motor vehicles&Tralers						
					30	Transport equipment						
					31	Furniture - OtherManf - Repair&Installation						
					51	Air transport						
					58	Publishing Activities						
					72	R&D						
					74	Other prof, scientific, technical & Veterinary						
PEERS AVERAGE		**0.683495**		**13.76701**		**47.62764**		**60.9031**				

b) AFTER

MRS								
UNPAID_BASIC		Lowest		Low		High		Inconsistent
AVERAGE		2.111895		10.29397917		349.6594		
	50	Water transport	5	Mining	1	Agriculture	21	Pharmaceutical
	59	Motion video tv sound & Broadcasting	20	Chemicals	22	Rubber&Plastic	53	Postal & Courier
	71	Architectural and Engineering	43	Construction	25	Metal Products	61	Telecommunication
	74	Other prof, scientific, technical & Veterinary	49	Land transport & Pipelines	26	Computer, electronic and opticals		
			52	Warehousing and supporting transport	28	Machinery and equipment		
					29	Motor vehicles&Tralers		
					30	Transport equipment		
					31	Furniture - OtherManf - Repair&Installation		
					58	Publishing Activities		
					62	Computer programming and consultancy		
					72	R&D		
PEERS		1.904379		11.37751433		349.6646		

Table APPENDIX 24.3 – MRS Unpaid-Basic – Before and After Crisis – Unproductive Industry Analysis

a) BEFORE

MRS				
UNPAID_BASIC		**Medium**		**High**
AVERAGE		35.86290188		77.593115
	73	Advertising and market research	65	Insurance and Pension
	79	Travel agency, tour operator and other reservation service and related activities	77	Rental and leasing activities
			94	Activities of membership organisations
			95	Repair of computers and personal and household goods
			96	Other personal activities
PEERS				
AVERAGE		**36.5905688**		**63.304326**

b) AFTER

MRS		
UNPAID_BASIC	**DMU**	**Low**
AVERAGE		36.45002938
	45	Wholesale&Retail&Repair of Motorvehicles
	64	Financial Services
	65	Insurance and Pension
	66	Auxiliary to fiancing
	69	Insurance and Pension
	78	Employment Activities
	79	Travel Agencies
	84	Public Admin and Defence & Social Security
	94	Activities of Memberships Organisations
	96	Other personal activities
PEERS		
		41.8483565

Table APPENDIX 24.4 – Contribution of Unpaid to GVA– Before and After Crisis – All Industry Analysis

a) BEFORE

CONTRIBUTION								
UNPAID_BASIC	**Low**		**Medium**		**High**		**Inconsistent**	
AVERAGE	144.4061		383.059978		2117.525			
	45	Wholesale&Retail&Repair of Motorvehicles	1	Agriculture	19	Coke&Petroleum	16	Wood
	46	Wholesale trade	5	Mining	35	Electricity-Gas-Steam-Airconditioning	24	Basic Metals
	53	Postal & Courier	10	Food-Beverages-Tobacco	37	Sweerage - Waste - Remediation	84	Public Admin and Defence & Social Security
	62	Computer programming and consultancy	13	Textiles-Apparel-Leather	52	Warehousing and supporting transport	86	Human Health
	66	Auxiliary to fiancing	17	Paper	59	Motion video tv sound & Broadcasting	95	Repair of computers and personal household goods
	69	Legal and Accounting	18	Printing&Reproduction of recorded media	64	Financial Services		
	71	Architectural and Engineering	20	Chemicals	65	Insurance and Pension		
	73	Advertising and Market Rsearch	21	Pharmaceutical				
	87	Residential care & Social Work	22	Rubber&Plastic				
	78	Employment Activities	23	Non-metalic mineral				
	79	Travel Agencies	25	Metal Products				
			26	Computer, electronic and opticals				
			27	Electrical equipment				
			28	Machinery and equipment				
			29	Motor vehicles&Tralers				
			30	Transport equipment				
			31	Furniture - OtherManf - Repair&Installation				
			50	Water transport				
			51	Air transport				
			55	Accomodation & Food & Beverages				
			58	Publishing Activities				
			72	R&D				
			74	Other prof, scientific, technical & Veterinary				
			77	Rental&Leasing				
			80	Security and Investigation - Services to Buildings and Landscape & Other Admin				
			90	Arts & Libraries & Gambling				
			93	Sports				
			94	Activities of Memberships Organisations				
			96	Other personal activities				
PEERS								
AVERAGE	150.2131		310.93685		1166.076			

b) AFTER

CONTRIBUTION								
UNPAID_BASIC	**Low**		**Medium**		**High**		**Inconsistent**	
AVERAGE	100.63602		116.4759		303.0381			
AVERAGE (Narrow)	54.04718							
	53	Postal & Courier	25	Metal Products	1	Agriculture	22	Rubber&Plastic
	66	Auxiliary to fiancing	31	Furniture - OtherManf - Repair&Installation	20	Chemicals	79	Travel Agencies
	71	Architectural and Engineering	45	Wholesale&Retail&Repair of Motorvehicles	21	Pharmaceutical		
	96	Other personal activities	50	Water transport	28	Machinery and equipment		
			78	Employment Activities	29	Motor vehicles&Tralers		
			94	Activities of Memberships Organisations	30	Transport equipment		
					58	Publishing Activities		
					62	Computer programming and consultancy		
					64	Financial Services		
					72	R&D		
					87	Residential care & Social Work		
PEERS								
AVERAGE	186.10685		109.5442		254.683			
AVERAGE(Narrow)	42.48693							

Table APPENDIX 24.5 – Contribution of Unpaid to GVA– Before and After Crisis – Productive Industry Analysis

a) BEFORE

CONTRIBUTION				
UNPAID_BASIC		**Lowest**		**Low**
AVERAGE		84.21519294		192.9977404
	19	Coke&Petroleum	1	Agriculture
	53	Postal & Courier	5	Mining
	71	Architecture & civil engineering	10	Food-Beverages-Tobacco
	74	Other prof, scientific, technical & Veterinary	13	Textiles-Apparel-Leather
			17	Paper
			18	Printing&Reproduction of recorded media
			20	Chemicals
			21	Pharmaceutical
			22	Rubber&Plastic
			23	Non-metalic mineral
			24	Basic Metals
			25	Metal Products
			26	Computer, electronic and opticals
			27	Electrical equipment
			28	Machinery and equipment
			29	Motor vehicles&Tralers
			30	Transport equipment
			31	Furniture - OtherManf - Repair&Installation
			35	Electricity-Gas-Steam-Air-conditioning
			37	Sewerage
			50	Water transport
			51	Air transport
			52	Warehousing and supporting transport
			58	Publishing Activities
			62	Computer programming and consultancy
			72	R&D
			87	Residential care and social work
PEERS		**Lowest**		**Low**
AVERAGE		70.139684		216.1151767

b) AFTER

CONTRIBUTION						
UNPAID_BASIC		**Lowest**		**Low**		**Inconsistent**
AVERAGE		**20.32537**		**268.8297371**		
	50	Water transport	1	Agriculture	53	Postal & Courier
	74	Other prof, scientific, technical & Veterinary	5	Mining	71	Architectural and Engineering
			10	Food-Beverages-Tobacco		
			20	Chemicals		
			21	Pharmaceutical		
			22	Rubber&Plastic		
			25	Metal Products		
			26	Computer, electronic and opticals		
			28	Machinery and equipment		
			29	Motor vehicles&Tralers		
			30	Transport equipment		
			31	Furniture - OtherManf - Repair&Installation		
			43	Construction		
			49	Land transport & Pipelines		
			52	Warehousing and supporting transport		
			55	Accomodation & Food & Beverages		
			58	Publishing Activities		
			59	Motion video tv sound & Broadcasting		
			61	Telecommunication		
			62	Computer programming and consultancy		
			72	R&D		
			86	Human Health		
			87	Residential care & Social Work		
PEERS		**20.3254**		**214.6354189**		

Table APPENDIX 24.6 – Contribution of Unpaid to GVA– Before and After Crisis – Unproductive Industry Analysis

a) BEFORE

CONTRIBUTION				
UNPAID_BASIC		**Medium**		**High**
AVERAGE		218.7453063		500.6876833
	73	Advertising and market research	65	Insurance and Pension
	79	Travel agency, tour operator and other reservation service and related activities	77	Rental and leasing activities
			94	Activities of membership organisations
			95	Repair of computers and personal and household goods
			96	Other personal activities
PEERS AVERAGE		266.633765		511.0998

b) AFTER

CONTRIBUTION		
UNPAID_BASIC		**Low**
AVERAGE		**315.3231292**
	45	**Wholesale&Retail&Repair of Motorvehicles**
	46	**Wholesale trade**
	47	**Retail**
	64	**Financial Services**
	65	**Insurance and Pension**
	66	**Auxiliary to financing**
	69	**Insurance and Pension**
	78	**Employment Activities**
	79	**Travel Agencies**
	80	**Security and Investigation - Services to Buildings and Landscape & Other Admin**
	84	**Public Admin and Defence & Social Security**
	94	**Activities of Memberships Organisations**
	96	**Other personal activities**
PEERS		321.9850727

Appendix 25 – Comparison Diagnostics of NCS-only with NCS-total labour – Real Values – All Industries

a) NCS ONLY

Source	SS	df	MS
Model	210.5827	1	210.5827
Residual	283.2176	614	0.461266
Total	493.8002	615	0.802927

Number of obs	616
F(1, 614)	456.53
Prob > F	0
R-squared	0.4265
Adj R-squared	0.4255
Root MSE	0.67917

lgva	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
lncs	0.473031	0.0221388	21.37	0	0.429554	0.516507
_cons	4.728407	0.2188945	21.6	0	4.298534	5.15828

DIAGNOSTICS	VALUE
VIF	1
hettest (p-value)	0.2848
hettest, rhs(p-value)	0.2848
estat imtest, white(p-value)	0.1708
ovtest(p-value)	0.0007

b) NCS – Total

Source	SS	df	MS
Model	362.2607	2	181.1304
Residual	131.5395	613	0.214583
Total	493.8002	615	0.802927

Number of obs	616
F(2, 613)	844.1
Prob > F	0
R-squared	0.7336
Adj R-squared	0.7327
Root MSE	0.46323

lgva	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
lncs	0.24941	0.0172845	14.43	0	0.215	0.283354
lTTUSHRT	0.519944	0.0195566	26.59	0	0.482	0.55835
_cons	3.791488	0.1534016	24.72	0	3.49	4.092745

DIAGNOSTICS	VALUE
VIF	**1.31**
hettest (p-value)	0.3788
hettest, rhs(p-value)	0
estat imtest, white(p-value)	0
ovtest(p-value)	0