Essays on Economic Inequalities

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Contents

A General Outlook of the Work

This work relates to income inequalities studied from two different perspectives: ICT innovation (Chapter 1-2) and bargaining among social groups (Chapter 3-4). ICT innovation affects the number of jobs but also the structure of the labor market, with important consequences on income distribution. ICT innovation could destroy more jobs than it creates, for the first time since the beginning of industrialization; meanwhile the advanced ICT softwares are reducing that professions typically associated with the middle class, in favor of those that lies to the extremes of pays. On the other hand, the ability of each social group to attract resources is a second source of movements in income distribution; in particular, bargaining can take place within each company (firms versus trade-unions) and within the government (political parties competing to impose welfare regime).

In Chapter 1 we estimate the effect of internet revolution on the number of jobs. The fourth industrial revolution, which began with the rise of internet technology, is now seeing the development of increasingly sophisticated artificial intelligence software. One consequence of such development is the ever-more serious risk posed for jobs. Chapter 1 shall examine this phenomenon in three steps; first, we shall empirically show that productivity growth over the last two decades was led by ICT; secondly, we shall discuss whether these productivity gains have affected the structure of employment by examining the data coming from 16 OECD countries and how such outcomes may be linked to innovation in ICT. Finally, a forecasting logistic model on the evolution of employment will be provided, projecting that by 2040-50 unemployment and atypical forms of work will affect 60% of the workforce in most of the countries observed.

In Chapter 2 we observe the structure of job market over the last 25 years in order to find which professions have expanded and which ones have reduced and then we link this outcome to middle class thinning and the consequent income inequality growth. The underlying hypothesis is that ICT innovations are changing job structures, at least in the most industrialized countries. Firstly, this chapter takes the studies of Acemoglu and Autor (2010) and Goos et al. (2009) as a starting point and then updates their results for 16 European countries. The outcome we have found is an accentuation of the dynamics already observed in the literature. On the one hand, the number of non-routine jobs has increased while routine ones (both skilled and non-skilled) have become fewer; on the other hand, while the number of both low-paid and high-paid jobs has risen, those with average compensation have fallen almost everywhere. The consequence is a progressive thinning of the middle class and

a change in income distribution among Western populations. Secondly, Chapter 2 links these findings with the recent intensification of the populist phenomenon. We shall be discussing an original theory, consistent both with the literature and with the empirical evidence, which describes the populist origins and its future prospects. In Chapter 3 shift our consideration to the social dynamic of inequalities. Income inequalities increase and decrease according to the capability of each social group in appropriating the national added value. The final outcome of this partition may be seen reflected on the price level. The lasting debate about the origins of inflation has determined two opposing approaches: monetarism and bargaining. The aim of Chapter 3 is to put these aspects together in an innovative synthesis. To investigate this item, we used an Input-Output (IO) approach and we developed an original mathematical process to define the real price index variations. After that, we tested this theoretical definition with an empirical study on Italian inflation over 30 years where we elaborated 31 official I-O tables compiled by the Italian statistics bureau (ISTAT). By this verified definition, inflation is strictly due to the level of wages and profits. This level, in turn, depends both on monetary government intervention (monetarist approach) and on collective bargaining among trade-unions and stakeholders (classic bargaining approach). Finally, by this model, theoretical implications are derived and summed up in six different settings *ceteris paribus*.
Finally, in Chapter 4 we link income inequalities to Health Systems in a European perspective. With a sociological slant, we compare European countries in the context of neoliberal era, focusing on healthy life years for elderly (HLY65+). Firstly, we outline the theoretical state of the art in the literature on health inequalities, stressing the important relationship that links health inequalities to geographic area. In the second part of Chapter 4 we observe data relating to the changes of HLY65+ in the European member states and we correlate these results with the income inequality measured by the Gini index. The last part of Chapter 4 advance some comments on health inequalities in the context of the neoliberal era and in relation to geographic place and welfare policies.

Chapter 1

Long-Term Mass Unemployment and ICT Innovation

1.1 Introduction

Web, Big Data, Internet of Things and Artificial Intelligence respectively represent the nervous system, the memory, the physical body and the mind of a gigantic system that in a few decades could definitively replace human beings in all kinds of work (Kurzweil, 2005). According to a report by the World Economic Forum (2016), we are only at the beginning of the fourth industrial revolution. Developments in the GNR (Genetics, Nanotechnology and Robotics) sectors are amplifying, opening up new possibilities for production and consumption that were previously unimaginable. If it is true that we have just entered the age of a new industrial revolution, then we need to identify the single, most important invention of our era; to highlight the technology which has allowed the emergence of such a vast range of innovative sectors and applications. Every industrial revolution has had its pivotal technology. Innovations such as the steam engine (first industrial revolution), electricity (second industrial revolution) and electronics (third industrial revolution), are called General Purpose Technologies (GPTs). The economic historian Gavin Wright offers a simple definition: GPTs are deeply innovative ideas or techniques that can potentially have a major impact on many sectors of the economy. "Impact" in this case means that many sectors will see a remarkable boost in productivity. Information and Communication Technology (ICT), and specifically the World Wide Web, is the GPT of the fourth industrial revolution, which began in the late 1990s. Most economic historians concur with the assessment that ICT meets all of the criteria to be considered as GPTs. In fact, in a list of all the candidates for this classification compiled by the economist Alexander Field, only steam power got more votes than ICT, which was tied with electricity as the second most commonly accepted GPT.

In this paper we firstly investigate the impact of ICTs on productivity growth over several industrialized countries and secondly we evaluate the effect of productivity growth on the employment structure. As for the first step, the economic research on this item, typically proxied the drivers of productivity through investments in Research and Development (R&D) as in Griliches (1979), Patel and Soete (1988), Guellec and Van Pottelsberghe de la Potterie (2004) and O'Mahony and Vecchi (2009). However, since the mid-1990s, the economic literature has also focused on ICT as source of productivity growth in industrialized countries (Venturini, 2009; Pieri, 2018). Moreover, Polder et al. (2017), considered ICT the main infrastructure of knowledge economies (i.e. R&D-based). Like in Pieri (2018), we estimate the impact of ICTs on productivity growth, foscusing on the improtance of capital stocks in ICT, RD and non-ICT economic sectors. Secondly, we also consider the spillover channel, which recognized the possibility for technological investments in ICT to promote the diffusion of knowledge across firms and countries (Brynjolfsson and Hitt, 2003; Tambe and Hitt, 2014; Marsh et al., 2017). We found that productivity growth over the last 20 years has been mainly lead by ICTs.

In the second step we wonder which is the impact of productivity growth on employment within the fourth industrial revolution. This is a controversial issue in literature. Economists have been arguing for two centuries that the final effect of innovation on jobs should be positive. Ricardo's famous chapter on machinery suggests that labour saving technology reduces the demand for undifferentiated labour, thus leading to technological unemployment (Ricardo, 1817). As economists have long understood, however, an invention that replaces workers with machines will have effects on product and factor markets alike. An increase in the efficiency of production which reduces the price of one good, will increase real income and thus increase demand for other goods. Hence, in short, technological progress has two competing effects on employment (Aghion and Howitt, 1994). Firstly, as technology replaces labour, there is a destructive effect, requiring employers to reallocate their labour supply; and secondly, there is the capitalization effect, as more companies enter industries where productivity is relatively high, leading employment in those industries to expand. Which will prevail in the fourth industrial revolution?

While technological innovations and software development around ICT technologies are full of enormous potential, on the other hand, their ability to replace even the most intellectual jobs is worrying many economists who have trouble predicting what would happen in a scenario with less and less need for human work. A number of books, some quite alarmist and pessimistic (Keen 2015; Carr 2015), some more cautious and optimistic (Brynjolfsson and McAfee 2012, 2014; Ford 2009, 2015; Pistono 2012; Cowen 2013; Kaplan 2015; Rifkin 1997, 2014), have been published arguing that ours is an age of increasing technological unemployment. These books have been complemented by research papers highlighting the rise of automation and the increasing share of income being taken by capital in Western economies (Frey and Osborne 2013; Fleck, Glaser and Sprague 2011; ILO 2013; Pratt 2015; Sachs et al. 2015). These have in turn been complemented by the work of a number of leading journalists and economic opinion writers (Packer 2013; Krugman 2012, 2013). The gravity of this scenario is not only a question of the risk of job losses, but also a paradigmatic change in the quality of future jobs. Among the factors leading these great changes that are bound to have a disruptive influence on the first half of the 21st century, participants in an extremely large-sample survey at the World Economic Forum (2014) listed new technologies in first place.

Furthermore, in this paper we estimate the impact of productivity on the employment. Moreover, we extend these regressions also to and index that we introduce as a novelty in this paper which adds to the unemployment rate, two categories of data from atypical contractual forms of work: involuntary part-time and temporary jobs. The evolution of these types of jobs over time shows how the structure of job market has changed. We call the sum of the unemployment rate, involuntary part-time and temporary job rate Labour Devaluation Rate (LDR). One of the novelties of this paper is just that we run our analysis and estimation considering not only the unemployment rate but also the wider concept expressed by LDR. Our estimations suggest that from 1995 to 2016, the productivity growth has positively impacted both unemployment and LDR. Recalling that productivity has increased mainly because of ICT innovation, according to the finings of step 1, we will conclude that ICT innovations are causing a severe reversion of the productivity historical effect on employment.

In Section 2 of this paper we observe the unemployment rate and LDR over a long period, starting from the 70s and 80s (according to the availability of the OECD dataset), in 16 industrialized OECD countries. In Section 3, we run a fine panel estimate to prove that productivity growth over the last 15 years has been mainly led by ICT and by the replacement of the workforce in favor of capital. Therefore, we can update the empirical evidence already stated in past literature; moreover our dataset is one of the largest ever used in this field (over 4200 observations), reinforcing the validity of our outcome. In Section 4, we advance an estimation model to regress LDR on the average hourly productivity trend of the economy. We plug the productivity growth rate and the appropriate control variables suggested by literature into the model as independent variables for LDR. We are trying to find out whether productivity growth has positively affected employment in these 16 countries. If this is the case, we can use the findings of Section 3 (i.e. that productivity growth is mainly caused by R&D and ICT, as supported by Pieri et al. 2018; Cardona et al. 2013; Dahl, 2011) to conclude that ICT innovation has positively affected the long-term LDR trend. In the end, in Section 5, we use the same estimating equation to predict in which year countries could reach an LDR rate of 60%, *ceteris paribus.* Our estimations point to a grave forecast in terms of the rate of LDR.

1.2 Some General Statistics

In this Section we are going to illustrate some statistics about developed countries and long-term unemployment. The general hypothesis behind this comparison is proofing that the long-term unemployment is increasing. In the next sections we would link this observed trend to ICT innovations, controlling for structural reforms of job market. We shall start from the classical unemployment data provided by OECD and than we go ahead. We selected intentionally only industrialized countries, because it is here that the most advanced automated technologies have been applied first, and it is therefore from here that you can see upcoming venture trends[1]. Moreover we show a long-term time series (from 1985) just in order to observe structural changes in employment.

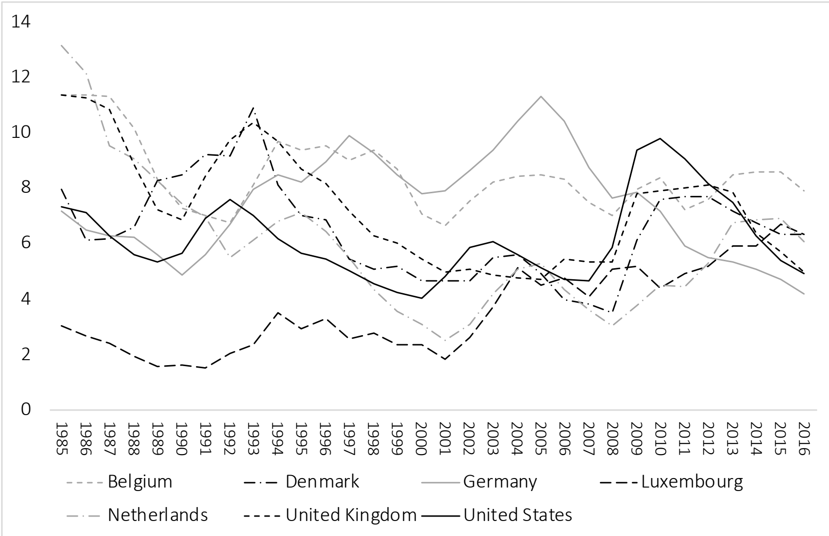

Figure 1.1: Rate of unemployment as % of Labour Force, 1985-2017, OECD

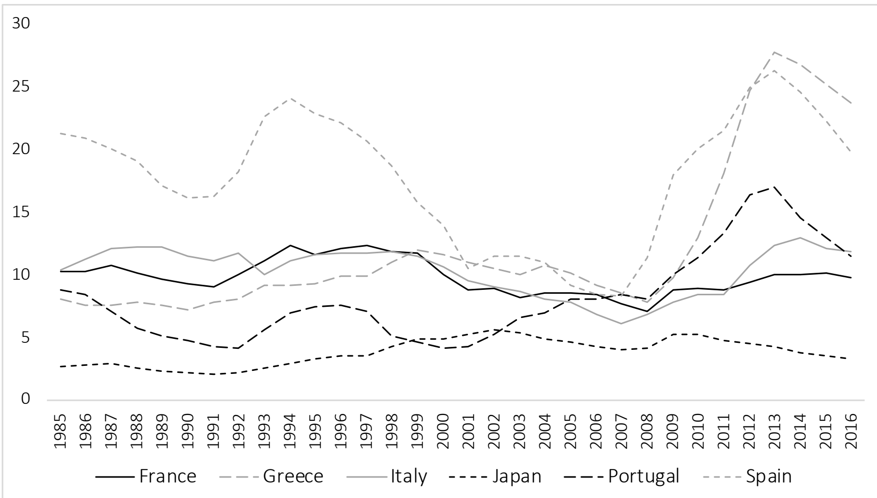

Figure 1.2: Rate of unemployment as % of Labour Force, 1985-2017, OECD

[1]These countries are: USA, UK, Italy, Spain, Portugal, Greece, Belgium, Luxemburg, Denmark, Germany, Netherlands, France, Japan.

Figure 1.1 and 1.2 show that the unemployment trend has not been constant over the period considered. We can only observe that there are two big waves, easily connectable to the dot.com bubble burst between the period 1997-2003, and to the Financial global crisis started in USA between 2008-2014. However, if we only look at unemployment data we cannot observe a constant long-term increasing trend, therefore we could initially conclude that ICT innovation and other structural reforms in the job market, has not affected occupational levels.

However, as McKinsey (2015) pointed out, the new digital technologies will not eliminate jobs all at once, but more likely will gradually replace some parts of them, changing the quality of human work. For this reason, the time series on unemployment do not exhibit a stable upward trend. The problem with this simplified approach then, as McKinsey would suggest, is that it looks only at unemployment, which is the final effect of job robotization. On the contrary, it is not enough to consider only unemployment *per se*; we need to also examine how the labor market has evolved in recent decades. If in the 70s and 80s, for example, permanent jobs, workplace stability and career opportunities for seniority were all consolidated realities; nowadays the physiognomy of job market has been distorted. The introduction of new atypical job contracts has created the so-called *gig economy*. It has largely favored self-employment, and has caused the phenomenon of precarious occupations to explode.

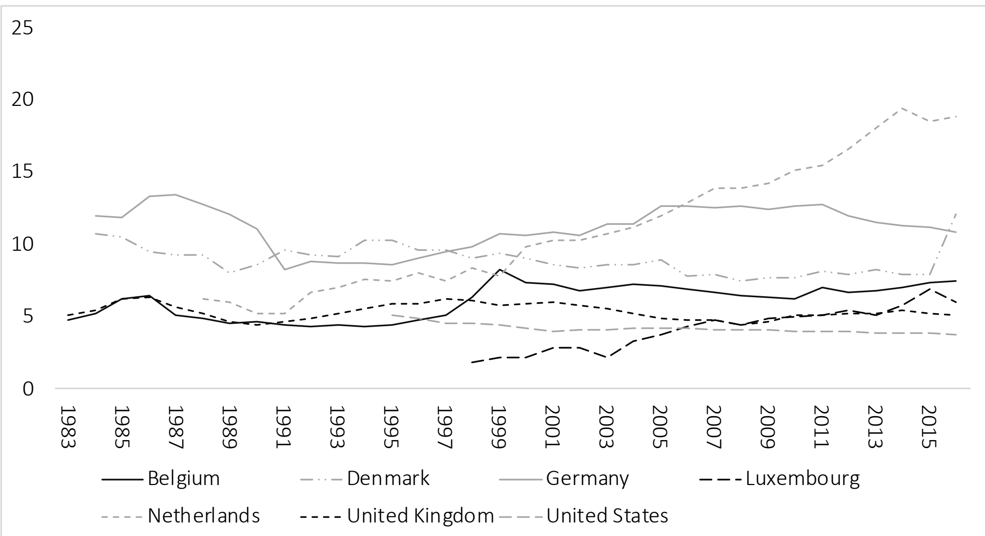

Figure 1.3: Temporary workers as % of employment, 1985-2017, OECD

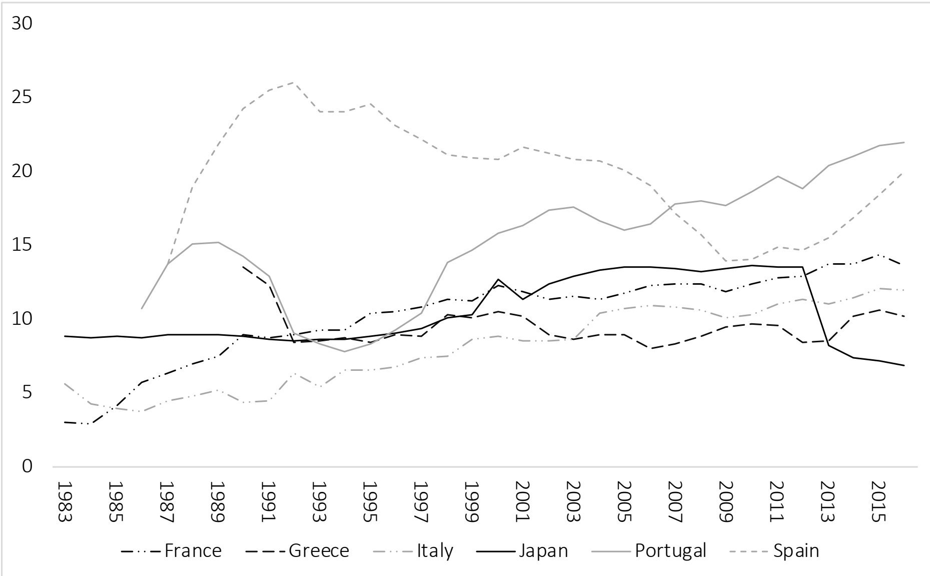

Figure 1.4: Temporary workers as % of employment, 1985-2017, OECD

Data reported in Figure 1.3-1.4, provided by OECD statistics, show the percentage of temporary workers related to the total employment. According to OECD, temporary workers statistics "include wage and salary workers whose job has a pre-determined termination date. National definitions broadly conform to this generic definition, but may vary depending on national circumstances. This indicator is broken down by age group and it is measured as percentage of dependent employees (i.e. wage and salary workers)". Unlike the data on unemployment, data describing the percentage of employees who are only temporary workers show a much more definite trend, common to a whole range of countries and generally on the rise. For the countries in which provide the longest time series (compiled until 1983), it is also possible to observe that in the early 1980s temporary employment was largely limited to a minority of employees. In France, for example, it was just 3.34% against the current 16.89%, in Italy it was 6.61% in 1983 against 15.4% in 2017, and similarly for all other countries where the values in 1983 never exceeded 5-6% of the workforce.

Historical trends in temporary employment are showing that a change in the way work is structured is underway, first of all, in terms of quality. If at the beginning of the 1980s almost all contracts offered permanent employment, today this is no longer the case. A massive wave of precariousness has invaded the labor market. The percentage of new types of contracts, characterized by short-term employment, is no longer negligible. This trend is precisely what the World Economic Forum was predicting (2016) when it spoke of peer-to-peer and crowdsourcing platforms. Moreover, these data refer to the total employed population, thus they include those whose jobs are still governed by the collective labor contracts drafted in the previous period. This systematically leads to a gross underestimation of the extent of the phenomenon. To predict the future trends we could observe the conditions under which people are employed today. To know the real dynamics towards which we are moving, we could take into consideration temporary-employment data only referred to young people (15-24 years old), directly provided by OECD statistics.

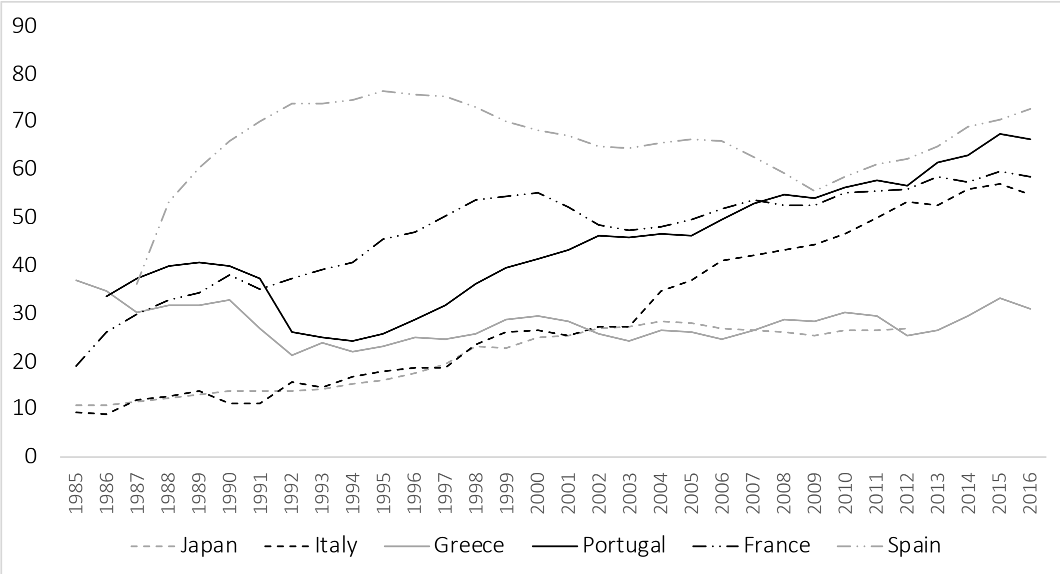

Figure 1.5: Temporary workers as % of employment (15-24 years), 1985-2017, OECD

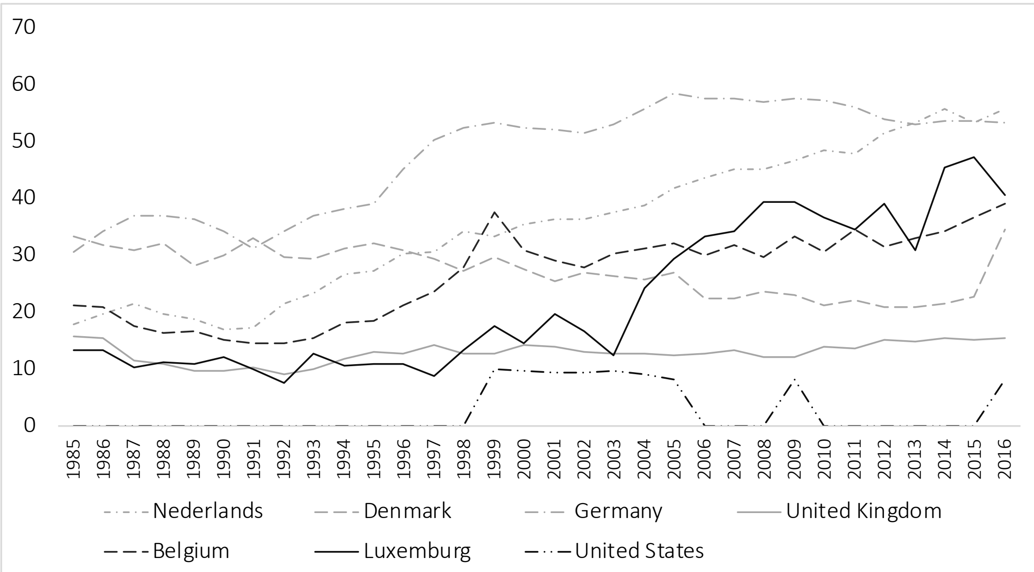

Figure 1.6: Temporary workers as % of employment (15-24 years), 1985-2017, OECD

First of all, it must be said that job instability among young people is traditionally higher compared with the rate of temporary work inclusive of all age groups.

However, the percentage of precarious workers among young people has exploded over the last 30 years, reaching unprecedented levels in the history of social statistics (during peacetime), passing from rates of approximately 10-20% to 40% in most countries, while even exceeding 50% in many others. In Germany, Holland, Italy, France and Portugal, rates of job precariousness for youth have even reached as high as 60%. These data should not be interpreted, for instance, to state that Italy offers rosier labour market perspectives than its German counterpart. The graphs show that youth precarious employment has grown enormously since the 1990s, faster than total temporary worker rates. This means that the job contracts enjoyed by the previous generation have not been offered to the new ones, radically changing the job market structure in the direction of becoming progressively more and more unstable, fluid, indefinite.

Moreover, there is also an other labour force statistics that we should observe in order to study the evolution of job market structure: those people who have permanent jobs but are forced into involuntary part-time. A lot of companies, in order to avoid bankruptcy or the need to fire a significant component of their employees, have created mandatory part-time plans. However the final economic effect is the same: a reduction in the number of hours worked and therefore in costs (payroll). This phenomenon, as shown in the following graphs, is affecting an ever-increasing percentage of workers and could be linked to new technologies (as we will be examining). OECD statistics provide this data, splitting voluntary from involuntary part-time jobs. According to OECD, a person is considered an involuntary permanent part-time worker if he/she declared his/her inability to find a permanent full-time work. In almost all industrialized countries, the percentage of permanent non-voluntary part-time workers in the labour force has been continuously increasing.

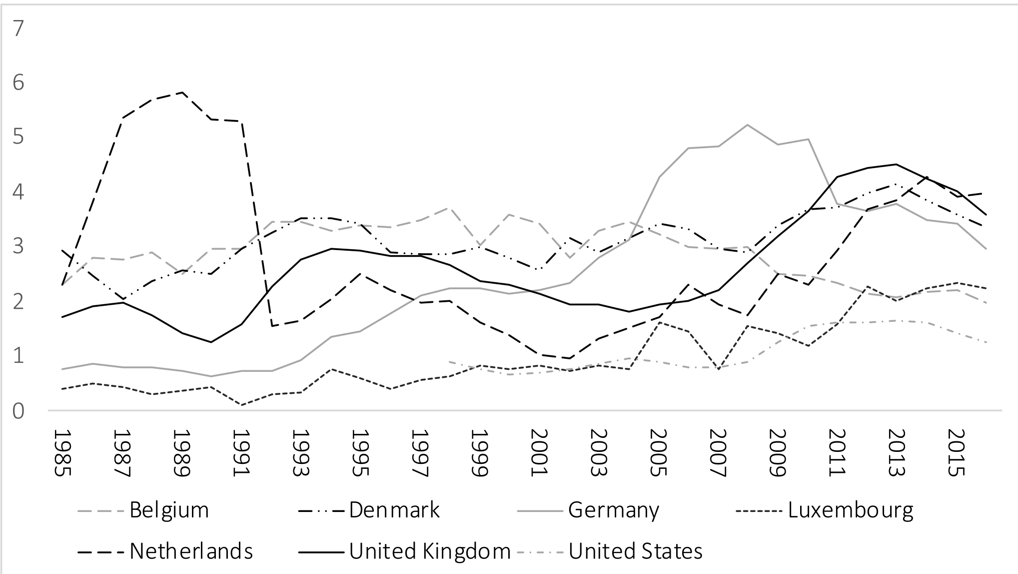

Figure 1.7: Share of involuntary part-timers in Labour Force, 1985-2017, OECD

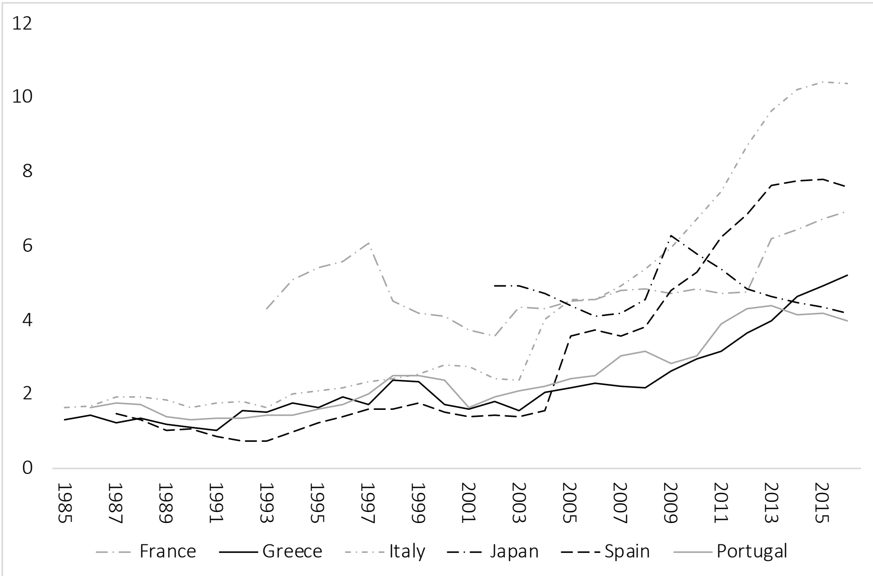

Figure 1.8: Share of involuntary part-timers in Labour Force, 1985-2017, OECD

In 1985 only 1-2% of permanent workers were involved in this phenomenon; in 2016 the share rose on average to 4-5% with peaks in Italy (10%) and in Spain (7%).

Now we are ready to build-up a new and simply indicator to measure the job market structure. We shall sum the unemployment rate, the rate of temporary jobs and the rate of involuntary part-time workers (adjusted on workforce and referred to all age groups) getting a statistics which helps to describe the evolution of real labour conditions, revealing much more significant information than that obtained considering the unemployment rate alone. The sum of all these components, that represents forms of atypical work, in addition, reveals a long-term trend, which is not so evident if one only observes the trend of unemployment, but it is consistent with the above-mentioned World Economic Forum hypotheses (2014).

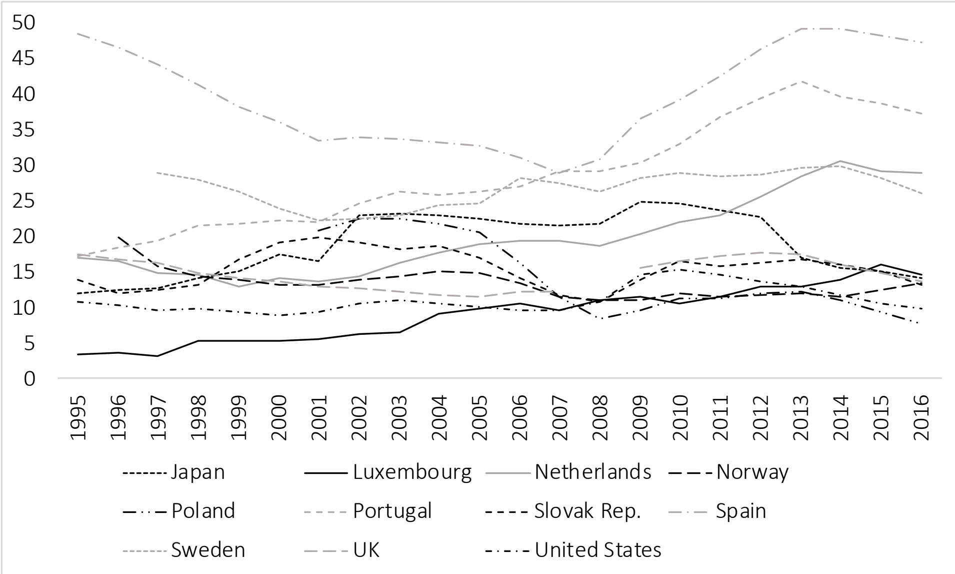

Figure 1.9: % people without a permanent full-time employment on total labour force, 1995-2016, OECD

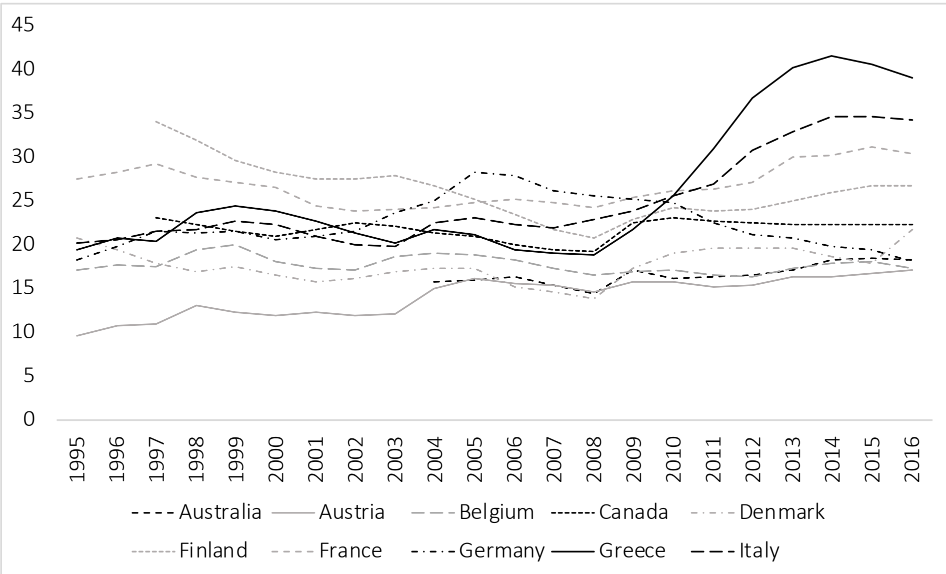

Figure 1.10: % people without a permanent full-time employment on total labour force, 1995-2016, OECD

The rates so calculated allow us to grasp the epochal leap in progress into the new millennium. The traditional position of permanent employment, within a stable workplace over time, with career prospects for seniority, with a team of colleagues working together towards common results, which had been the most typical form of work, is gradually becoming itself a form of atypical work. This scenario is already evident when observing the same statistics for youth. If this trend does not reverse, within the next 20 years the percentages now affecting youth employment specifically, will expand to describe the total workforce, with unpredictable economic, political and social consequences.

Finally, let us define the arithmetic sum of the unemployment rate, the rate of temporary workers and the rate of involuntary part-time workers as the Labor Devaluation Rate (LDR), a measure which put together unemployment and underemployment. LDR can be calculated both for total and young workforce, even if in this study we will consider LDR only for total workforce. These three variables can be summed since they are each other independent: the unemployed rate does not include temporary and involuntary part-time workers since they are classified as employed; involuntary part-time workers do not include temporary workers since OECD only counts part-time workers with permanent contracts. The increase in LDR implies that the total number of hours worked has decreased with regard to the active population. The trends presented in the table unequivocally demonstrate that we are in a slow but progressive withdrawal of human labor from the economy. We have not yet reached unemployment rates of 20-30% (Except for Portugal and Spain), but we are headed in that direction by reducing the number of hours worked in a working day (involuntary part-time workers), increasing the number of *gig jobs* (i.e. jobs on call, therefore fewer loads of working hours), and ultimately raising the number of temporary jobs contracts in comparison with permanent ones. The substantial increase in LDR will be connected, in the following sections, to the ICT innovation, controlled by structural reforms in the job market.

1.3 R&D and ICT Impact on Productivity Growth

In this section we want to find out what the impact of ICT has been on total productivity growth for the 11 most industrialized OECD-member countries: USA, UK, Spain, Italy, Portugal, France, Germany, (The) Netherlands, Luxemburg, Austria, Denmark and Finland. To this end, we have been examining data compiled from 2000 to 2014 (the last year available) by EU KLEMS and WIOD. We chose the most industrialized countries since these are where the impact of ICT on productivity growth is expected to be highest, thus they can best provide a glimpse of what will most likely happen in the future for the less developed countries. The survey was limited to these particular 11 countries due to a lack of data for the other industrialized nations[2].

In literature, productivity in ICT impact analysis is classically measured in terms of total factor productivity (TFP), derived by the constant term pre-multiplied before

[2] In the next section we shall continue considering these same 11 countries, but we will also need other kinds of data which will be provided by OECD. Thanks to the availability of the OECD database, in the next sectio we will be able to add other five countries (Greece, Portugal, Japan, Belgium and Canada) to our analysis.

the Cobb-Douglas function (Griliches, 1998; Gholami, 2009; Strobel, 2016; Ahmed, 2017). This classical approach is based on the assumption that competitive input markets (each input is paid to its marginal product) and input exhaustion (all revenue is paid to factors) lead to a condition of equilibrium in which an input's factor share equals its output elasticity. However, when the neoclassical assumptions fail, the TFP found by the Cobb-Douglas function may provide a poor approximation of true productivity. This failure could reflect production spillovers, omitted variables, embodied technological progress, measurement error or reverse causality, all of which could lead to a positive link between TFP growth and ICT intensity. Since we want to find this link between productivity and ICT capital and determine its intensity, we will use hourly productivity as our unit of measurement. Of the readily available statistical aggregates, in fact, GDP per hour worked is, in principle, the most relevant for productivity comparisons across the OECD countries (Wingender 2018). In practice, it is particularly useful when comparing productivity growth, as we are doing in this paper.

Moreover, hourly productivity automatically accounts for all the current economic effects of all past and recent innovation. Only technical progress, in fact, can explain how the same single hour of human labor can produce more goods or services in one year than in another. Hourly productivity is derived from the ratio between the added value (of countries or industrial sectors) expressed at constant US PPP, and the total number of hours worked (in the country or in the industrial sector). Using hourly productivity, moreover, makes it possible to correct the effect of economic crises that cut jobs but do not necessarily reduce productivity. Therefore, following the approach of Cantore et al. (2017), we define hourly productivity as:

$$\rho_t = ln\Big(\frac{y_t}{H_t}\Big) \tag{1.1}$$

Where ρ is the hourly productivity and y is the added value of a firm/industrial sector/country and H is the total amount of hours worked in the same firm/industrial sector/country.

Now we need to explicate a relationship between ICT and hourly productivity. The model used for analyzing the role of ICT in productivity growth is built on the traditional production function approach (Griliches, 1998). In particular, we adopt the Cobb-Douglas functional form, which has been widely used in previous studies analyzing the impact of ICT on business performance (Alpar and Kim, 1991; Brynjolfsson, 1996). Starting from the production function of Gholami et al. (2009) we assume the production function as follows:

$$Y_{i,j,t} = A(\lambda_{i,j,t}; S_{i,j,t}) f(ICT_{i,j,t}, NICT_{i,j,t}, H_{i,j,t}) \tag{1.2}$$

Where Y is the added value of sector i for country j at time t, A is the shift parameter which is dependent on an unobserved technical change parameter λ; the spillover effects of knowledge S; ICT is the ICT Capital employed by each sector i of each country j for each year t; $NICT$ is the non-ICT Capital employed; H are the total hours worked within the sector i. λ varies across sectors (α_i) and over time according to $ICT \cdot t$, an interaction between time trend and ICT capital stock which describes the specific technical change over the period.

Considering that the capital of ICT may not be the only contributor to knowledge capital, we also include the national R&D effort in knowledge capital production. These stocks are built from annual investment flows by means of the perpetual inventory method and by adopting an asset-specific rate of geometric depreciation. As a measure of R&D input, we use the cumulative value of industry research and development investments provided by EU-KLEMS database; we construct this stock by imposing a standard depreciation rate of 15% as in Pieri (2018). We must consider R&D because its impact on productivity growth may be strong and statistical significative. By doing so we counter the omitted variable problem. If we did not take into account the effect of R&D, we would have overestimated the impact of ICT on productivity growth. Therefore $S(ICT, R\&D)$ and λ depends also on $R\&D \cdot t$. Assuming a Cobb-Douglas functional form of A(.), (2) can be rewritten as follows after substitutions:

$$Y_{i,j,t} = e^{\lambda_{i,j,t}} ICT^{\beta_1} NICT^{\beta_2} H^{\theta} R\&D^{\beta_3} S^{\gamma} \tag{1.3}$$

Where:

$$\lambda_{i,j,t} = \beta_7 ICT_{i,j,t} \cdot t + \beta_8 R\&D_{i,j,t} \cdot t + \alpha_{i,j} + \nu_{i,j,t}$$

Taking the Log-form:

$$\begin{aligned} y_{i,j,t} = \beta_1 ln(ICT_{i,j,t}) + \beta_2 ln(NICT_{i,j,t}) + \theta ln(H_{i,j,t}) + \beta_4 ln(R\&D_{i,j,t}) + \\ + \gamma ln(S_{i,j,t}) + \beta_7 ICT_{i,j,t} \cdot t + \beta_8 R\&D_{i,j,t} \cdot t + \alpha_{i,j} + \epsilon_{i,j,t} \end{aligned} \tag{1.4}$$

Where $y_{i,j,t}$ is the logarithm of added value $Y_{i,j,t}$, $R\&D_{i,j,t}$ is the intermediate consumption on Research and Development for industrial sector i, country j and year t and $\epsilon_{i,j,t}$ is the error term .

Now, we add and subtract 1 to the parameter θ for hours worked as follows:

$$\begin{aligned} y_{i,j,t} = \beta_1 ln(ICT_{i,j,t}) + \beta_2 ln(NICT_{i,j,t}) + (\theta - 1) ln(H_{i,j,t}) + ln(H_{i,j,t}) + \\ + \beta_4 ln(R\&D_{i,j,t}) + \gamma ln(S_{i,j,t}) + \beta_7 ICT_{i,j,t} \cdot t + \beta_8 R\&D_{i,j,t} \cdot t + \alpha_{i,j} + \epsilon_{i,j,t} \end{aligned} \tag{1.5}$$

Now, we move on the right hand of the equation (3) $ln(H_{i,j,t})$ and by logarithm proprieties[3]:

$$\begin{aligned} \rho_{i,j,t} = \beta_1 ln(ICT_{i,j,t}) + \beta_2 ln(NICT_{i,j,t}) + \beta_3 ln(H_{i,j,t}) + \beta_4 ln(R\&D_{i,j,t}) + \\ + \beta_7 ICT_{i,j,t} \cdot t + \beta_8 R\&D_{i,j,t} \cdot t + \gamma ln(S_{i,j,t}) + \alpha_{i,j} + \epsilon_{i,j,t} \end{aligned} \tag{1.6}$$

Where $\beta_3 = \theta - 1$.

[3] $ln(Y_{i,j,t}) - ln(H_{i,j,t}) = ln\left(\frac{Y_{i,j,t}}{H_{i,j,t}}\right) = \rho_{i,j,t}$, recalling that $y = ln(Y)$.

Finally, we have to specify the form of S which captures the spillover effects of ICT and R&D. According to existing literature, ICT and R&D induce indirect effects on productivity growth. These effects typically take the form of network externalities and knowledge spillovers induced by better idea circulation and information management (Fuss and Wavermann, 2005, Becchetti and Adriani, 2005). Given its non-rival and non-excludable nature, knowledge spills over across space and time through various channels (trade, patents, people, etc.), yielding productivity gains that are proportional to the technological, geographical, or trade proximity between innovators and recipients. These externalities can take place at any level of economic activity, i.e., among firms, industries, regions and countries (Keller, 2004). Therefore, we need to plug these effects into the model; without them we would underestimate the final effects of ICT and R&D on hourly productivity.

Now allow us to briefly recall how we calculate ICT and R&D spillovers within industrial sectors, domestic and abroad. Following the guidelines put forth in literature regarding spillovers, the spillover variables are measured, for each industrial sector, as the weighted sum of other sectors' ICT capital, where the weights are sector i's bilateral intermediate consumption shares (Park 2007, Gholami 2009, Pieri 2018). For example, we have incorporated trade shares with each individual trade partner in the construction of the external ICT capital of sector i. In other words, our measure of ICT spillover is obtained as it follows:

$$ICT_{i,k}^{sp} = \sum_{k=1}^{h} \sum_{j=1}^{n} \frac{Z_{i,j,k}}{Z_i} ICT_{j,k} \qquad j \neq i \tag{1.7}$$

Where n is the number of sectors, h is the number of countries (i.e. 43 according to WIOD)[4], i iterates through all the intermediate goods j for sector i, $Z_{i,j}$ is the intermediate consumption of sector i from sector j, and Z_i is sector i's total intermediate consumption. Therefore, $Z_{i,j,k}/Z_i$ is the bilateral import share, which in turn weights sectors j's domestic and abroad ICT capital. The equation for R&D spillovers is the same, except for ICT_j, which is replaced by R&D$_{j,h}$, the consumption of R&D in the other sectors j and countries h.
Therefore the final estimating equation is:

$$\begin{split}\rho_{i,j,t} = \beta_1 ln(ICT_{i,j,t}) + \beta_2 ln(NICT_{i,j,t}) + \beta_3 ln(H_{i,j,t}) + \beta_4 ln(R\&D_{i,j,t}) + \\ + \beta_5 ln(ICT_{i,j,t}^{sp}) + \beta_6 ln(R\&D_{i,j,t}^{sp}) + \beta_7 ICT_{i,j,t} \cdot t + \beta_8 R\&D_{i,j,t} \cdot t + \alpha_{i,j} + \epsilon_{i,j,t}\end{split} \tag{1.8}$$

Where $R\&D^{sp}$ is the spillover effect of Research and Development for each sector i,

[4] As Timmer et al. (2014, 2015) warn, WIOD data is lacking for 9.1% of world commerce, therefore our spillovers are modestly lower than the real ones, i.e. we would expect them to have a slightly higher impact than we found in this paper. However, this should not change our findings since intermediate imports represent on average 21.21% of total intermediate consumption considering all sectors of all countries in WIOD. Therefore only 1.93%, on average, of intermediate consumption is excluded by our analysis.

country j and each year t and ICT^{sp} is the spillover impact of ICT from the other sectors for the same sector and country, during a specific year.

Our analysis tries to be the widest possible, therefore we do not only consider data for countries as a whole, but we estimate our outcomes starting from individual industrial sectors' data. For each country, in fact, we consider the hourly productivity of several industrial sectors. Therefore we need comparable data for capital distinguished as ICT and non-ICT for our 11 countries and for several consecutive years. The main source of these kinds of data are gathered by EU KLEMS dataset (released 2017, revised in July 2018), which collected integrated tables from 1979 to 2015 for European countries plus the USA. For each country, EU KLEMS database provides 28 industrial sectors, therefore we have built up a balanced panel database of ($26 \times 15 \times 11$) 4,620 observations for each variable. EU KLEMS database take capital stocks by industry and asset type directly from Eurostat to ensure compatibility with official data. In general, for the countries covered its last release, the Perpetual Inventory Method (PIM) with a geometric depreciation rate, is the preferred method of the national statistical offices and it is employed by EU KLEMS[5]. We also use the SEA (Socio Economic Accounts) database, provided by Timmer et al. (2015) in WIOD, which collects data about added value for each industrial sector of each country of each year, and the hours worked for each commodity, for each country for each year. We use these two databases to calculate hourly productivity for each industrial sector and the other independent variables. All variables are considered at constant PPP US millions (2010). Unfortunately, EU KLEMS database do not provide any information about the composition of the workforce (female employment, migration, educated workers, employment of the elderly and the retirees) which could be taken into account near to total hours of work ($H_{i,j,t}$); it neither distinguish public capital from private one. These data are available, but only for country-scale, while in our regressions we need data at industrial sector scale, homogenized to EU KLEMS database. Nevertheless, our regressions are informative, as shown by several studies with similar methods and variables used already present in the literature (Becchetti and Adriani, 2005; Park, 2007; Gholami er al., 2009; Pieri, 2018).

In WIOD database 6 out of 56 industrial sectors can be summed up and be referred to as ICT intermediate consumption. Following the approach of Strobel(2016), we aggregate S9 (Printing and reproduction of recorded media), S17 (Manufacture of computer, electronic and optical products), S18 (Manufacture of electrical equipment), S38 (Motion picture, video and television program production, sound recording and music publishing activities; programming and broadcasting activities), S39 (Telecommunications), S40 (Computer programming, consultancy and related activities; information service activities) and we get the total ICT intermediate consumption. By difference, non-ICT intermediate consumption is the residual part of total intermediate consumption.This will be useful to estimate spillover effects.

We run an initial Pool OLS regression on the database in order to test which re-

[5] http://www.euklems.net/TCB/2018/Metholology_EUKLEMS_2017_revised.pdf, p.9

gression model would be the best. The Breusch-Pagan statistical test rejects the hypothesis that the pooled OLS model is adeguate (p-value = 0) in favor of a Random Effects and Fixed Effects model, and the Hausman test rejects that in the null hypothesis, the Random Effects model is adeguate (p-value = 2.24e-23) in favor of a Fixed-effects model. Therefore, we report only Fixed Effects models, in the simplest case (equation (2)), with the introduction of $R\&D$ (equation 5) and finally, with spillover effects (equation (7)). Therefore our outcomes are:

Where (1), (2), (3) are three different estimated models: respectively, the equation (8) without R&D and spillover effects, the equation (8) without spillover effects, and the complete equation (8). Outcomes are robust in all three equations. All signs of estimated parameters are consistent with their economic interpretation: ICT, their spillover and non-ICT intermediate consumptions impact positively on hourly productivity; R&D and its spillovers have a positive effect on hourly productivity as literature has already widely indicated; finally, the interaction between time trend and ICT and R&D exhibit a positive effect each year, meaning that the impact of CIT and R&D on productivity has increased over the period, year per year. The outcomes also suggest that it has been correct to plug the R&D variable into the model ; on the contrary, had this variable not been introduced, its effect would have been completely absorbed by ICT, overestimating its final effects on productivity. More interesting is the outcome about hours worked.

Canonical real business cycle (RBC) models predict that labor input increases in response to a favorable technology shock, while canonical New Keynesian (NK) models expect a negative sign of hours worked. Galí and Gambetti (2009) show that the response of hours worked to technology shocks has substantially changed over time; for example, in their paper, they show that in the US economy this relationship was negative at the beginning of the post-war era and turned positive or reached zero towards the end. However, in existing literature, much remains unknown about the effect of working hours on labour productivity (Collewet and Sauermann, 2017). In theory, there could be four effects, reciprocally opposed. Longer hours per each person who belongs to labour force (H/L +) combined with a higher employment rate (E/L +) means the replacement of capital with labour; fewer hours worked (H/L −) associated with a higher employment rate (E/L +) means that the workforce is more relaxed; more hours worked (H/L +) combined with a lower employment rate (E/L −), on the contrary, leads to a higher exploitation of the workforce, i.e. increased worker fatigue; finally, a decrement in hours worked (H/L −) associated with a decrement in employment rate (E/L −) leads the workforce to be replaced by capital. We could summarize these possible scenarios in the following table:

What is the theoretical effect of each one of the four scenarios on productivity growth? On the one hand, worker fatigue, after a number of hours worked, could decrease the marginal effect on productivity (Pencavel, 2015). On the other hand, more relaxed working times should raise the marginal effect of the workforce on productivity (Menko, 2013). As for the other two scenarios, classical economic theory based on a Cobb-Douglas production function in a context of perfect competition, suggests that

Table 1.1: The impact of R&D and ICT on hourly productivity, dependent variable $\rho_{i,j,t}$

	(1)	(2)	(3)
ln(ICT)	0.0986	0.09498	0.07874
	(0.0111)***	(0.0125)***	(0.0131)***
ln(NICT)	0.0816	0.0793	0.0795
	(0.02716)***	(0.0272)***	(0.0270)***
ln(H)	−0.4855	−0.4604	−0.4374
	(0.0219)***	(0.0241)***	(0.0251)***
ln(R&D)		0.0165	0.0111
		(0.0052)***	(0.0053)**
ln(ICT^{sp})			0.0490
			(0.0107)***
ln($R\&D^{sp}$)			0.0153
			(0.0067)***
ICT×t	7.55e-08	5.03e-08	5.59e-08
	(1.54e-08)***	(1.60e-08)***	(1.60e-08)***
R&D×t		2.10e-08	1.78e-08
		(7.97e-08)***	(7.94e-08)**
C.E.	5.3982	5.1918	4.6954
	(0.2126)***	(0.2247)***	(0.2367)***
Observations	4494	4231	4231
$R-Squared$	0.9496	0.9425	0.9432

Notes: 1. Significance Level: * 10%, ** 5% and ***1%

2. Standard errors in parentheses. Hourly productivity coefficients are expressed as output elasticities. All specifications include industry fixed effects. Full tables are available from the authors upon request.

3. As for Fixed-Effects models, the estimated Country-Effects (C.E.) coefficients are not reported for ease of exposition.

	H/L (+)	**H/L** (−)
E/L (+)	replacement capital	liveliness
E/L (−)	fatigue	replacement workforce

Table 1.2: Matrix for type of job and level of retribution

workforce and capital can be indifferently exchanged on the productive frontier, i.e., the replacement effect on productivity growth should be neutral. However, as we recalled at the beginning of this section, it is not very realistic to assume perfect competition for this kind of analysis, so the effect of replacing labour/capital is *a-priori* theoretically uncertain.

Our data on these 11 OECD developed countries indicate that we currently find ourselves in the fourth scenario, where the employment rate has decreased over the last 15 years, with the number of hours worked per person in the workforce L has followed the same trend. This should lead us to expect the impact of H on productivity growth to be neutral. On the contrary, we suggest in this paper that the number of hours worked has a statistically significant negative effect on productivity. However, according to our data, H decreases in the major part of productions, i.e. the average effect of H on productivity is positive. Recalling that we are in the fourth scenario of table 4, we conclude that workforce replacement (i.e. a decrement i H) has contributed to raising productivity. These findings are consistent with the most recent literature; Venturini (2015) and Pieri (2018), among others, estimated that the contribution of hours worked on productivity is negative and statistical significative, in all European countries. This paper expands these outcomes to include other industrialized countries, increasing the number of industrial sectors examined for each country (28 instead of the 19 used by Pieri (2018)) and updating the estimates to 2014.

Next, we plug the values observed in 2000 and in 2014 for all independent variables into the estimated models to find the increment in hourly productivity estimated by the model; then, we re-plug the independent variables of 2014 into the three models, but keeping ICT, ICT^{sp}, R&D and $\text{R\&D}^{sp}$ as they were in the year 2000. In this way, we can find the percentage of productivity growth due to ICT and R&D. The following table reports the average influence of ICT and R&D on total productivity growth for each sector i of each country j between 2000 and 2014.

These outcomes of ICT contribution to productivity growth, recall those found by Van Ark and Inklaar (2005) for the period 2000-2005. Moreover, they are in line with the findings of Jorgenson et al. (2008) with respect to the US. Our estimations as shown in the appendix 2, reveal that, on average, ICT did indeed impact US productivity growth by 56% (64% summing up R&D contribution).

The table shows that, on average, in the 11 countries analyzed, ICT and R&D have caused more than 60% of all productivity growth. In addition, the ICTs by themselves alone represent 46.43% of global productivity growth even if they represent

Table 1.3: Impact of Drivers on Productivity growth

	Productivity growth (predicted)	17.62%
Components of productivity growth	ICT Intermediate Consumption	8.18%
	R&D Intermediate Consumption	4.45%
	No-ICT Intermediate Consumption	2.37%
	Workforce Replacement	2.56%
Contribution to productivity growth	ICT Capital	27.93%
	ICT Within-Industry spillovers	14.57%
	ICT Investments Specific TC	3.50%
	R&D Capital	14.93%
	R&D Within-Industry spillovers	−1.83%
	R&D Investments Specific TC	1.40%
	No-ICT Intermediate Consumption	13.24%
	Workforce Replacement	25.93%

only 2.47% of total Capital employed in each country. Non-ICT, on the other hand, is responsible for only 13.45% of total productivity growth, even though it represents 97.53% of total capital employed by the economies. In addition, we should underline the effect of hours worked: an increase of 25.28% in productivity growth is due to hours worked. Recalling table (4), we are examining a scenario of decreasing hours worked and diminishing employment rate, therefore H stands for capital replacement; the lower H is, the higher the replacement effect is. Based on the outcomes of our estimations in table (3) we conclude that a significant part of productivity growth in the last 15 years has been reached by replacing workforce with capital. The aim of this paper is to determine what is driving the trend for H, as we will show in our analysis in the following section.

Overall, these findings demonstrate that the knowledge economy, i.e. ICT technologies and R&D capital stock, are the leading sectors responsible for productivity growth in the first 15 years of the 21st century. We also show the impact of ICT and R&D for each country between 2000 and 2014 in specific bar histogram plots in the appendix 2. Here, we only show the average contribution of ICT, non-ICT, R&D and hours worked to productivity growth in our 11 countries, sector by sector:

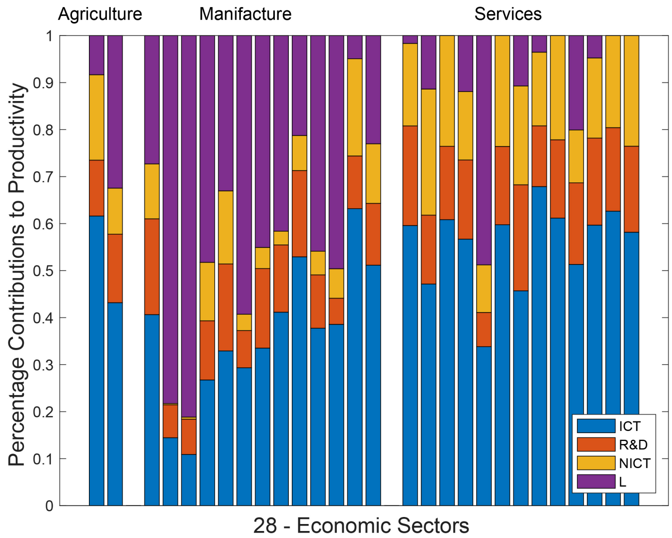

Figure 1.11: % Contributions to Productivity Growth, Average on 16 Countries for 56 Sectors

Figure 9 shows the contribution of R&D and ICT on productivity growth for each one of the 28 sectors analyzed. ICT contribution to productivity is dominant in almost all sectors. Its influence is higher in the service industry with peaks in S23-Professional, Scientific, Technical, Administrative and Support Service Activities (67.87%), S24-Public Administration and Defense; Compulsory Social Security (61.17%), S27-Health and Social Work (62.64%) and S18- Accommodations and Food Service Activities (60.84%) while it is lower in the manufacturing industry with peaks in S14-Electricity, Gas and Water Supply (63.17%), S11-Machinery and Equipment (52.93%) S15-Construction (51.15%). On the other hand, while the effect of replacing workforce with capital is particularly strong in the manufacturing sector, it has also started to affect many sectors of the service industry such as S25-Public Administration and Defense (20.08%), S19-Telecommunications (48.78%), S18-Accommodations and Food Service Activities (11.91%).

The same bar histograms in reference to single countries (found in Appendix 2) confirm the findings reported in recent literature but also add a great deal of new and more detailed data. In countries like Germany, the UK and the USA, ICT was responsible for more than 50% of total productivity growth; this was most evident in Germany where in practically every sector, almost all productivity growth was due to ICT (51.05%) or workforce replacement (26.69%). On the other hand, Italy and Spain have seen a lower ICT impact on total productivity growth (around 50%). Italy is something of an outlier: ICT had quite a weak effect on productivity growth (14.87%) while non-ICT capital has proved to have a far stronger effect (25.47%), together with workforce replacement (33.33%). Overall, in all the countries surveyed, workforce replacement concerned mainly manufacturing sectors (S3-S15) with H contributing an average of 42.97% towards total productivity growth. However, what is more interesting, this trend also affected service industries (S16-S28). For these sectors, 8.68% of total productivity growth, on average, was due to workforce replacement.

At this point, we have proven two stylized facts regarding our 16 OECD countries: on the one hand LDR rate has hugely increased in each one of our countries over the last 30 years; on the other hand productivity growth has been proven to be mainly led by ICT technologies. Now we want to show the strength in the link between the movements in LDR and in hourly productivity. If LDR had been influenced by hourly productivity trends, we would have been indirectly able to calculate the impact of ICT on workforce and its sign, which is the main focus of this paper.

1.4 Productivity Growth Impact on LDR

In this Section we test our main hypothesis that productivity growth in the last 25 years, lead mainly by ICT technologies, as just shown, is causing a progressive reduction of human labor. The dependent variable is the Labor Devaluation Rate (LDR). The main independent variable studied in the following model, is a proxy for technological innovation (hourly productivity). Controlling for other variables that take into account for structural elements in the job market of each country, we test if the huge increment in LDR could be in part related to the lasting ICT innovations.

Regressing LDR on hourly productivity has the economic sense of studying how productivity gains have affected the structure of the workforce (and whether they have been affected in any way). Together with hourly productivity, other control variables for institutional characteristics of job market must be added. Our first three controls are 'trade union density', 'collective bargaining coverage' and 'employment protection legislation' which cover the most important characteristics of the wage bargaining system, as per Young et al. (2017). In particular, as for "employment protection legislation" we use the EPL (Employment Protection Legislation) database provided by OECD. This independent variable is crucial since it controls for that part of temporary wage contracts growth due to structural reforms beyond ICT. So that, if a country has relaxed its EPL through institutional reforms over the time series considered, we expect to observe an increase in the rate of temporary contracts (Dolado et al., 2002; Alesina et al., 2008) that, in turn, affects the LDR. Plugging the EPL index in our panel estimations, we are sure to separate the ICT innovation effects on LDR from the institutional reforms of the job market.

Furthermore, we control for the impact of unemployment benefit schemes which should affect incentives to apply for a job: higher benefits reduce incentive to accept a new job (Benham, 1983) and this, in turn, raises unemployment (Filges et a., 2015). Moreover, GDP, according to Okun's law and as emphasised by Sarkar (2013) and by Bayrak and Tatli (2018), negatively affects unemployment: when GDP grows, unemployment is in fact expected to drop and vice versa. Finally, I control for the inflation rate which we use as a proxy for the monetary policy effects on employment. A Panel Dataset was built from 1995 to 2016, which included 16 industrialized OECD countries, for a total of 352 observations for each variable. We excluded some countries because of limited data availability from OECD. The model used to determine the factors affecting LDR is a logistic regression model. This model works well for limited response in to the dependent variable; in this case LDR is a value between 0 and 1. Moreover, a logistic model fits well for describing demographic transitions over time, and jobs robotization recall just to a structural change in the employed population (a progressive loss of jobs, captured by LDR). The application of this model for this data analysis has been well documented in Peng et al. (2002) and in Stoltzfus (2011).

$$ln\Big(\frac{LDR_{\mathrm{i,t}}}{1-LDR_{\mathrm{i,t}}}\Big) = ldr_{i,t} = f(\rho_{i,t}; X_{i,t}) \tag{1.9}$$

Where $f(\cdot)$ is a linear combination of hourly productivity (ρ) and other control variables (X_{it}). By appropriately manipulating the equation, we can obtain a new algebraic formulation that allows us to estimate the model with a simple linear regression. Next, we explicate control variables and find the estimating equation:

$$\begin{aligned} u_{i,t} = {} & \beta_1\rho_{\mathrm{i,t}} + \beta_2 TU_{\mathrm{i,t}} + \beta_3 C_{\mathrm{i,t}} + \beta_4 ln(Sb)_{\mathrm{i,t}} + \beta_5\pi_{\mathrm{i,t}} + \beta_6 ln(GDP) \\ & + \beta_7 P_{i,t} + \alpha_i + \gamma_1 + ... + \gamma_{21} + \epsilon_{\mathrm{i,t}} \end{aligned} \tag{1.10}$$

Where α_i is the country-specific fixed effect while γ_i are the 21 dummy variables for time-specific fixed effects; $\rho_{i,t}$ is the hourly productivity of country i in the year t; TU is the rate of trade-unionization of the working class; C is the percentage of workers covered by a collective national contract; Sb the logarithm of unemployment subsides paid by the government; $\pi_{i,t}$ is the inflation rate; GDP is the logarithm of Gross Domestic Product and P is the degree to which job are protected from dismissal.

Breusch-Pagan statistical test rejects the hypothesis that the pooled OLS model is adequate, favoring instead the Random effects model. Therefore, we compare a Within OLS Trasformation model (WH), a First Difference OLS model (FD), a Random Effects (RE) model and a Fixed Effects (FE) model. As LDR is not random but deterministically associated with certain historical, political, geographical and other facts, as Egger (2000) pointed out, we prefer the FE model, since it accounts for country-specific fixed effects. Indeed, in WH and FD transformation models there is no intercept by construction while in RE models the intercept is assumed to be identical for all countries, i.e. with no country-specific fixed effects. In addition, the FE model fits better than the RE, also because the Hausman (1978) test reveals that there is correlation between the random effects errors and the explanatory variables (p-value 1.6559e-16). Finally, we checked that there are no problems of endogeneity among regressors of equation (10) in FE, WH and FD models[6]. Estimation of all models are run by using robust standard errors for clusters. Finally, we also run a fixed effects-2SLS (FE-2SLS) model, where we instrument the productivity with the equation (8) used in the previous section. In this section, as for FE-2SLS, we gather data for equation (8) at country level in order to homogenize them to the other variables of (10)[7]. We show the outcomes of estimates both for the case of classical unemployed index, provided by OECD, and for what we call LDR, as dependent variables.

The outcomes of the estimates are as the following:

[6]The correlation between the error term and each one of regressors for the three models (FE, WH, FD), is always very close to 0. We show the correlation matrix Regressors-Estimation Errors of only FE model in Appendix 3. FE model is, indeed, the ones which fits better our data.

[7]Unfortunately data on ICT and non-ICT capital stock are not available for Belgium, Portugal and Canada.

Table 1.4: Panel Model: HAC (Robust SE), dependent variable $ldr_{i,t}$

	Within	FD	RE	FE	FE-2SLS
Const	−	−	−2.7143	7.6584	15.1864
			(5.049)	(4.9824)	(4.7201)***
Productivity	0.0292	0.0167	0.0148	0.0365	0.0666
	(0.0061)***	(0.0104)	(0.0032)***	(0.0063)***	(0.0097)***
Inflation	−0.0568	−0.0129	−0.0540	−0.0462	−0.0190
	(0.0124)***	(0.0040)***	(0.0115)***	(0.0110)***	(0.0113)
lnSubsides	0.0763	0.0542	0.2008	0.2055	0.1096
	(0.0566)	(0.0138)***	(0.0787)**	(0.0667)***	(0.0433)**
EPL	−0.3895	−0.1482	−0.3361	−0.3920	−0.2682
	(0.0807)***	(0.0403)***	(0.0865)***	(0.0590)***	(0.2233)
lnGDP	−0.5646	−1.0628	0.0037	−0.8394	−1.5459
	(0.4564)	(0.5971)*	(0.3182)	(0.3680)**	(0.3821)***
Trade-union	0.0058	0.0008	0.0006	0.0019	0.0083
	(0.0084)	(0.0119)	(0.0104)	(0.0104)	(0.0113)
Coverage	−0.0014	−0.0025	−0.0014	−0.0031	0.0026
	(0.0039)	(0.0023)	(0.0052)	(0.0032)	(0.0039)
F(6, 15)	4.02e-9***	1.66e-07***	8,51e-72***	3.92e-10***	3.29e-06***
Observations	352	336	352	352	263
$R - Squared$	0.4708	0.1794		0.9013	0.9275

*Significance Level: * 10%, ** 5% and ***1%

**Dummies for FE time specific effects are not significative, therefore We re-estimated eq.(2) removing them

***For the F-test on regressors are shown p-values

Table 1.5: Panel Model: dependent variable $u_{i,t}$

	Within	FD	RE	FE	FE-2SLS
Const	–	–	−1.6646	13.5329	23.1032
			(3.9224)	(5.0816)***	(3.9962)***
Productivity	0.0288	0.0331	0.0049	0.0349	0.0706
	(0.0061)***	(0.0107)***	(0.0033)	(0.0080)***	(0.0116)***
Inflation	−0.0732	−0.0248	−0.0654	−0.0613	−0.04139
	(0.0151)***	(0.0048)***	(0.0139)***	(0.0140)***	(0.0158)**
lnSubsides	0.1137	0.0827	0.2673	0.2769	0.1468
	(0.0816)	(0.0292)**	(0.1096)***	(0.1038)**	(0.0763)*
EPL	−0.4029	−0.1281	−0.3874	−0.4061	−0.2654
	(0.1124)***	(0.0425)***	(0.0977)***	(0.1037)***	(0.2475)
lnGDP	−1.1610	−2.9163	−0.1397	−1.3834	−2.2461
	(0.3542)***	(0.4791)***	(0.2323)	(0.3645)***	(0.3428)***
Trade-union	0.0117	0.0021	0.0041	0.0071	0.0111
	(0.0089)	(0.0114)	(0.0063)	(0.0104)	(0.0083)
Coverage	−0.0021	−0.0016	−0.0023	−0.0038	0.0034
	(0.0021)	(0.0024)	(0.0065)	(0.0046)	(0.0044)
F(6, 15)	6.53e-8***	1.66e-07***	8,51e-72***	3.92e-10***	5.30e-07***
Observations	352	336	352	352	263
$R-Squared$	0.4472	0.465		0.8609	0.8930

*Significance Level: * 10%, ** 5% and ***1%

**Dummies for FE time specific effects are not significative, therefore We re-estimated eq.(2) removing them

***For the F-test on regressors are shown p-values

The control variables of the panel confirm some empirical evidence already underlined by literature: the known inverse relationship between inflation and employment is respected; a higher level of unemployment benefits has a positive impact on the total LDR level, as it discourages people from seeking employment; the higher the protections from dismissal are, the lower the LDR is, simply because is more difficult to fire workers. Finally, the other two control variables (trade-unionization and percentage of workers covered by a national collective agreement) do not appear to be statistically significant (i.e. their effect has already been captured by trade union and coverage control variables) in any model. More interesting is the outcome in our interest variable: data found in this panel gives us an answer to our initial question. The productivity growth of the entire occupied population has impacted the LDR, and this impact has been positive.

The FE model reveals, with a significance of over 99%, that technical innovation from 1995 to 2016 contributed positively to explaining the trend (generally increasing) of that segment of the labor force which does not have permanent full-time employment. The reduction in the bargaining power of workers, the state subsidies paid to the unemployed, the GDP trend and the known inflation levels during the period are not sufficient to explain the increase in LDR workers. If the new generation of technologies had created more work than they destroyed, the sign of productivity should have been negative; if the innovation process had had a neutral effect on LDR, its regressor parameter should have been statistically not-significant, but data reveal this is not the case.

These findings are also true for the classical unemployment measurement but with a different impacts of the independent variables. Indeed, the productivity growth (mainly lead by ICT, as seen in the previous section), stronger affects LDR (0.0365) than unemployment (0.349); this is consistency to McKinsey (2015) hypothesis that digital technologies replace jobs only gradually, changing, over the middle-term, the structure and the quality of employment (more flexible jobs, part-time and atypical contracts). Moreover, inflation comes out to negatively impact unemployment approximately by 50% stronger than LDR, that is less sensitive to price variations (-0.0462 instead of -0.0613). The same holds for all the other independent variables; unemployment subsides and GDP seems to affect LDR with lower parameters than for unemployment. Overall, the labour force without a permanent full-time job (i.e. LDR) is more sensitive to ICT innovation than the simple unemployed workforce, while it is less strongly affected by the other classical control variables. Only for the independent variable that captures the institutional protection of jobs it is found a parameter quite identical.

According to Schumpeter, technical innovations are supposed to occur in swarms, destroying existing monopoly profits which are merely the precondition for technological competition. The industrial growth process is composed of a series of endogenously caused continuous and discontinuous of deviations from a hitherto existing equilibrium and the overshooting and gradual adjustment to a new temporary equilibrium

(Rahmeyer, 1989). The extent of technical knowledge is largely endogenously determined by the amount of profit-motivated R&D expenses, as our estimations take into account. The sources of new technical knowledge are both scientific inventions and accumulated practical past experience in construction and development (Nelson and Winter, 1982; Dosi and Nelson, 2010). The evolutionary theory of innovation is the theory of economics of innovations which, starting with Shumpeter, tells us that through creative destruction, capitalism is a process in constant motion which continually creates and destroys new markets. This could be the case of the more traditional markets that have been replacing from the 90s by the new high-tech firms, characterized by a very strong automation. While the first generation of Web businesses (Web 1.0) were largely focused on delivering firm-developed, closed products and services top-down through a centrally managed server to customers, Web 2.0 businesses are completely new markets, in substitution of the previous ones. Typical business examples include online community review and rating (Amazon, Netflix), social bookmarking (Del.icio.us, Furl), online social networking (MySpace, Facebook), blogging (Blogspot), wikis (Wikipedia, HowTo), peer-to-peer file and content sharing (Napster, YouTube, Flickr, Slashdot), mashup (Google Maps), music remix (ccMixter), interactive recommendation systems (Pandora), mobile applications on smartphones (Shazam on Apple's iPhone and RIM's Blackberry), massively multiplayer online games (Half-Life, World of Warcraft) and virtual worlds (Second Life). These new sectors are replacing entire traditional markets, deleting thousands of jobs (Arakji and Lang, 2010), consistently to our empirical findings. We could be in front of a great technological transition.

1.5 Long-Run LDR Forecast

Are medium-long term forecasts possible? Of course, in the long run all the economic variables may change and therefore it is very difficult to venture forecasts. However, different scenarios can be constructed according to the initial assumptions. The number of LDR workers has increased significantly over the last 25 years, and, as we have found through empirical analysis, the growth in hourly productivity has been one of its main driving factors. An interesting simulation could be to study what would happen if hourly productivity continued to increase at a certain stable rate, while the other control variables remained unchanged. The idea behind this type of simulation would be to see what impact technological development would have on the LDR level if the social variables (for which model controls) remained constant. If the State refrains from any further monetary and fiscal policy intervention, if it always pays the same unemployment benefits, if the legislation protecting workers no longer changes and if the unionization rate does not change, the model suggests that the share of LDR workers would increase anyway, if hourly productivity increased.

What is the reasonable expectation regarding how the share of LDR workers would move over time? The hypothesis is that, other conditions being equal, the increase in hourly productivity should affect the number of LDR workers through a logistic curve. In literature, in fact, it has been amply demonstrated that the development of leading technologies takes place through the logistic curve. The first economist to have this insight, although indirectly, was Schumpeter, who distinguished the main invention emerging in a given period from the cluster of other discoveries linked to it. The vintage invention, which Gavin Wright defines as GPTs (General Purpose Technologies), is a disruptive technology in that it disrupts the productive paradigms of the past, is transversal to all sectors, and can be developed in many new applications (the bunches). As they develop, GPTs first exhibit an exponential-like explosive effect, but subsequently, they gradually exhaust their innovative potential because they have been fully developed. When the last GPT has been fully developed, the productivity of the economic system stagnates, and it does not recover until the discovery of a new GPT.

Now, the latest GPT still in progress (internet), as empirically shown, is destroying, for the first time in the history of industrial revolutions, more hours of work than it creates and consequently, the share of LDR workers is increasing. As GPTs develop historically according to a logistic curve and as the share of LDR workers is guided by the implementation and development of this latest GPT, we could reasonably expect that the entire evolution of LDR workers over time has been following a logistic trend. The other control variables should not cause any kind of long-term trend on the share of LDR workers, because they are social variables. They depend therefore on the type of interaction between agents, which in turn depends on the free individual choices which by definition cannot be schematized in a deterministic model. In fact, we could have a historical phase in which workers are stronger and organized, followed by another one where entrepreneurs acquire greater influence; by this example, we would first observe a reduction in the share of LDR workers, and in a second phase an increment. Precisely for this reason it would not make sense to presuppose an *a priori* trend of these variables. The technological evolution, on the other hand, is different since it is much more deterministic: the logistic curve used to describe the development of GPT inventions reflects a process independent of human will, according to which a great technological discovery increases the knowledge of man and the greater knowledge in turn leads to new discoveries until all the fields of the new GPT have been explored and it is not possible to develop it further.

Our Fixed Effects model in (2) is already a logistic equation (remember that this specification was necessary because dependent variable LDR is between 0-1). Therefore, entering the parameters estimated together with regressors values available in the last year (2016), we are able to forecast certain scenarios. In these simulations, as explained above, we keep the social variables constant and equal to their value in 2016. On the contrary, we try to increase the hourly productivity according to different fixed rates over time (the kind of growth assumed gives different forecast scenarios).

$$LDR_{\mathrm{i,t}} = 1 - \frac{1}{1 + e^{\alpha_i + \beta_1 \rho_{i,t}(1+r)^t + \beta X_{i,2016}}} \tag{1.11}$$

Where r is the rate of productivity growth, $t = 1$ is the calendar year 2017, β is a row vector of the estimated parameters in table 6 (FE) and X is the column vector of control variables. The outcomes are reported in the table, each country observed recorded separately. We have proposed 5 different scenarios: the first assumes that productivity grows at a constant annual rate equal to the average recorded over the previous 22 years (from 1995 to 2016), which is different for each country; the other scenarios, instead, assume growth to take place at progressively increasing rates from 2% per year to 5%. We have chosen to forecast the year when a country will reach a LDR threshold of 60%. Indeed, this is the same percentage used by McKinsey (2015) and Vardi (2015); therefore, we will be able to compare my findings with theirs.

The outcomes in Table 6 are impressive. The share of people, out of the total work-

Table 1.6: Year when 60% labour force will be without a permanent full-time employment, according to different yearly productivity rates of growth.

	Average (last 5 years)	2%	3%	4%	5%
Austria	2038	2061	2046	2039	2034
Belgium	2042	2058	2044	2037	2033
Canada	2051	2067	2050	2041	2036
Denmark	2037	2059	2045	2038	2033
Finland	2038	2060	2045	2038	2034
France	2033	2047	2037	2031	2028
Germany	2037	2052	2040	2034	2030
Greece	2040	2056	2043	2036	2032
Italy	2042	2051	2040	2034	2030
Japan	2050	2071	2053	2044	2038
Luxemburg	2029	2044	2035	2030	2027
(The) Nederlands	2039	2055	2042	2036	2032
Portugal	2034	2052	2040	2034	2030
Spain	2031	2038	2031	2027	2025
United Kingdom	2048	2070	2052	2043	2038
USA	2045	2068	2051	2042	2037

force, who will be unemployed, temporary workers, or forced to work part-time or in mini-jobs, will exceed 60% of the total already between 2040 and 2050 in most of the countries analyzed, under the assumption that the average growth rate of hourly productivity will be 3%. If hourly productivity rises by the same average rate recorded from 1995 to 2016, practically all countries will reach the 60% threshold between 2030 and 2040. These results are in line with those of Vardi (2015) and McKinsey (2015). Moreover, if productivity gains were to rise 4% per year, almost all countries would reach the above limit before 2040. Some countries reach the target before others because they start from very different levels of LDR workers: for example, Spain already had 47.27% of workers in those categories in 2016, Italy 35.26% and Portugal 37.40%

and therefore will reach 60% much sooner. On the contrary, countries like England or Japan start at much lower levels, at 13.69% and 14.25% respectively, so they will take more years, on average, to reach the threshold of 60%. In any case, these predictions, supported by econometric estimates, suggest that in the next two or three decades the labor force could be completely transformed by the fourth industrial revolution. These results do not appear to be robust mainly because the LDR starting level is very different country by country; moreover, these outcomes are very sensitive to the productivity growth rate. As suggested by the estimates, even a small but persistent difference in the rate of productivity growth lead to very different outcomes on the long-run. However, the estimation model is proofed to be robust, as shown in the Appendix 3, therefore the great differences in the forecasts are mainly due to the hypothesis on the productivity growth and to the beginning LDR level. As conclusions, the scenarios drawn by these forecasts should be interpreted with caution, even if they provide a general and interesting indication: in a few decades, most jobs could be canceled.

1.6 Conclusions

This paper first tested the empirical evidence, in 16 OECD countries, of growing unemployment and a radical change in work structure over a long period of time. From a situation where 90% of the workforce was employed in full-time employment (during the 1980s), we have moved to a situation where nowadays between 25-35% of the workforce is either unemployed, or has a temporary, short-time, involuntary part-time job.

The reasons for this structural change in labour in industrialized countries are not only social (trade-unions, unemployment benefits, legal protection of the workplace, etc.), but also technological. However, the development of technology in the last two decades has been incontrovertibly driven by ICT. Therefore, for the first time since the first industrial revolution, technical progress, on average, is creating fewer jobs than it is destroying. This statement has been validated by empirical analysis. Moreover, the paper estimates LDR movement with a logistic curve. The fact that outcomes are robust and statistically significative, reinforces the hypothesis that the LDR trend is propelled by ICT, since literature has already shown that technological development over the long-term is logistical. This outcome has allowed us to forecast future LDR values. By 2040, according to our estimates, in most OECD countries observed, LDR will be approximately 60% of workforce.

Since we are probably only at the beginning of this process, this trend may not yet seem particularly evident, but the statistical estimates reveal that we could already have embarked on a logistical path. This logistic curve, indeed, grows very slowly at the beginning, but then it explodes. In 30 years, the time series on employment could indicate a bell curve trend over the period between 1970 and 2040. The Nobel Prize winning economist Wassily Leontief agreed, stating definitively in 1983 that "the role of humans as the most important factor of production is bound to diminish in the same way that the role of horses in agricultural production was first diminished and then eliminated by the introduction of tractors". In what became known as the 'great decoupling', the demand for human workers fell as businesses were able to output more goods and services at cheaper rates using machines (Rotman, 2013).

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1.8 Appendix 1

In this appendix we would test the direction of causality in our main estimations.

We computes the Granger causality test for panel data put forward by Dumitrescu and Hurlin (2012). In the test, all the coefficients are allowed to vary across cross-sections in the panel. The test is computed by running standard Granger causality regressions for each cross-section, taking the average of the test statistics (W-bar) and standardizing it (Z-bar). Z-bar follows a standard normal distribution.The number of lags in the Granger causality regression, K, and the number of time-periods in each cross-sectional unit i, T_i, must satisfy the following condition:

$$T_i > 5 + 2K$$

Firstly, we run the Dumitrescu-Hurlin test (2012) on ICT-productivity database that counts for 308 cross-sections and 15 time-periods. Because of the short length of time-periods we prefer to run the panel causality test only for 1 Lag.

In this Table, we found that there is a bidirectional-causality between ICT and hourly productivity. It is interesting since it means not only that productivity growth is associated to ICT capital, but also that an increase in productivity causes in turn a raise in ICT capital employed by firms. Is ICT both a cause and a consequence of economic growth? The pioneering work of Cronin et al. (1991) found bidirectional causality between telecommunication investment and GDP in the US, using data for the 1958-1988 period. The second cusality-direction, ($rho \rightarrow$ ICT) although studied relatively infrequently, is also important because it concerns how productivity growth

Table 1.7: Granger Causality Test for panel data: ICT-Productivity

Null Hypothesis	W-bar	Z-bar	p-value
$\ln(ICT) \nrightarrow \ln(\rho)$	3.2410	17.7346	0.0000***
$\ln(\rho) \nrightarrow \ln(ICT)$	3.7459	22.1226	0.0000***
$ICT \nrightarrow \rho$	3.2528	17.8379	0.0000***
$\rho \nrightarrow ICT$	3.6217	21.0430	0.0000***

can generate the resources to invest in ICT technologies and to serve additional ICT-related demand created by rising income. Intuitively, a feedback loop (or bidirectional causality) may be expected, especially in economies of less affluent countries which rely on the advent and acceptance of new and disruptive technologies for economic growth (Banerjee et al. 2020).

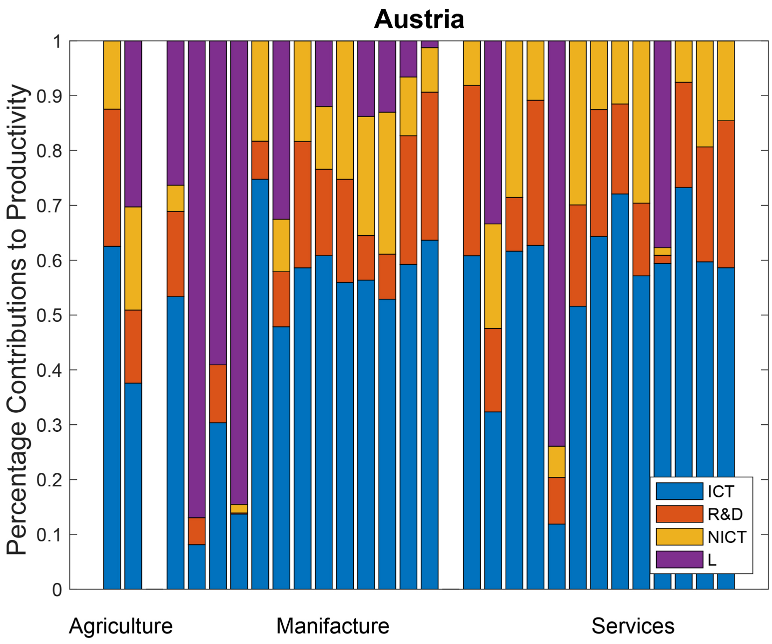
Secondly, referring to the LDR panel estimations (Table 1.4), we have a database with 22 time-periods and 16 countries; because of the small length of the time series we prefer to set 1 Lag.

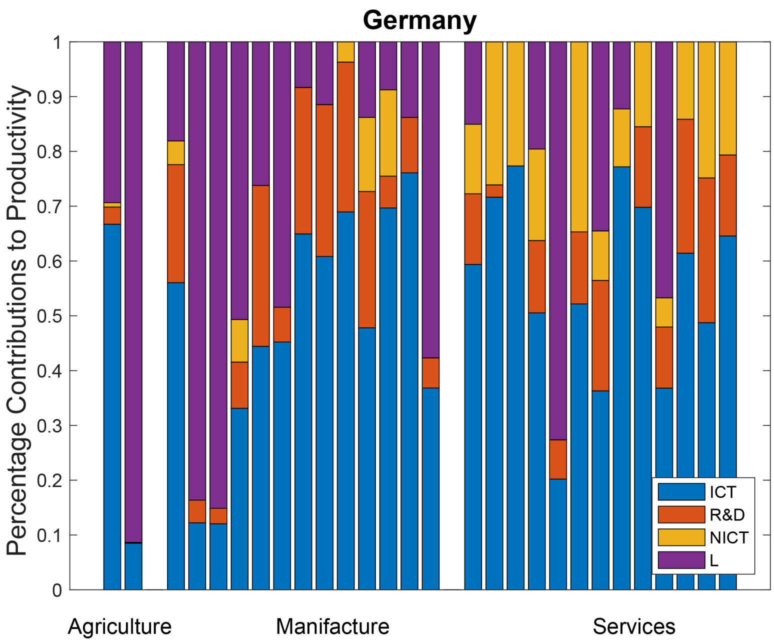
Table 1.8: Granger Causality Test for panel data: LDR-Productivity

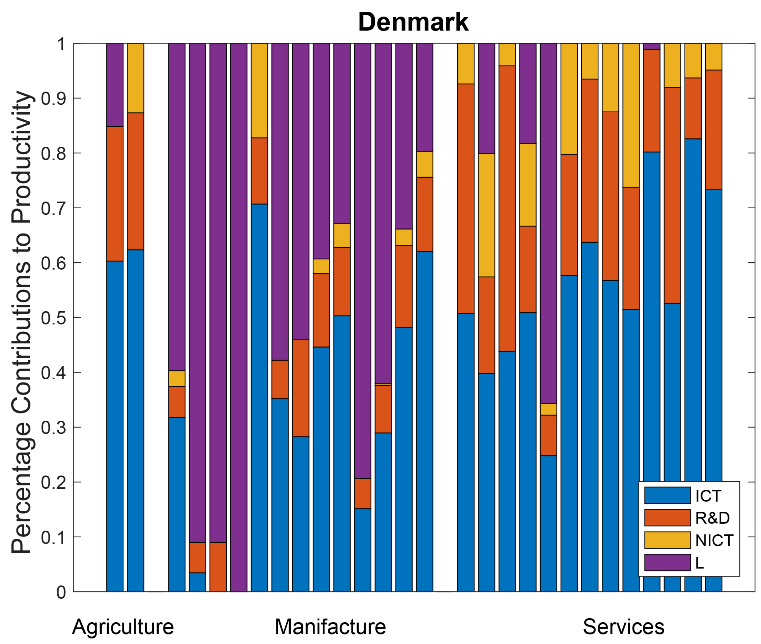
Null Hypothesis	W-bar	Z-bar	p-value
$ldr \nrightarrow \ln(\rho)$	3.0386	4.4378	0.0000***
$\ln(\rho) \nrightarrow ldr$	1.2775	0.3692	0.7120
$LDR \nrightarrow \rho$	2.9030	4.1246	0.0000***
$\rho \nrightarrow LDR$	1.1060	-0.0268	0.9786

This second table found a direct association between LDR and hourly productivity growth. The causation is unidirectional; is the raise of productivity that has caused an increase in the level of unemployment and other not full-time permanent jobs. Taking together the outcomes of these last two table withe the sign of estimated parameters in the equations (1.8) and (1.10), we can conclude that an increment in ICT capital causes a raise in the hourly productivity that in turn stimulate the demand for ICT capital; productivity growth, in turn, causes LDR increase. Therefore, we can state that an increment of ICT capital is reducing full-time permanent jobs: ICT$\uparrow \rightarrow \rho \uparrow \rightarrow$ LDR$\uparrow$.

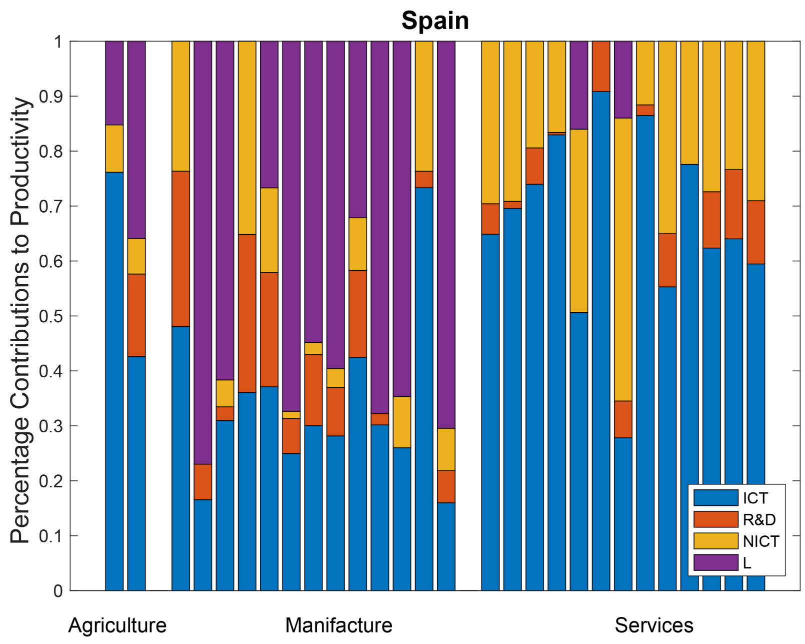
1.9 Appendix 2: Empirical Results of all the Models in Section 1.3



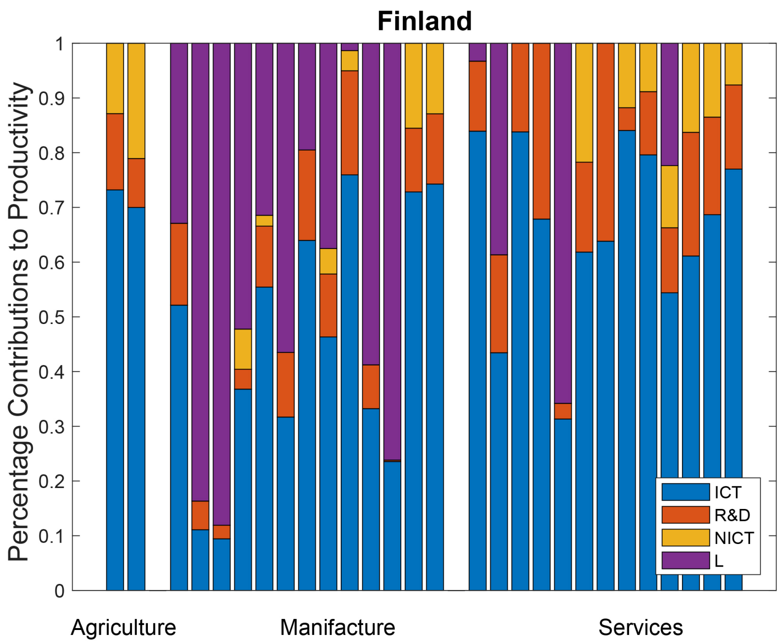




Denmark
Percentage Contributions to Productivity
ICT
R&D
NICT
L
Agriculture
Manifacture
Services



Spain
Percentage Contributions to Productivity
ICT
R&D
NICT
L
Agriculture
Manifacture
Services


Finland
Percentage Contributions to Productivity
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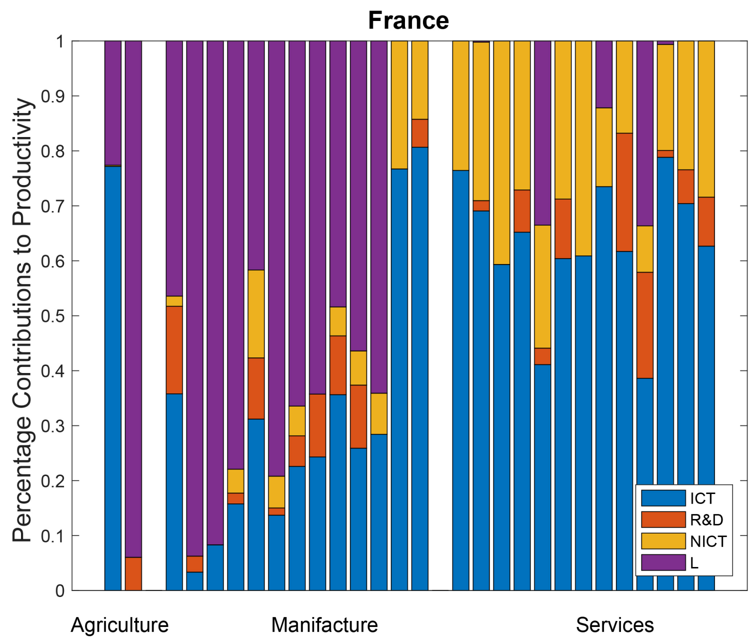
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
ICT
R&D
NICT
L
Agriculture
Manifacture
Services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Percentage Contributions to Productivity
0
0.1
0.2
0.3
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1
ICT
R&D
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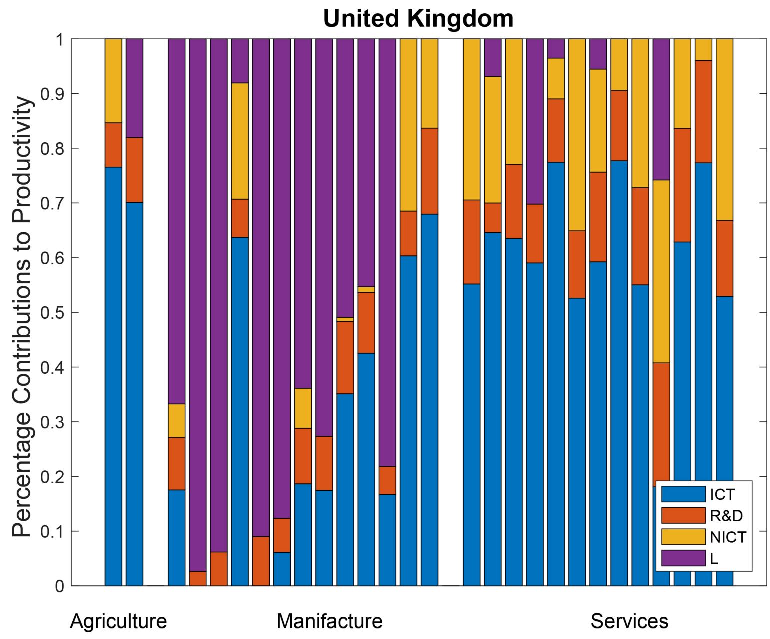
Services


United Kingdom
Percentage Contributions to Productivity
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0.7
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0.4
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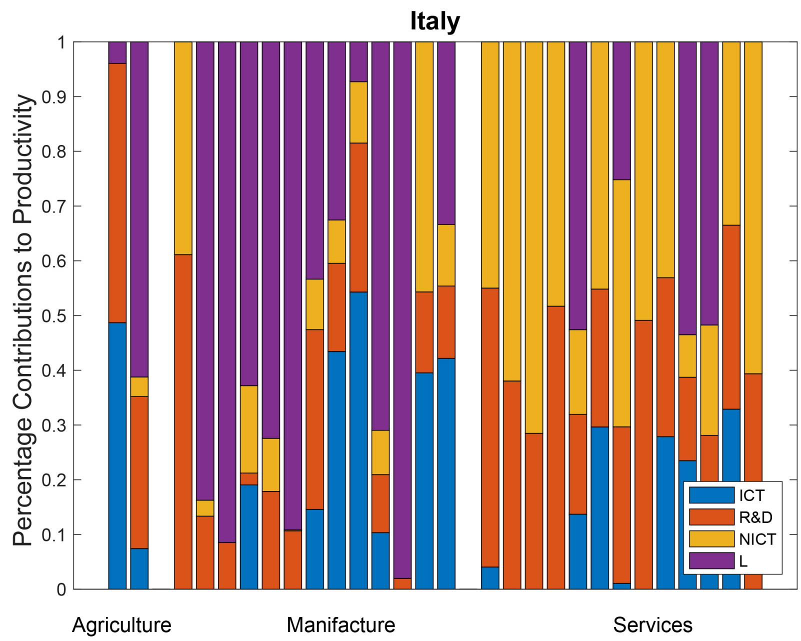
0
ICT
R&D
NICT
L
Agriculture
Manifacture
Services


Italy
Percentage Contributions to Productivity
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0.8
0.7
0.6
0.5
0.4
0.3
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ICT
R&D
NICT
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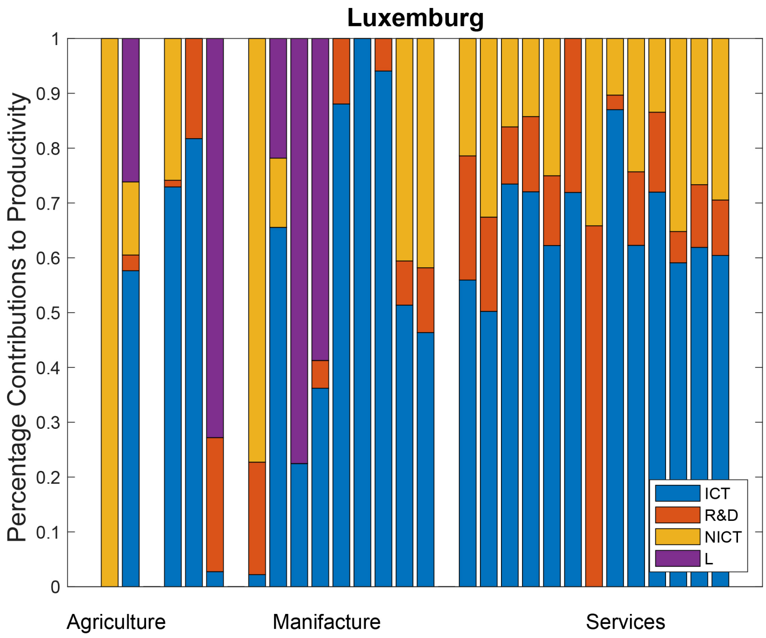
Luxemburg
Percentage Contributions to Productivity
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
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ICT
R&D
NICT
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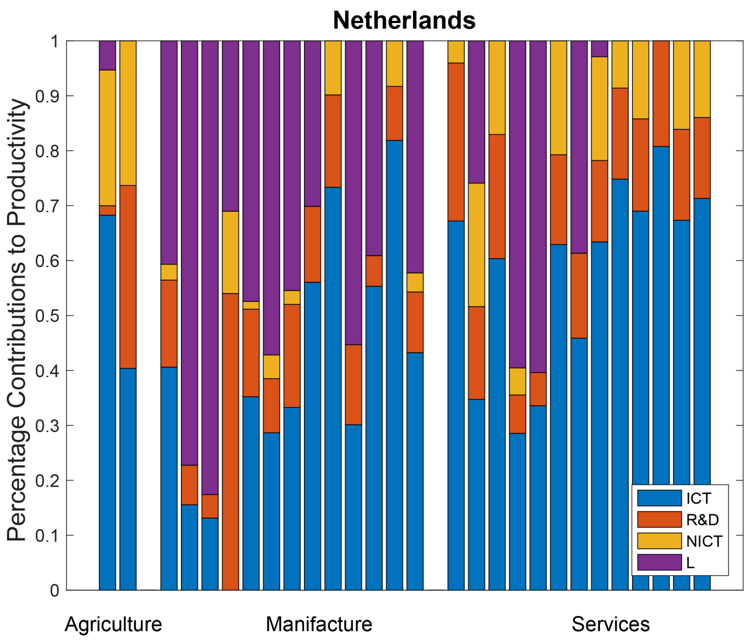
Agriculture
Manifacture
Services


Netherlands
Percentage Contributions to Productivity
1
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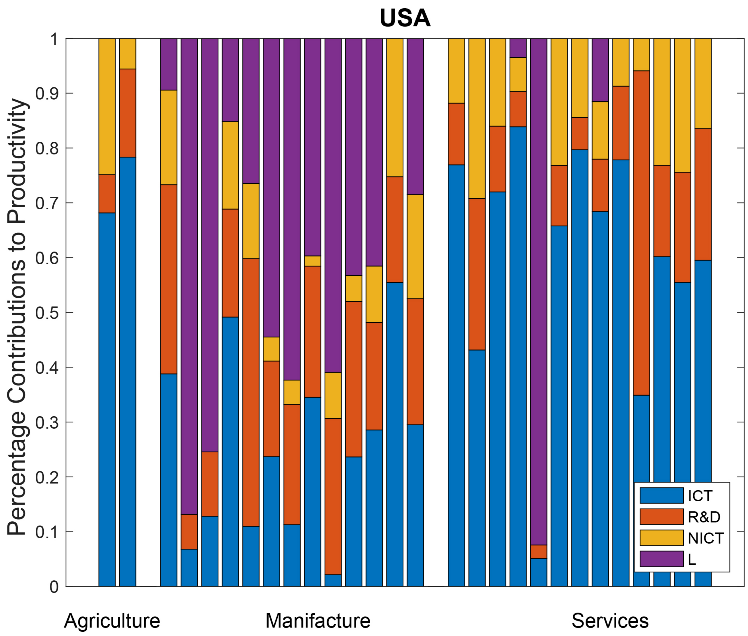
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
ICT
R&D
NICT
L
Agriculture
Manifacture
Services



1.10 Appendix 3: Robust Check

As a robustness check, we work only on the FE estimation which is the reference model of this paper; indeed, as we stated in the Section 4, it is the one which fits best.

Firstly, we removed each independent variable from the model, one at a time, and we tested for this omission. In particular, we are interested in testing hourly productivity as an independent variable; according to the hypotheses of this paper, its omission should reduce the goodness of fit of the model and the test should state that it is wrong to omit it.

The following table shows that the independent variables for the percentage of workers covered by a national collective agreement (Coverage) and the trade-unionization (Trade-union) of the labour force, could be omitted improving the goodness of fit of the model, just as suggested by the outcomes of table 3. The other variables, on the other hand, should not be removed, according to the test. Therefore, this is a further confirmation of the fact that hourly productivity affects LDR rate; indeed, if it is removed from the model, the goodness of fit of the model worsens.

Now, we run a second check for the robustness, dropping one country at a time. By this way, we verify if there are countries which heavily affects the final outcome of our estimation by themselves. The following estimations are always run with robust standard errors. Table 5 shows that our outcomes are robust with respect to the exclusion of individual countries from our sample. The independent variable that

Table 1.9: Robust Check 1: Sequential Regressors Omission Test

Omitted-Variables	p-value	Akaike	Hannan-Quinn	Schwarz
Productivity	4.44e-06***	−111.528	−77.702	−26.528
Inflation	0.0132**	−265.456	−231.630	−180.456
Empl.subs	0.0007***	−227.813	−193.987	−142.813
Protection	1.41e-05***	−221.811	−187.986	−136.811
GDP	0.0032***	−219.529	−185.704	−134.530
Trade-union	0.5673	−275.881	−242.055	−190.881
Coverage	0.9892	−276.943	−243.118	−191.944
FE model	–	−274.945	−239.581	−186.081

*Significance Level: * 10%, ** 5% and ***1%

**P-value refers to omitted variable test. Null Hypothesis: omitted variable parameter is zero

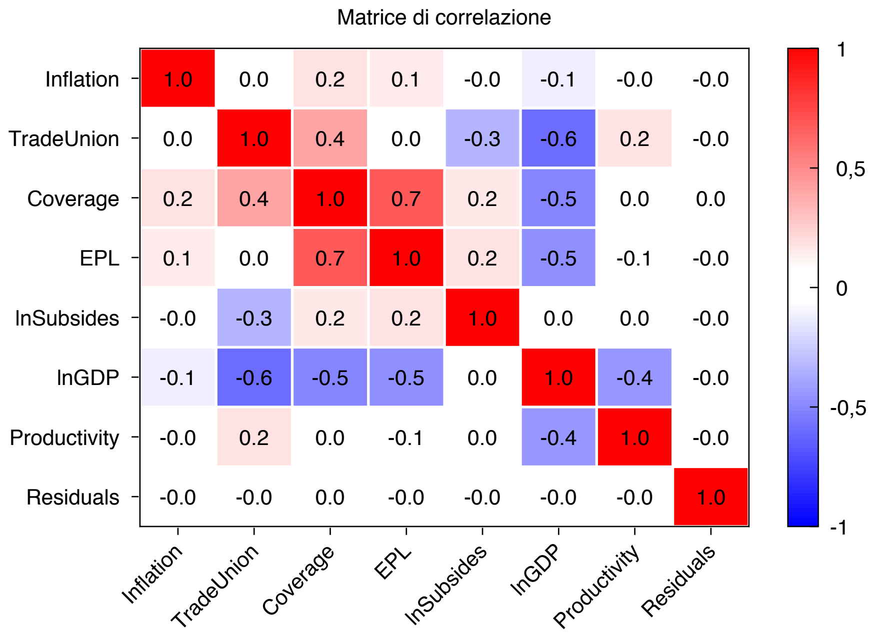
accounts for productivity is always statistically significative and always positive, i.e. the productivity trend of the last 22 years has caused, together with other variables, the upward in LDR index. Moreover, this check shows that by excluding Luxembourg (which could be considered an outlier country due to its small dimensions and peculiar economic conditions), the general estimation improves. In the end, our FE panel estimation is robust compared to countries (table 5) and to their independent variables (table 4). Therefore, the economic considerations regarding the results found in table 3 are reinforced by this robust check.

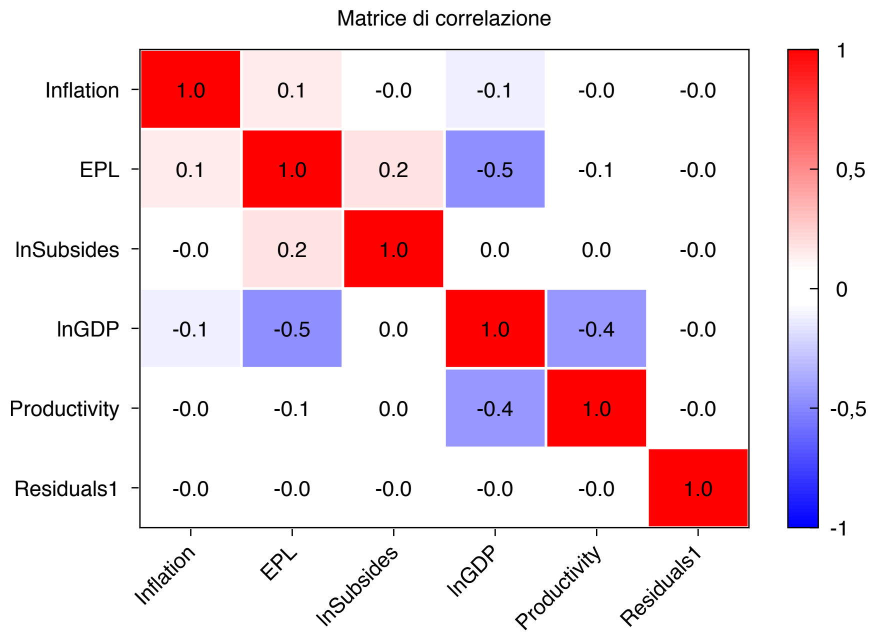
Finally, we report here the correlation matrix of regressors and error terms for the estimation of equation (1.10).

Table 1.10: Robust Check 1: Sequential Regressors Omission Test

Omitted-countries	Productivity	Inflation	Empl.subs	Protection	GDP	Trade-Union	Coverage
USA	0.0192	−0.0290	0.1665	−0.4216	-1.0471	0.0035	6.22e-05
	(0.0028)***	(0.0104)**	(0.0462)***	(0.0687)***	(0.3294)***	(0.0061)	(0.0030)
UK	0.0193	−0.0313	0.1552	−0.4142	−1.040	0.0040	0.0004
	(0.0028)***	(0.0097)***	(0.0396)***	(0.066)***	(0.3166)***	(0.0061)	(0.0031)
Japan	0.0194	−0.0229	0.1691	−0.4426	−1.0460	0.0054	6.12e-05
	(0.0029)***	(0.0092)**	(0.044)***	(0.06768)***	(0.3036)***	(0.0057)	(0.0031)
Canada	0.0198	−0.0283	0.1627	−0.4209	−1.1108	0.0036	0.0003
	(0.0028)***	(0.010)**	(0.0390)***	(0.0673)***	(0.3300)***	(0.0060)	(0.0029)
Belgium	0.0201	−0.0291	0.1631	−0.4074	-1.0501	0.0048	0.0003
	(0.0028)***	(0.0099)**	(0.0037)***	(0.0623)***	(0.3220)***	(0.0060)	(0.0031)
Germany	0.0210	−0.0286	0.1452	−0.3889	-1.1452	0.0017	−0.0009
	(0.0027)***	(0.0099)**	(0.1452)***	(0.0603)***	(0.3130)***	(0.0068)	(0.0027)
Luxemburg	0.0179	−0.0348	0.1266	−0.4378	−1.141	0.0022	0.0004
	(0.0042)***	(0.0092)***	(0.0310)***	(0.081)***	(0.3134)***	(0.0072)	(0.0029)
(The) Nederlands	0.0181	−0.0233	0.1780	−0.4370	−1.008	0.0062	0.0015
	(0.0026)***	(0.0095)**	(0.0463)***	(0.0551)**	(0.2929)***	(0.0050)	(0.0027)
Austria	0.0198	−0.0283	0.1718	−0.3965	−1.1372	0.0006	9.55e-05
	(0.0028)***	(0.0103)**	(0.0366)***	(0.1007)***	(0.3576)***	(0.01588)	(0.0029)
Denmark	0.020	−0.0278	0.1825	−0.4065	−1.1166	0.0023	4.57e-05
	(0.0035)***	(0.0105)**	(0.0658)**	(0.0076)***	(0.3621)***	(0.0071)	(0.0030)
Greece	0.0189	−0.0223	0.1675	−0.4039	−0.9414	0.0026	0.0054
	(0.0028)***	(0.0123)*	(0.0406)***	(0.0622)***	(0.3413)**	(0.0067)	(0.0042)
Spain	0.0175	−0.0275	0.1680	−0.4102	−0.8119	0.0056	−0.0022
	(0.0026)***	(0.011)**	(0.0429)***	(0.0543)***	(0.2708)***	(0.0061)	(0.024)
France	0.020	−0.0283	0.1617	−0.4155	−1.051	0.0045	0.0006
	(0.0029)***	(0.010)**	(0.0366)***	(0.0658)***	(0.3128)***	(0.0060)	(0.0032)
Italy	0.01931	−0.0266	0.1618	−0.4227	−1.0544	0.0034	8.29e-05
	(0.0030)***	(0.011)**	(0.0399)***	(0.0068)***	(0.3136)***	(0.0062)	(0.0031)
Portugal	0.020	−0.0268	0.1583	−0.5547	−1.1857	0.0031	0.0010
	(0.0025)***	(0.0116)**	(0.0387)***	(0.1654)***	(0.2618)***	(0.0074)	(0.0037)
Finland	0.0189	−0.0235	0.1581	−0.4525	−0.9856	−0.0011	0.0005
	(0.0031)***	(0.0097)***	(0.0350)***	(0.0901)***	(0.3525)**	(0.0059)	(0.0035)

*Significance Level: * 10%, ** 5% and ***1%, 330 observations





The first figure shows the correlation matrix in the case of equation (1.10). As it is possible to observe, there is zero correlation, ie.e no endogeneity, between the residuals of our estimations (FE-model) and the other regressors. However, there is high correlation between GPD and trande-union and between the percentage of workers covered by collective national contracts and the protection of job from fire. Protection and Trade-union are not statistical significative according to our estimation, therefore, we can easily take them out from the model and re-estimate it. We get strongly statistical significative estimations for all the other regressors, and now, finally, the correlation matrix has everywhere low values, especially the correlation between residuals and regressors, that is always 0.

Chapter 2

Middle Class Thinning and the Rise of Populism

2.1 Introduction

Technological progress in ICTs has decreased the demand for medium-skilled labor, while the demand for both low- and highly-skilled labor has risen. Economists, including Autor et. al (1997), Levy and Murnane (2012), Acemoglu and Autor (2010), and many others, have documented this trend in a number of accurate studies (Autor et al., 1997; Autor et al., 2006; Autor and Dorn 2010; Autor and Dorn 2013). Their findings in the literature seem to show that the well-known phenomenon of *skill-biased technical change*, usually associated with innovation, is not working as traditionally expected with ICTs. By definition, *skill-biased technical change* favors people with more human capital by requiring more educated workers to be hired and reducing the demand for less-skilled workers. On the contrary, the innovations which have been developing in the fourth industrial revolution seem to affect the labour market in two ways. The demand for certain skilled jobs has increased while the demand for other kinds of skilled jobs has seen a reduction. Conversely, while the demand for some low-skilled jobs rose, the demand for others dropped. To explain these distinctions, we reference the work of Acemoglu and Autor (2010) who have suggested that jobs can be divided into a two-by-two matrix: cognitive (highly skilled) versus manual (low-skilled) and routine or non-routine.

These two economists found that the demand for workers who carry out routine-task jobs has dropped, regardless of whether such jobs are cognitive (highly-skilled) or manual (low-skilled). This leads to the polarization of employment between two types of jobs: non-routine cognitive jobs versus non-routine manual jobs. The fall in the demand for workers in routine manual professions entails a further reduction in the wages of this sector, which was already the least remunerated of the four categories. Conversely, the reduction in demand for workers doing cognitive but routine jobs has been associated with a wage enhancement. Usually, an increment in the workforce supply lowers the pay; therefore, why have wages for cognitive non-routine professions increased? This can only be explained by assuming that the demand for highly-skilled workers has increased more than proportionally with respect to the supply. On the other hand, even though the demand for low-skilled workers has increased in comparison to medium-skilled ones (Autor and David, 2010), wages have diminished (Autor et al. 2008). This is possible only if the supply of low-skilled jobs has increased proportionally, i.e. there have been more medium-skilled workers who lost their jobs compared to the number of the new low-skilled workers demanded by enterprises.

On the one hand, there is an increase in the demand for workers doing non-routine cognitive jobs, which involves an increase in remuneration for those positions which were already the most remunerative ones even before the ICT revolution; on the other hand, there is a further impoverishment of the populations employed in occupations that have always been the least remunerative. Finally, there is an increased impoverishment of an important part of the middle class, forced to fall back on less remunerative jobs or remain unemployed. This could explain the link between the development of new ICTs and the increase in inequality. Recent empirical studies have shown how this 'job polarization' has been happening in the US (Juhn 1994, 1999; Acemoglu 1999; Autor, Katz and Kearney 2006, 2008; Lemieux 2008; Autor and Dorn 2010; Acemoglu and Autor 2010), UK (Goos and Manning 2007), West-Germany (Spitz-Oener 2006; Dustmann et al. 2009) and across European countries (Goos et al. 2009; Michaels et al. 2014).

Recalling the work of Acemoglu and Autor (2010), Jaimovich and Siu (2014) have discovered a correlation between the polarization of work and the speed of the recovery of employment rates after the last three recessions. For most of the nineteenth and twentieth centuries, after each recession employment usually increased rapidly, but since the 1990s employment has recovered much more slowly and never completely. When Jaimovich and Siu compared the 80s, 90s and 2000s, they discovered that the demand for employees to carry out routine cognitive tasks like cashiers, post office clerks as well as for routine manual tasks like machine operators, masons and tailors was not only diminishing, but the rate of its decline was accelerating. These jobs decreased by 5.6% between 1981 and 1991, 6.6% between 1991 and 2001 and 11% between 2001 and 2011. On the contrary, employment in both cognitive non-routine and non-routine manual jobs grew in all three decades. Many middle and lower-class wage-earners became unemployed after their jobs became obsolete, while a few entrepreneurs enjoyed most of computerization's financial benefits. Autor and Dorn (2013) also document a structural shift in the labour market, with employees reallocating their labour supply from middle-income manufacturing to low-income service occupations. Arguably, this is because the manual tasks of service occupations are less susceptible to computerization, as they require a higher degree of flexibility and physical adaptability. In the words of Brynjolfsson and McAfee (2014), new technologies began "encroaching into human skills in a way that was completely unprecedented". In summary, the literature suggests a growing job polarization that is in turn associated with income inequality growth.

In this paper we study the evolution of job categories in 16 European countries (those for which sufficient data are available). As Goos et al. (2009) have done, we firstly distinguish between routine and non-routine jobs and between skilled and unskilled jobs. Then, we update their data by checking whether the trend they found in 2009 has reversed or been maintained. Subsequently, using an appropriate classification of occupations, we also update the Acemoglu and Autor (2010) data relating to the changes in the percentages of low, medium and high-income occupations, out of the total number of employed people. The second part of the paper is a literature review which try to link these outcomes from the job market to the birth of populism. Referring to the median voter theorem and to the model of Meltzer and Richard (1981), the general idea is that the progressive modification of job market structure (found in the empirical part of the paper) is also changing the form of income distribution, modifying, in turn, the political preferences, as already stated by Frey et al. (2018). Moreover, we recall the policy-bundle theory by Roemer (2001) and we discuss the recent literature about the value issue that could have affected the voters together to economic distributive variables and we found that the social identity both for nation and income class (Shayo, 2009) are a second source of reasons that, together to middle class thinning due to job robotization and its consequent polarization, could be leading to new forms of political participation: the populism.

2.2 The Estimations

In this section we first update the findings of Goos et al. (2009) in order to determine the net effect of technological changes in terms of percentage variations among all types of jobs for 16 European countries. Secondly, following the approach of Acemoglu and Autor (2010), we analyze the distributive effect among low, middle and high-income classes due to the change in the job structure observed in the first part of this section.

We start from job structure analysis. Our primary source for employment data is the harmonized individual-level European Union Labor Force Survey (ELFS) for the period 1993-2017. The ELFS contains data on employment listed according to economic activities. There are two datasets available: a more general one and another with more detailed economic activities. The more detailed dataset contains 2-digit International Standard Occupational Classification (ISCO) codes while the other contains 1-digit industry codes from the Classification of Economic Activities in the European Community (NACE revision 1). Of the 28 countries available in the ELFS, we exclude, as did Groose et al. (2009), 11 new EU member countries[1] and Iceland because of limited data availability. Data for the remaining 16 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway (non-EU), Portugal, Spain, Sweden and the United Kingdom) are sufficiently complete for a long-term comparative analysis.

From NACE revision 1, we extracted 15 different activities; the others are macro-categories which contain a mixture of the 15 minimal-activities. In 2008, ELFS statistics changed, adding 5 economic activities to the previous ones. Fortunately, each of these 5 items were aggregated into a single category of the original 15 economic activities, furthermore, it has been possible to get an homogeneous time series from 1995 to 2017. Then, we classified the 15 economic activities as routine/non-routine and skilled/unskilled. In order to distinguish the most highly-skilled jobs, we used the IOSO-08 classification (from ILO). IOSCO classification divides jobs into 10 major groups and 28 minor groups, and defines the level of skill for each group. IOSCO defines 4 levels of skill; for this analysis, we considered level 1 and level 2 as low-skilled jobs, and level 3 and 4 as highly-skilled jobs. In the end, to distinguish between routine and non-routine economic activities, we used the definition built-up proposed by Goos et al. (2009). The final outcome is summarized in the following table.

By the table is possible to observe 4 different jobs, according to the main idea of Acemoglu and Autor (2010). The first category is made up of non-routine but skilled jobs (NRS), like professionals, engineers, architects, medical doctors, teachers and

[1] Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovenia and Slovakia, Romania and Bulgaria

NACE code	R	NR	S	NS
Agriulture, foresty, fishing	YES			YES
Mining and quirryng	YES			YES
Manufacturing	Yes			YES
Electricity, gas, water supply	YES			YES
Construction	YES			YES
Wholesale and retail trade	YES			YES
Transportation, storage and communications	YES			YES
Hotels and restaurants		YES		YES
Financial and insurance activities	YES		YES	
Real Estate activities		YES	YES	
Public admn. & def.; compulsory social security	YES		YES	
Education		YES	YES	
Human health and social work activities		YES	YES	
Activities of households	YES			YES
Other service activities	YES		YES	

Table 2.1: Jobs categories, IOSCO and ELFS rielaborations

information and communication technology; the second category is for non-routine, unskilled jobs (NRNS) like those in hotels and restaurants; the third category is for routine, skilled (RS) jobs like those in public administration and defense, compulsory social security, financial and insurance activities; the last category is for routine, unskilled jobs (RNS), for example in manufacturing, mining, construction, etc. By using this classification, we calculated the percentage of each of the 15 ELFS economic activities out of total current employment, and then we aggregated them into these four categories of jobs and we calculated the spread between the first and the last value observed in the time series[2]. For the convenience of the reader we report in the Appendix four figures showing the complete time series, for each country, regarding these four job categories. From these figures, we observe that there exist a consistent trend for each job category.

[2]HINC-01. Selected Characteristics of Households by Total Money Income. Current Population Survey (CPS) Annual Social and Economic (ASEC), 2018. Available at: https://www.census.gov/data/tables/time-series/demo/income-poverty/cps-hinc/hinc-01.html

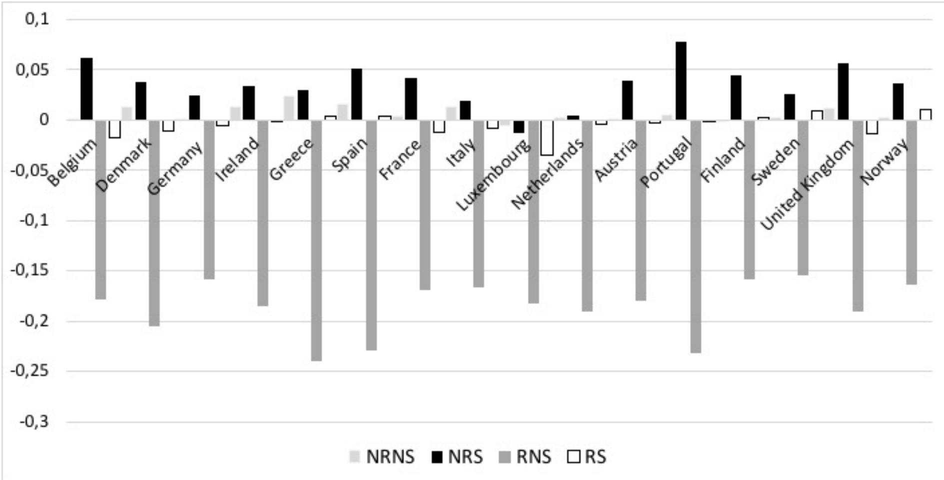


Figure 2.1: % variations routinely skilled/ not skilled and not routinely skilled/not skilled jobs on total labour force, 1995-2017, Eurostat.

Typical middle-class jobs are disappearing, while those with very high skills (cognitive) and very low skills (manual) are multiplying. This is due, on the one hand, to the fact that the most creative tasks that require intellectual speculation, and therefore are not currently replicable by artificial intelligence, survive. On the other hand, as the Moravec paradox states, tasks that require particular sensory-motor skills (for example the touch of a chef or a nurse) can be very cumbersome from a computational point of view, and are therefore (for the moment) more easily performed by humans. The result is what the philosopher Loi (2015) sums up well in his *Technological Unemployment and Human Disenhancement*: "On the one hand, employment grows for highly specialized managerial, professional and technical jobs; on the other, it also grows in food preparation and catering, for cleaning and maintenance work, in personal health care and in numerous occupations in security and protection services. By comparison, employment for routine forms of work with medium skills has fallen steadily in relative terms over the past three decades."

It is evident, therefore, that job structure has changed over the past 22 years. What are the distributive consequences? We investigate whether this new job structure has increased or reduced income inequality, using the statistics proposed by Acemoglu and Autor (2010). Instead of classifying jobs by distinguishing them by skill and routine level, we can sort them by salary level and then aggregate them into three macro-categories: low-income professions, high-income professions and middle-income professions. Taking into account, then, the changes in employment between the different jobs over a certain period of time, it is possible to study whether the middle-class occupations have fallen, increased or remained relatively constant.

We start by assuming that the general ranking of jobs according to their pay has not changed over time, which is a realistic assumption, already adopted by Acemoglu and Autor (2010). We use the same data of these authors from their job polarization analysis, published in the Eurostat ELFS and we consider the same 16 European countries. The work of Acemoglu and Autor was kept up-to-date until 2006. By adding the data of the following years as follows, we can update those statistics to 2017.

To classify the professions by remuneration, we use the values referring to the year 2014, the only year available from the ELFS. Job remuneration is expressed in hours, following the example of Acemoglu and Autor (2010). The value related to agriculture is not available; however, one referring to "Professional, scientific and technical activities" has been added. To decide the classification order, we take into account the inter-group variability among the 16 countries. We classify the professions for each of the countries observed, giving a value of 1 to unpaid jobs and a value of 15 to the most remunerated ones. We then combine the data in the table (8) to summarize the information obtained[3]. From the table it is possible to obtain a relatively precise, general classification of professions, valid for all the countries analyzed. The professions are then aggregated into three macro groups: low, medium and high income. Finally, the employment rates of these three groups are merged and they can be observed varying for the whole period examined (1995-2017). The following graph shows the difference in percentages of employment in the three macro-categories that are grouped by income[4].

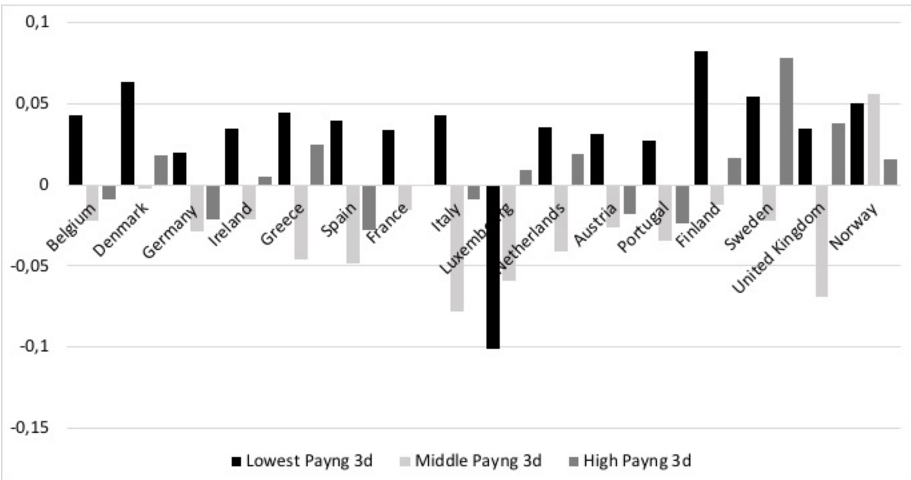


Figure 2.2: % variations low, middle and high jobs on total labour force, 1995-2017, Eurostat.

The study reveals that in 22 years in almost all European countries analyzed, the lowest paid professions have grown in terms of occupied jobs, by an average of around

[3]In the table we have identified the jobs with their corresponding NACE code.

[4]Households Below Average Income: An analysis of the UK income distribution: 1994/95-2017/18. Department for Work and Pensions, UK, 2018. Available at: https://www.gov.uk/government/statistics/households-below-average-income-199495-to-201718.

Table 2.2: Jobs categories classified by income (re-scaled 1-15), ELFS rielaborations

	I	**N**	**F**	**P**	**D**	**K**	**Q**	**C**	**B**	**S**	**M**	**O**	**L**	**H**	**G**
Belgium	1	2	3	14	13	12	7	9	8	5	11	15	10	6	4
Denmark	1	4	8	7	13	14	3	11	15	9	12	6	5	10	2
Ireland	1	3	5	14	15	12	8	7	11	4	13	9	10	6	2
Greece	2	1	5	12	14	13	7	6	10	3	9	15	8	11	4
Spain	2	1	5	12	15	14	10	8	13	3	11	9	7	6	4
France	1	2	7	12	15	14	3	10	11	4	13	5	8	9	6
Italy	1	2	6	14	12	15	10	7	13	3	11	9	8	5	4
Luxemburg	1	2	3	13	15	10	8	5	14	6	9	12	11	7	4
Nederlands	1	2	8	9	13	15	6	7	14	5	11	10	12 4	3	
Austria	1	2	7	10	14	13	6	8	11	4	12	15	9	5	3
Portugal	1	2	5	12	13	14	6	3	7	8	11	15	10	9	4
Finland	1	2	7	10	14	15	4	11	9	3	13	12	8	6	5
Sweden	1	2	7	10	14	15	4	11	9	3	13	12 8	6	5	
UK	1	3	8	11	14	13	5	6	15	4	12	10	9	7	2
Norway	1	2	5	8	10	13	6	9	14	4	12	15	11	7	3
Germany	1	2	5	10	15	14	7	11	12	6	13	9	8	3	4
Average	1.125	2.125	5.875	11.125	13.6875	13.5	6.25	8.0625	11.625	4.625 11.625	11.125	8.875	6.6875	3.6875	
Dev.St.	(0.341)	(0.718)	(1.627)	(2.125)	(1.352)	(1.366)	(2.144)	(2.407)	(2.526)	(1.821)	(1.3102)	(3.283)	(1.746)	(2.151)	(1.138)

4 percentage points with peaks of 7% in the case of Finland. At the same time, highly paid jobs have also increased in most countries. On the contrary, it is striking to notice how average-waged jobs have dwindled almost everywhere, with the sole exception of Norway. A similar trend explains the increased income inequality and polarization of incomes and the consequent thinning of the 'middle class', both in terms of wealth and in number of participants.

All these trends are changing the form of income distribution within industrialized countries. The study of income distribution has a long history. More than a century ago, Pareto proposed that income distribution obeys a universal power law, valid for all time and countries. However, subsequent studies found that this conjecture applies only to the top 1-3% of the population, therefore, until the end of the 20th century, it was common to approximate the distribution of income through a Gaussian (Di Matteo, 2004; Clementi and Gallegati, 2005). More precisely, it has been observed that the correct distribution pattern is a log-normal with a power law for the right tail, and it has been proofed to be the universal structure of income (Souma, 2001). In the two queues of Normal distribution there were few extremely rich or extremely poor individuals; at the center of the distribution, instead, there was the majority of the population, and they constituted the "middle class". This is changing: people with very low, no, or even negative income levels are growing, in the industrialized countries. As the left tail of the Gaussian became fatter and fatter, the tail on the far right of the distribution curve also acquired greater depth; the two combined phenomena reduced the central part of the distribution that visibly lost weight making the Power Law a better fit (Jones, 1997, Banerjee, 2006), coming back to Pareto hypothesis.

An interesting statistic for evaluating the ongoing middle class thinning is to study the form assumed by the percentages of population by constant income bands (The Equivalished Disposible Income). These bands are for household, not individuals, and they refer to the after-tax income. Each income band counts for the number of subjects who receive income between the two extreme band values. The central band must contain the average income in the center so that the graph is correct and comparable over time and with other countries. If the income were distributed Normally, the central zone should have the highest population share compared to all the others, while the percentage of population in the extreme tails should be similar to one another and in both cases be lower compared to the central zone. As an example we show only the cases of USA and UK; in the US the income distribution is better fitted by a Pareto distribution; as for the UK, the Normal distribution is still the better fit, however its income distribution is not anymore a Gaussian (statistical Normality tests fails).
As for the UK, we found official data from the Department of Work and Pensions which consider 100 income bands; ad for the USA the income bans provided by the Census Bureau are only 40.

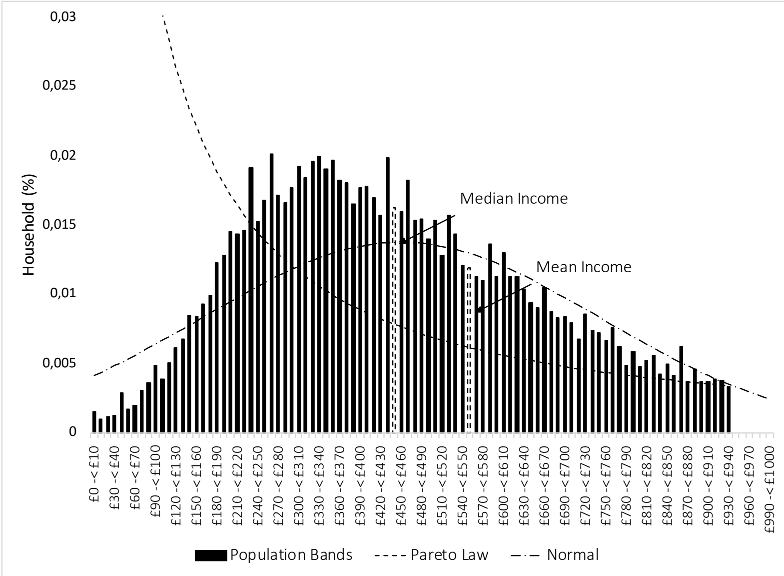


Figure 2.3: UK 2018, Department for Work and Pensions, Weekly Income, Rielaborations.

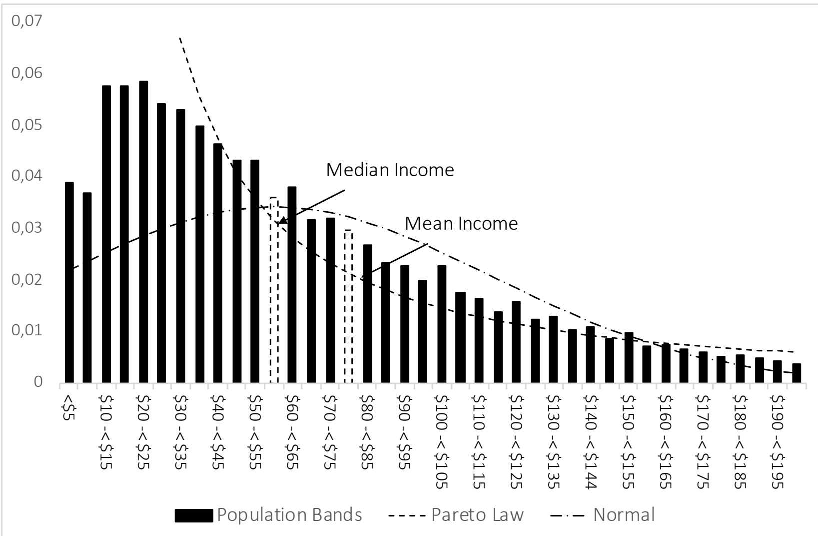


Figure 2.4: U.S. 2014 Census Bureau, Current Population Survey, Annual Social and Economic Supplement, Annual Income, Rielaboration.

Looking at England, in 2018, the great imbalance compared to the Normal case is remarkable; most people belong to the left tail, far before median income. The average income is approximately 613£ per week but we calculated that around 65% of the English population lives below the average income line. It is a distribution with strong skewedness on the left and as the inequality increases the curve becomes steeper and more displaced to the left. Similar evidence is found in the US. Normal distribution does not fit well anymore, even if the Partian distribution is still not appropriate. In the US the situation is even more radical than in the UK: more than 70% of total households are below the average income level. Compared to UK, the US income distribution seems to se far closer to the Paretian line than the Normal one.

Statistics	**UK**	**US**
mean	445£	57,500$
median	565£	77500$
Skewness	0.091	0.5128
Doornik-Hansen	0.0017	0.0053
Shapiro-Wilk	0.0003	0.0022
Lilliefors	0.0300	0.0600
Jarque-Bera	0.0322	0.1606
Normality SSE	0.0009	0.0015
Paretian SSE	0.0371	0.0009

Table 2.3: Equivalished Disposible Income, Main Statistics, Our rielaborations.
1. We reported the p-vale for the four Normality tests. Significance Level: * 10%, ** 5% and ***1%
2. SSE is for: Sum Squared Errors

In the Table 2.3 we report some statistics from the population income bands data used in Figure 2.3-2.4. The skewness is positive, as expected, indicating asymmetry to the left side of the distributions. UK skewness is lower, suggesting a higher income inequality in the USA, as noticeable in figure 2.4. We also run four Normality-tests on both the countries, finding that neither for UK nor for USA, the income distribution among population bands follows a Normal distribution. Finally, the most important statistic is SSE that we calculated both for Normal and Pareto distribution. We wanted to compare which of the two distributions fits better to the income distribution observed; in doing so, we associate the Normal and Pareto distribution to Uk and USA income distribution and then we calculated the Sum squared Errors (SSE), excluding the first six observation[5]. As for UK, the SSE is lower for the case of Normal distribution. This means that it fits better than Pareto distribution, however we cannot conclude that the income distribution in UK is Normal, since the Normality tests refused this hypothesis; we could state that UK is in a period of transition form an income Normal world to a Pareto one. As regard for USA, on the opposite, we found that the Pareto distribution is a better shape-estimator than Normal dis-

[5]The Pareto distribution for the first values is to high; comparing it for all income observations would have mislead the final outcome.

tribution (0.0009 vs 0.0015 SSE). We shall hypothesize that the transition which is involving the UK is going to end in USA.

In front of such a radical change in income distribution, many economists have started to call this last form of digital capitalism the *superstar economy*, which is a system characterized by superstar agents (Rosen, 1981; McKinsey, 2018; Bajgar e al. 2019). Superstar economies are perhaps better described by a power law, or Pareto curve, than a Gaussian one. In the power law curve a small number of people reap a disproportionate share of sales. This is often characterized as the 80/20 rule, where 20 percent of the participants get 80 percent of the gains, but it can be more extreme than that. Kim Taipale, founder of the Stilwell Center for Advanced Studies in Science and Technology Policy, has argued that, "The era of bell curve distributions that supported a bulging social middle class is over and we are headed for the power-law distribution of economic opportunities. Education per se is not going to make up the difference"[6]. By our findings on the opposite, the Pareto distribution seems to fit well quite for the whole income distribution (especially in the case of US). Certainly, when the variance of a Normal distribution goes to infinity and when the power of a Pareto distribution goes to zero, both the distributions converge in the case of perfect income equality. However, out of this case, especially if the distribution is getting more and more unequal, the Pareto distribution seems to fit better, and we found it in the case of USA. These epochal changes can seriously change the way democracies have always worked. According to the second assumption of the Median Voter Theorem, indeed, voters' preferences need to follow a Normal, bell-shaped distribution, whereby the majority of voters is located in the middle. This assumption is reasonable for Normal income distribution where voters are assumed to prefer a more left-wing or right-wing set of policies depending on their level of income. This leaves the middle classes as the majority in the middle. However, in a *superstar economy* dominated by the Power Law distribution, the median income voter could no longer have preferences close to the mean income voter, leading to a radicalization of political spectrum. In the next section we will discuss what is happening to the political preferences, in this new social context dominated by the ICT revolution.

[6] Presentation by Kim Taipale at the 21st Annual Aspen Institute Roundtable on Information Technology, August 1, 2013.

2.3 A Descriptive Discussion

In the previous section we have just found the ICT revolution has increased the job polarization entailing a decrease in the relative number of routine middle-income jobs (Autor, 2015). As a consequence, the share of non-routine jobs at the two ends of the income distribution is grown and the middle-class has reduced. Graetz and Michaels (2018), on a larger sample of countries, find that robot adoption has a positive effect on productivity but a negative impact on the share of hours worked by low-skilled workers, increasing income inequality. For example, in the US, over the period 1979 to 2013, productivity growth was eight times faster than hourly compensation: as productivity grew by 64.9 per cent, hourly compensation for 80 per cent of the American workforce grew only by 8.2 per cent, while the top 1 per cent of earners saw cumulative gains in annual wages of 153.6 per cent (Bivens et al., 2014). A growing body of work has identified automation as one of the prime forces driving the shifts in income shares along the occupational wage distribution (Autor et al., 2006; Autor and Dorn, 2013; Graetz and Michaels, 2015; Michaels et al., 2014; David, 2015), and from labour and owners of capital (Karabarbounis and Neiman, 2013). Impressive is the rapid decline in computing cost compared to the declining share of US employment in routine jobs shown by Frey et al. (2018). In this context, the median voter theorem (Downs 1957) could no longer favors the political preferences of the middle class just because it has been numerically reduced while the share of population under the median income has grown. The famous model by Meltzer and Richard (1981) states that in the case of right-skewed distribution of income, the position of the most disadvantaged fringes of the population will prevail over the residual middle-class, leading, in the hypotheses of their model, to a higher level of taxation/public intervention in economics. Indeed, the 72% of surveyed Americans fear a future in which computers and robots can do more human jobs, while 85% favor policies to restrict the use of machines to hazardous jobs (Pew Research Center, 2017). If workers who have lost out to automation do not accept labour market outcomes, they will resist the force of technology through non-market mechanisms, such as political activism (Mokyr, 1990; Mokyr, 1998; Mokyr et al., 2015). Nowadays, this political activism is called "populism", and its advent could be strongly associated to jobs robotization and the consequent middle-class thinning and income inequality growth. However, the distributional effects on the outcome of political elections are controversial in the literature. Romer (1975), Roberts (1977) and Melzter and Richard (1981) consider that the median voter is also the median productivity worker in the population. However, nothing assures us that the median voter in the redistribution of skills is necessarily the median voter in the distribution of redistributive preferences. The median voter theorem, indeed, suggests that democracy should be the best system to limit income inequality because voters could reduce it with each new election but then, why in the last 30 years, democracies have failed to limit the increases of inequality (Bartels, 2008; Bonica et al., 2013)? Why the most recent response of the electorate has been populism instead of a classical redistributive policy?

There are two strands of literature that explain how democracies fail to limit inequalities. The *asymmetric-participation theory* (Benabou, 2000) states that some groups of voters do not participate in elections and therefore citizens can exert an unequal influence on political results. This can generate a gap between the hypothetical and the actual median voter, leading to a level of redistribution that is not the one preferred by the majority of the population. A numerically consistent part of the electorate does not go to vote. Only in a scenario reflecting the hypothesis that the electorate which does not vote has the same income distribution as those who do vote, does the distinction between the voting and non-voting population become useless. However, it is more often the case that the income distribution of those who vote is significantly different from the distribution of real income of the country as a whole. Verba et al., (1993) and Wolfinger and Rosenstone (1980) found that those who vote tend to be richer and better educated than those who do not vote. So the voters, being richer on average than the total combined population of voters and non-voters (Bennett and Resnick, 1990), tend to prefer policies with low State redistributive intervention, even though the prevalence of poverty would elect representatives more favorable to more redistributive polices. Hill and Leighley (1992), indeed, found that redistributive public policies are more generous where the poor are better represented. The asymmetric participation theory contribute to solve the apparent paradox of democracies with free elections and income inequality growth but does not say anything to explain the birth of populism.

The second theory to explain why income distribution is got more and more unequal despite median voter theorem is the *policy-bundle theory* by Roemer, 2001, according to which voters' preferences do not include only the income distribution level; they vote also on the basis of their values. Corneo and Neher (2015) find that redistributive policies tend to adjust to the preferences of the voters who hold median views on values issues. In order to win elections, in a context of predominance of the value issue, the parties tend to satisfy the median value (and not income) preferences; however, voters with median value preferences do not necessarily have median income preferences. There are cases in which the predominance of the value issue is correlated with a greater redistributive preference and vice versa. In a lot of cases the majority of voters are against redistributive policies. A common outcome from both investigation and experimental evidence is that people often express a demand for redistribution that apparently contradicts their self-interest. In a more general version of the median voter, redistribution preferences of voters may depend on non-pecuniary factors. Alesina and Giuliano (2010), Corneo and Grüner (2002), Dahlberg et al. (2012), Fong (2001), Höchtl et al. (2012), Klor and Shayo (2010), Luttmer (2001), Luttmer and Singhal (2011), Shayo (2009) and Tyran and Sausgruber (2006).

The main non-pecuniary concerns are: the perception and tolerance of inequality, the perception of social mobility, identity and the social status (Corneo, Neher: 2015). In the current socio-economic context, not all these non-pecuniary concerns are good to explain the increased inequality income in democracies.

As for justice, Alesina and Giuliano (2010) note that often "individuals have views regarding redistribution that go beyond the current and future states of their pocketbooks. These views reflect different ideas about what an appropriate shape of the income distribution is: in practice, views about acceptable levels of inequality". Economic self-interest appears to be a rather weak predictor of voting behavior: poor people do not necessarily vote for extensive redistribution of income, and rich people sometimes support welfare programs from which they do not expect to benefit. The hypothesis of Alesina and giuliano (2010), could have been true for the last decades, explaining why democracies failed to limit inequalities, but it is unlikely that the current income distribution, at least in industrialized countries, is considered fair by the population, just because the inequality levels nowadays are at record comparing them to the statistics history (Oxfam, 2016).

The perception of social mobility is another factor that could reduce importance to income distribution. Benabou and Ok (2001), found, in their model, that there can be a range of individuals with income below the mean who oppose such policies because they rationally expect to be above the mean in the future, and the mass of people who oppose redistribution can be a majority in the population. Again, also for the perception of social mobility, it could have prevented redistributive polices in the last decades, but it seems hard to state it for the last years. Chetty et al. (2014), indeed, found that the increased income inequality in the US has grown the "birth-lottery" and Corak (2013) showed that intergenerational mobility is lowered by the more polarized labor market and this trend is likely to continue. Therefore, a lot of people that nowadays are below the mean income, have less rational reasons to expect to be above the mean in the future, furthermore they could not oppose redistribution anymore.

A different case is for the complex theme of Identity. Sometimes, individuals take care not only about their own self-interests but also about the status of their group. This feature is an implication of Social Identity Theory (Tajfel and Turner, 1979, Tajfel and Turner, 1986) which states that people vote in order to protect their group. Often people do not vote their economic self-interest; they also vote their identity (Shayo, 2009). Two prominent identity are nation and class. If income distribution enhances the status of the lower class more than it does national status then the class identification makes redistribution a more important issue. On the opposite, if members of the lower class tend to think themselves more as members of the nation as a whole than as members of the class as whole, they are less concentrated on income redistribution and vote for a lower level of redistribution. In the last years, both national identity and income class identity have come back in importance affecting the final election outcomes. Inglehart and Norris (2016) have shown that in South America, in the United States and in Europe, the society is becoming increasingly polarized, not only in income but also in values, splitting the voters in two groups: one liberally-minded and the other traditionally-minded. Income inequalities and social identity are the two sources of populism. Populism, therefore, is not only a classical redistributive political activism (in favor of lower income class), but it holds also social identity issues, widening its protests from income inequality to globalization (in favor of national sovereignty) and migration (in favor of ethnic homogeneity of the nation).

The job polarization found in the previous section and widely confirmed in the literature has been causing a growing income inequalities from 1990s (Frey et al., 2018) meanwhile globalization, migration and the Great Recession reinforced both the national and class identity (Colantone and Stanig, 2019). The growing wave of elections with an unexpected outcome for the middle class, defined under the generic category of "populism", seems to be the latest confirmation of the hypothesis that the increase in inequality mainly due to job robotization (class status) mixed to identity threats from globalization and liberal progressivism (national status), lead to a radicalization of the political framework, in contrast to the interests of the mean voter (Figueira, 2018).

Populism is a political category different from classical ideologies in the 20th century. In according to Mudde (2007), populism is characterized by three factors: anti-establishment (opposing the 'elites' and depicting the establishment as corrupt); authoritarian (emphasizing personal power of a charismatic leader and/or direct democracy instead of representative democracy); nativist (against multiculturalism). For this reasons the populists are often considered "heterogeneous" in their policy proposals (Colantone and Stanig, 2019). The definitions of "left" and "right" too, as political categories, seem to mix and disappear in the populist movements. This is certainly due, in part, to the convergence in political views between the traditional leftist and the right-wing parties which has made them less distinguishable from one another (Albright, 2010). The right and the left are merging more and more, sharing common values and discarding their historically divisive goals to favor this union. As the historical right increasingly embraces 'civil rights' and 'multiculturalism', the historical left relinquishes ideals of redistribution and class struggle. Thus, in opposition to this process of epochal political transformation, populism is emerging as a political force that welcomes certain elements traditionally belonging to the "left" and others more traditionally attributable to the "right". According to the median voter theorem, the most extreme fringes of population abstain from voting when parties with too similar programmatic content prevail; however, the more extreme socio-economic and environmental conditions become, the more radical political positions begin to seem more reasonable and by acquiring greater support they force politics to become radicalized in order to respond to new popular needs. This would ultimately return certain extreme fringes of the population to voting in a "contagion" effect (Mudde 2004, Rooduijn et al, 2014, Rydgren, 2005) that could explain the birth and the success of populism.

On the left, populism mutates the struggle against those it identifies as the 'elites' and the great economic lobbies in the name of greater redistributive justice; while on the right, populism embodies the awakened sense of community and national identity in opposition to globalization and cosmopolitism. Consequently, it fights against mass immigration and the consequent 'multiculturalism' and instead aims for the recovery of some traditional values of the family in opposition to the latest developments of 'civil rights'. In particular, The recent migratory flows that have affected Europe in the last 20 years have surely influenced the voters who need identity protection (Dalhberg et al., 2012). Inglehart and Norris (2016) stressed that a common catalyst for populist movements is voter dissatisfaction, for both economic and value issues. The economic dissatisfaction emerges from changing economic trends with a significant impact on society, including globalization, job insecurity and inequality. The cultural reason is a 'backlash' against the rise in progressive values since the 1970s, in relation to multiculturalism, gender equality and human rights (Inglehart, 1990). Similar factors are found by Elchardus and Spruyt (2016) with their concept of 'declinism', which is a political view according to which societies are getting worse due to multiculturalism, globalization, environmental issues and moral principles. In this context populism is combining the social identification of nation with the social identification of income class, widening the electorate in inedited ways. This could be the reason why it managed to win elections in a lot of countries.

However, within populism, there are at least two souls; we see this, for example, by comparing the first populist movements born among Western countries with those of Latin America (Kaltwasser, 2012). The economic programs of the populists range from extreme-left pro-redistribution platforms to rather conservative ones. From an economic perspective, then, it is rather difficult to identify a single populist platform (Colantone and Stanig, 2019). A part of the ex-middle-class hopes to "come back". They give their vote to populist forces that promise to restore the old Fordist and family capitalism, undermined by globalization and the financialization of the economy. There is a part of the ex- middle-class that feels dissatisfied by having seen the wealthy classes grab almost all the economic growth of the last two decades. Elchardus and Spruyt (2016) emphasized the link between "feelings of relative deprivation" and attraction to populism. These voters are attracted by political parties which oppose to the magnates of international finance, the opening of economies to the international markets, the mass immigration and therefore, as a corollary, the defense of national economy and identity (*nationalist populism*). On the other hand, an important slice of low-income people, especially young people with significantly lower prospects for a quality life-style compared to that enjoyed by their parents, could instead reject the capitalist order itself. This could give rise to populist political forces promising the nationalization of large amounts of capital from the hands of multinationals, banks and industrialists, and putting social production under collective control. Furthermore, faced with the prospect of not being able to afford to have a family because of employment instability and tight work schedules, coupled with the need to move to different countries to pursue their jobs, many of them could rediscover the values of family and patriotism (*socialist populism*).

The real difference between these two forms of populism lies in their different objectives. We see this gap examining what they mean when they talk about 'elites'. Both forms of populism, in fact, oppose a Power, but it is not exactly the same for both: for nationalists this power is represented by the banks, by Jewish finance and by Masonic lodges; for the socialists this power is also certainly represented by banks, lobbies and Freemasonry, but to these institutions they add the multinationals as well as the medium-small and private family-run firms, in favor of an economy managed collectively. Both forms of populism then claim the principle of 'nation', but here again they each define it differently: the nationalist populists interpret the nation as a means of building the country's economic supremacy even at the cost of damaging others countries and reducing the attention to income class issue; the socialists defend the principle of 'nation' as a tool to allow the people to govern themselves, i.e. to liberate themselves from the domination of international bodies of dubious democracy (Eichenberg and Dalton, 2007) and to defend employment and labor rights against the uncontrollable fluctuations of international markets. Finally, both forms refer to traditional cultural forms: nationalist populists focus their rhetoric on mass immigration, fighting it harshly but at the same time without analyzing its deep causes (Mudde, 2013); moreover, they are culturally opposed to unconventional gender philosophies and claim the indisputable preeminence of the traditional patriarchal family. Socialist populist movements not only oppose mass migration interpreted as a shift of the industrial reserve of low-cost unemployees, they also propose policies of active political and economic support in the countries of origin of the emigrants so that the causes that generate it are remedied; finally, they oppose gender theory and defend the primacy of the natural family (despite respecting the different sexual orientations) devoid of patriarchal or matriarchal interpretations.

Who will prevail? No one can say. Almost certainly, if the condition of inequality and identity instability do not change over the next two decades, populist movements are likely to become stronger. Moreover, the more time passes, the fewer people there will be who have been part of the middle class in the past and therefore, perhaps, the consensus to adhere to a socialist form of populism could grow more rapidly than the tendency towards nationalist populism. Furthermore, it appears quite clear that the political distance between nationalist and socialist populist forms will become more and more evident as traditional parties are definitively defeated and marginalized. Once the common enemy, 'Globalism', is eliminated the two factions will face off more openly, each one defending its own political vision. But before this can happen, the residual middle classes, by mutual agreement with the new rich, could opt for an authoritarian regime, as an extreme measure to curb the advance of populism. It is not a coincidence that the residual middle-classes together to upper classes have begun to speak of congenital 'malfunctions' of democracies as they would allow 'extremist' forces to rise to power. They also coined the oxymoronic term 'authoritarian democracy' to identify democracies with a populist government; moreover, they invented social categories as 'hater groups', to delegitimize their political opponents and justify their 'corrective' (coercive) intervention.

2.4 Conclusions

This paper confirms the trend that has long been established in the literature: we are moving towards a society where there is less and less need for routine jobs (being replaced by machines, in particular by ICTs and artificial intelligence), whether they are skilled or unskilled. This paper updates these findings to show that this process has advanced beyond the results of the last study by Goos et al. (2009). At the same time, the paper shows that this change in job structure has been accompanied by a progressive reduction in the number of medium-income jobs (typical of the clerical class) in favor of high and low income jobs. Compared to Acemoglu and Autor's (2010) findings, our updated outcomes revealed that even the number of medium-income jobs has been reduced. This double long-term trend has produced a rise in inequalities and a permanent thinning of the middle class. The current income distribution curves are no longer a Gaussian but are going towards a world dominated by the Power Law function. Under such conditions, extreme radical political ideologies are far more likely to develop.

If the trend of inequality is not reversed, sooner or later the ousted members of the middle class, now impoverished, could unite their votes with the traditional members of the working class, and together they could reach more than the majority of votes in the parliaments. Today the permanent full-time employment rate is lower than at any time in the last 20 years (OECD stat), the real income of lower-class jobs is below 1990s levels. Meanwhile, productivity, GDP, corporate investment, and after-tax profits are also at record highs (OECD stat). The probability that new social disorders will arise and the consequent danger for liberal societies are the main concern for many Western countries. If the aforementioned trends are not reversed, greater political and social turbulence than ever before will have to be expected in the coming years. At the moment, working conditions and the situation of job distribution are experiencing completely unprecedented upheaval.

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2.6 Appendix

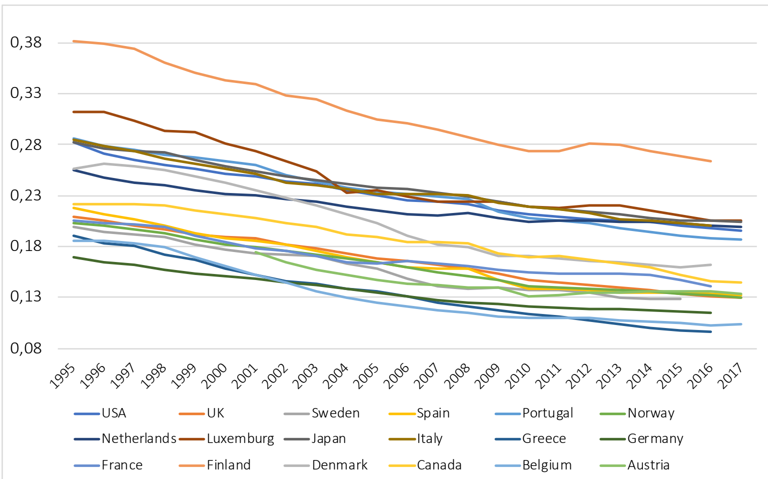


Figure 2.5: Routinary non skilled economic activities, 1995-2017, ELFS Rielaborations.

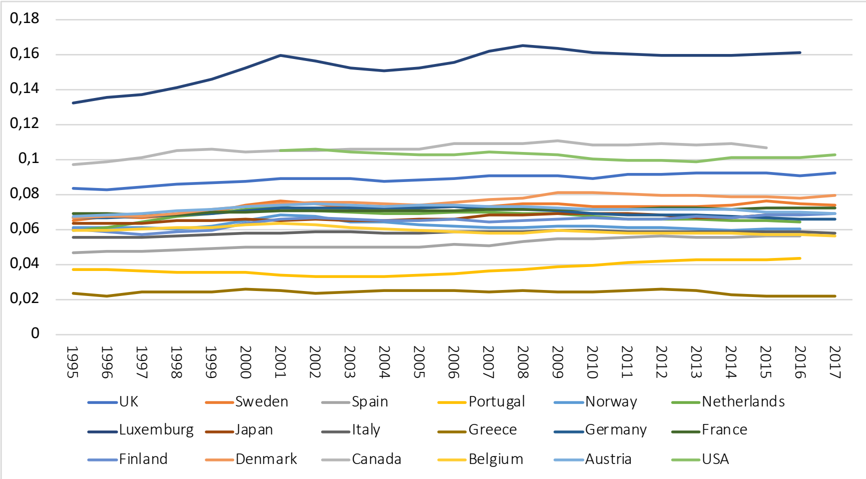


Figure 2.6: Routinary skilled economic activities, 1995-2017, ELFS Rielaborations.

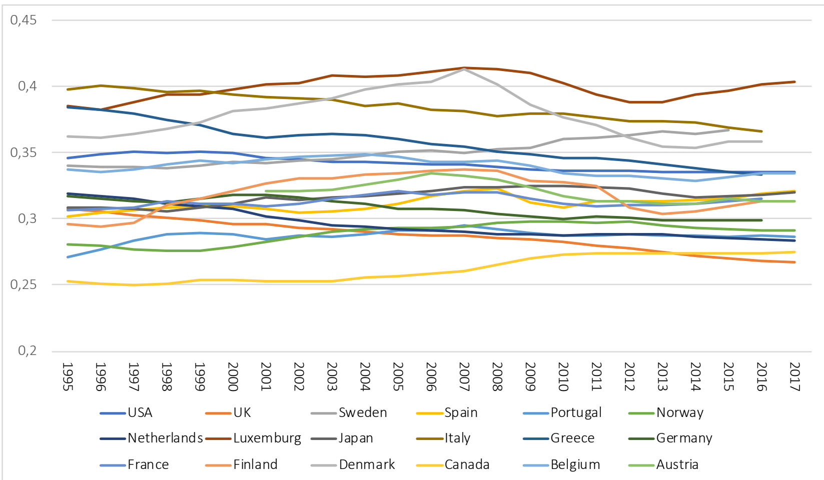


Figure 2.7: Non Routinary non skilled economic activities, 1995-2017, ELFS Rielaborations.

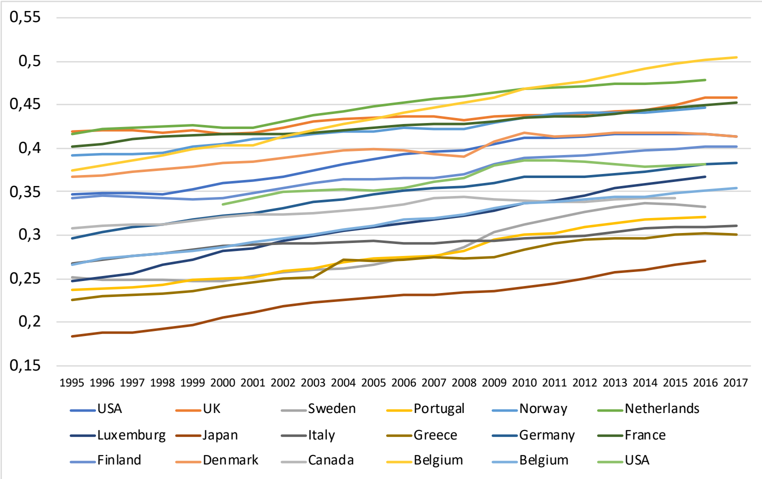


Figure 2.8: Non Routinary skilled economic activities, 1995-2017, ELFS Rielaborations.

Chapter 3

Inflation as Income Distribution

3.1 Introduction

The literature explains inflation by following mainly two opposite approaches: monetarism according to Friedman (1970), Lucas (1972) and more recently to Evans (2017) and bargaining based on the writings of Sraffa (1960), Minsky (1986), Krishna (1991) and more recently Pacitti (2015). The first approach emphasizes the importance of the Central Bank and the decisions about monetary emission it can dictate, or the effects on monetary emissions indirectly generated by the banking system as a whole, as influenced by the interest rate fixed by Central Bank itself. The second approach, neo-corporatism, on the contrary, is focused on the role of workers' collective bargaining power; their demand for higher wages without a correspondent productivity increase, would force employers to raise prices in order to reach their target profit rates.

According to a large body of literature on neo-corporatism, when centrally organized wage bargaining institutions, capable of enforcing negotiated wage restraint, exist in a country, government policies of inflation containment are more effective since a huge number of workers' wages can be decided by a single institution. The risk persists that these workers' institutions may unceasingly continue to demand higher wages. In this case it becomes harder to break the trend of increasing wages and thus, in turn, inflation. From the monetarist perspective, the price-wage behavior of private economic agents is determined by the agents' expectations about monetary policies. Inflation would indeed be a function of the policies followed by the monetary authority from such a perspective. Havrilesky and Granato (1993), moreover, have argued that independent and inflation-adverse central banks are far more important than corporatist hypotheses. In response to these findings, Al-Marhubi and Willett (1995) have criticized the statistical test used by Havrileski and Granato, following Calmfors and Driffill's (1988) approach, stating that instead of using a linear formulation of the relationship between centralization and inflation, a curvilinear model (where intermediately centralized systems are the most inflationary) would have been more suitable to testing the neo-corporatist thesis. Other important neo-corporatist contributions may be found in Iversen (1999), who has shown that centralization of wage bargaining can significantly influence the optimal policy choices of a central bank. Daniels et. al. (2006) concludes that, *ceteris paribus*, a greater central bank conservatism in a nation with a larger extent of centralized wage bargaining will tend to reduce inflation less than a country with a relatively larger share of companies that experience decentralized wage setting. Therefore, they state that coordinating wage setters incentivize restraint in nominal wage growth since enterprises know that higher wages contribute to inflation. Confirmation of this comes from Giordano (2001) who found that countries where large unions figure prominently in the wage formation process are not typically affected by particularly high rates of inflation. Milner (2018) also states that companies, especially in the 70s, claimed to organized workers collectively in order to sign multiyear agreements, thus managing to control prices.

To better inquire the monetarist and neo-corporatist theses, we need to look at inflation over a time sufficiently large where periods of high and persistent inflation alternate to period of stable and low inflation. In this study we focuses on the decades 1970-2000. The causes of the "great" inflation of the 1970s and the consequent sudden period of small inflation remain a subject of debate in the literature. The strong increase in the inflation rate in the '70s could be explained, according to a monetarist approach, by the expansionist monetary policy adopted with the purpose of minimizing the costs borne to finance the growing public debt in a lot of Western countries (Bertoccio, 2002). The impact of monetary financing of a fiscal deficit on the inflation rate was firstly formalized by Sargent and Wallace (1981) and then extended by the study of Leeper (1991) who identifies three regimes that correspond to Active Monetary/Passive Fiscal (AM/PF), Passive Monetary/Active Fiscal (PM/AF), and Active Monetary/Active Fiscal (AM/AF). According to the monetarist perspective, high and persistent inflation occurs when the monetary policy is more accommodating than fiscal policy (PM/AF). Therefore, the high inflation of the '70s is explained by the excessive creation of money due to "fiscal dominance". On the other hand the neo-corporatist approach underline the role of bargaining among social groups. Olson (1982) argued that in market economies social groups with common interests engage a rent-seeking behavior trying to extract gains for their members from generality. According to this perspective, the intensity of the distributive struggle is an important determinant in explaining cross-national differences in unemployment and inflation during the economic crisis of the 1970s. Paloheimo (1984), analyzing our same period 1970-2000, found that both the rates of unemployment and inflation were moderate in countries with a low level of distributive struggle, while countries with a high level faced severe problems of unemployment and inflation. Moreover, the stagflation of the 1970s, i.e. the combination of rising inflation and rising unemployment, had narrowed the space for free collective bargaining and compelled many governments to intervene in wage setting. As noted by Visser (2007) both direct and indirect state intervention in wage negotiations, reached a peak in the late 1970s with relevant consequences in terms of inflation.

In this paper, we employ production networks theory to estimate the impact of fiscal/monetary policy, unions-firms bargaining and technological evolution, on price dynamics. Two recent events have brought to the forefront the importance of interconnections between firms and sectors in aggregate economic performance. Consider firstly the 2011 earthquake in Japan and secondly, on a grander scale, the financial crisis in 2007-2009 recession. These events have brought with them a renewed emphasis on the complex web of linkages that constitute the backbone of the economies. Terms like "too interconnected to fail" or "systemically important firms" have become commonplace in public discourse (Carvalho, 2014). Therefore, the procedure we suggest is an extension of the work of Sraffa (1961). We start from the Input-Output (I-O) model used by Leontief (1986); secondly, we split the added-value of each sector into its profits and wages, according to Sraffian approach. Finally, we employ the price model in physical data showing an algebraical method which let us find the price variation between two consecutive years without knowing the matrix of intermediate inputs expressed in physical terms.

When we want to study prices through the production networks theory, the general problem is that I-O tables do not distinguish between prices and quantities: they only show their product. As noticed by De Mesnard (2006), physical matrices do not exist in the operational world. Prices and physical tables are a chimera in the operational world. In these cases the literature suggests the *price model in nominal terms* (Blair and Miller, 2009), however, it assumes that the prices ratios remain constant when we apply distributive shocks on the added value vector $\mathbf{v}$.

The first innovation of our model is that the prices ratios are free to vary as if we had a physical matrix even if we cannot observe it. In this way the ratios between prices are free to move as the conditions imposed on the system ($\mathbf{v}$) vary, and therefore the forecasts are more correct. Secondly, thanks to our model, we are able to explain variations on prices distinguishing the effects of profits, wages and the technology level of the economy. Thirdly, in this study we apply this method to a long I-O time series of observational data (1970-2000), that is rare to find in the literature. We found, for the case of Italy, that its well-known period of "great inflation" can be described primarily by a bargaining factor (among companies, trade-unions and the government) and only secondly by technical progress. Our model, indeed, lets us distinguish the weight that the technological factor had over this period (mainly the oil shock) from the weight of trade union and political bargaining, finding interesting outcomes. As fourth point, in the Sraffian and post-Ricardian Literature, usually, government has no role on inflation, since the final outcome on prices only depends on the level of profit-wage set. In this paper, on the opposite, we shall show that fiscal monetary policy may affect prices through the channel of profits and wages, i.e. the well-known phenomenon of political capture.

Chapter 2 develops the new model to study inflation; Chapter 3 applies the model to the Italian case and distinguishes the inflationary effects induced by technology from the purely distributive ones. In Chapter 4 we derive from the theoretical model, six different price-trend scenarios *ceteris paribus*, which can be blended to describe the complex phenomenon of inflation both in terms of technology, fiscal policy and unions-firms bargaining. Finally, Chapter 5 summarizes the conclusions of the paper.

3.2 The Theoretical Model

Classical multi-function econometric models, such as VAR, SVAR or VEC, are usually employed to investigate the role of macroeconomic variables, such as interest rate, exchange rate, monetary supply, etc., on prices, often linking shocks on raw material prices as oil, to macroeconomic recessions (Cunado and de Gracia, 2003, Herrera and Pesavento, 2009, Lardic and Mignon, 2006, Lee and Ni, 2002, Tang et al., 2010). However, the econometric models used to analyze inflation have two drawbacks: they ignore sector heterogeneity, and they are based on unverifiable assumptions on the growth process (Abildgren, 2007; Wu and Zhang, 2013; Walheer, 2016). There is no guideline, indeed, to choose the proper assumptions on the price equation of a country. Assumptions on technology, market structure, technological change, and other aspects of prices are typically unverifiable. Furthermore, price analysis based on specific assumptions of the econometric models may lead to biased results.

The advantage of an I-O analysis can be observed at least from the following two perspectives. First, a distributive, fiscal or technological shock is gradually realized through the inter-connection between industries and the I-O tables give a comprehensive structural description of the entire economy (Carter, 1974, Leontief, 1986). Therefore, by using the information provided by an I-O table, an I-O model enables us to dissect the complex interdependencies of industries within an economy, and measure the complete inflationary effect of trade-union bargaining, technology progress and fiscal policy. Secondly, while other empirical methods ignore the indirect or ripple effects, an I-O analysis allows capturing inter-industry linkages and measures both the direct and indirect effects of income, fiscal and technological shocks (Kerschner and Hubacek, 2009, Liu and Ren, 2006). Since I-O models are based on periodical input-output table or social accounting matrix instead of time series data, these studies provide more comprehensive policy evaluations than econometric studies, which are highly dependent on stylized facts (Libo et al 2013). I-O models and computable general equilibrium models are already utilized to shed more light on the agents behavior change and to simulate alternative outcomes under various shocks (Berument and Tasci, 2002, Guivarch et al., 2009, Kerschner and Hubacek, 2009, Leduc and Sill, 2004).

These two drawbacks in econometric models and these two advantages of I-O models form the motivation to propose a new I-O model taking sector heterogeneity into account, without resorting to any unverifiable assumptions on any aspects of the growth process. In the I-O approach fiscal policy, coefficients of production, profits and wage costs are exogenous since the general-equilibrium relationships that interrelate them cannot be described by this kind of models. However, we do not intend to analyze how bargaining process, political capture and technology progress occur and affect each others. We are focused on a step forward: given the workers organization (in large collective institutions or not), given the nominal wage level reached by trade-unions contention with companies, given the technology employed in response to bargaining and developement, which is the final effect on inflation?

This model only explains prices by the level of real income distribution and by the technology used. The results can only be interpreted in this way: for example, if the observed data show that prices have risen, the model allows us to calculate the weight by which general wage bargaining, profits and the technology employed have affected them. However, it is not the intention of this article to study the social process underlying the stipulation of wage contracts, political capture and the change of production techniques. Certainly, these variables are interdependent, and the model does not intend to make claims about how they affect each other. We are only interested in investigating how each of these exogenous variables, individually, has impacted on prices.

In the I-O literature there are two models to evaluate price effects of income distributions among sectors: the price model based on monetary data and the price model based on physical data. The price model based on monetary data starts with a nominal I-O table where physical quantities and prices are not known separately. This approach sets prices equal to total cost of production (intermediate inputs plus the added value) so that each price found is equal to 1. This illustrates the unique measurement units in the base year, i.e. the amounts that can be purchased for 1$.

$$\tilde{\mathbf{p}} = (\mathbf{I} - \mathbf{A}^T)^{-1}\mathbf{v} \tag{3.1}$$

Where $\mathbf{A}$ is the square matrix of intermediate inputs expressed in nominal terms ($a_{i,j} = \frac{p_i s_{i,j}}{p_j q_j}$), $\mathbf{v}$ is a vector of added values divided by gross products expressed in nominal terms ($\mathbf{x}$), so that: $\mathbf{v} = [v_1/x_1, ..., v_n/x_n]$. In the base year $\tilde{\mathbf{p}}$ is a unitary vector; variations in $\mathbf{v}$ causes variations in $\tilde{\mathbf{p}}$ that coincide with percentage variations in (unknown) prices.

On the opposite, the price model based on physical data finds the exact value of prices starting from an I-O table expressed in physical data.

$$\mathbf{p} = (\mathbf{I} - \mathbf{C}^T)^{-1}\boldsymbol{v} \tag{3.2}$$

Where $\mathbf{C}$ is the square matrix of intermediate inputs expressed in physical terms ($c_{i,j} = \frac{s_{i,j}}{q_j}$), and $\boldsymbol{v}$ is the vector of added value divided by gross products expressed in physical terms ($\mathbf{q}$). Either the value-based coefficients, $\mathbf{A}$, or the physical coefficients, $\mathbf{C}$, are assumed fixed in applications of the input-output model. However, assuming fixed $c_{i,j}$ (i.e, a fixed "engineering" production function) has been seen by many as less restrictive than fixed $a_{i,j}$ (a fixed "economic" production function), because in the latter case both a physical coefficient, $c_{i,j}$, and a price ratio, p_i/p_j, are assumed unchanging (Blair and Miller, 2009). For this reason we prefer to adopt the price model based on physical data.

There are two main innovation in our model: we split the added value vector $\boldsymbol{v}$ between profits and wages; we use a I-O physical data approach without knowing the matrix **C**. Following the Sraffian approach, if we separate profits from wages, we would need of an adding condition for wage determination. Let us consider the following set of equations which represents a generic economic system:

$$\begin{array}{ccccccc}
x'_1P_x \oplus & y'_1P_y \oplus & ... & \oplus\, z'_1P_z & = & XP_x \\
+ & + & + & + & & \\
x'_2P_x \oplus & y'_2P_y \oplus & ... & \oplus\, z'_2P_z & = & YP_y \\
+ & + & + & + & & \\
... & ... & ... & ... & = & ... \\
+ & + & + & + & & \\
x'_nP_x \oplus & y'_nP_y \oplus & ... & \oplus\, z'_nP_z & = & ZP_z \\
= & = & = & = & & \\
\tilde{x}P_x & \tilde{y}P_y & ... & \tilde{z}P_z & &
\end{array}$$

Where $X, Y, ..., Z$ are the total supply of each sector's i product expressed in physical terms; $(P_x, P_y, ..., P_z)$ are the prices referred to the n sectors of the economy; $(x'_1, ..., x'_n, ..., z'_1, ..., z'_n)$ are the intermediate (in physical terms) consumptions necessary to realize the sectors' products in their gross quantities[1]. The system is in equilibrium if it holds: $X > \tilde{x}$, $Y > \tilde{y}$, ..., $Z > \tilde{z}$. The difference between the vertical sum of gross production $(XP_x, ..., ZP_z)$ and the horizontal sum of intermediate inputs consumed $(\tilde{x}P_x, ..., \tilde{z}P_z)$, determine the GDP[2].
The same system may be expressed showing income distribution between wages and profits.

$$(x'_1P_x + y'_1P_y + ... + z'_1P_z)(1 + r_1) + WL_1 = XP_x$$

$$(x'_2P_x + y'_2P_y + ... + z'_2P_z)(1 + r_2) + WL_2 = YP_y$$

$$. . . . .$$

$$(x'_nP_x + y'_nP_y + ... + z'_nP_z)(1 + r_n) + WL_n = ZP_z$$

Where $r_1, ..., r_n$ are the different rate of profits for each production; W is the total payroll paid to all the workers of economy; $L_1, ..., L_n$ are the shares of total payroll in the economy (W), paid by each sector and they add up to 1[3].

[1] The sums per line are not algebraic, but economic, indeed they are indicated by $\oplus$: this symbol states that, for example in the first line, to produce X quantity of the first sector product, it is necessary to consume x'_1 quantity of the same product, y'_1 quantity of y, and so on until the z'_1 quantity of z. On the contrary, the sums per column are algebraic since they represent the amount of a given sector's product demanded by the other ones as an input.

[2] We assume, as in the I-O tables used in this paper, that all sector's products are meanwhile used as final and intermediate goods. Therefore the difference between the vertical sum of gross production and the horizontal sum of products consumed during the production process, correspond to value added + taxes less subsidies on products (for intermediate and final uses), i.e. GDP according to the System of National Accounts.

[3] It holds: $\sum_{i=1}^{n} L_iW = W$, i.e. $\sum_{i=1}^{n} L_i = 1$.

This system may be written in matrix form as the following product:

$$\begin{bmatrix} X - x'_1(1+r_1) & -y'_1(1+r_1) & \dots & -z'_1(1+r_1) & -L_1 \\ -x'_2(1+r_2) & Y - y'_2(1+r_2) & \dots & -z'_2(1+r_2) & -L_2 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ -x'_n(1+r_n) & -y'_n(1+r_n) & \dots & Z - z'_n(1+r_n) & -L_n \end{bmatrix} \begin{bmatrix} P_x \\ P_y \\ \vdots \\ P_z \\ W \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

In a more compact form we have:

$$\hat{\mathbf{q}}(\mathbf{I} - (\mathbf{I} + \hat{\mathbf{r}})\mathbf{C}^T - \ell) \begin{bmatrix} \mathbf{p} \\ W \end{bmatrix} = \vec{0} \tag{3.3}$$

Where $\hat{\mathbf{q}}$ is the diagonal matrix whose elements in the main diagonal are the gross products expressed in physical terms; $\hat{\mathbf{r}}$ is the diagonal matrix whose elements in the main diagonal are the profit rates sector by sector; ℓ is the vector of labor inputs and $\mathbf{p}$ is the price vector. The system has n equations but there are $n+1$ unknown variables (n prices and W). In order to find the solution vector $\mathbf{p}$, we should determine another condition which contains at least a quantity of one good of the system. We should choose a linear combination which fits very well with our aim of inflation determination. For now, we shall define this generic equation as: $H(q_x, q_y, ..., q_z, q_L) = G$, where $q_x, ..., q_z$ are quantities of each sector's product and q_L is a quantity of Labour (they could be all zero except for at least one). The complete system of equations is:

$$\begin{bmatrix} X - x'_1(1+r_1) & -y'_1(1+r_1) & \dots & -z'_1(1+r_1) & -L_1 \\ -x'_2(1+r_2) & Y - y'_2(1+r_2) & \dots & -z'_2(1+r_2) & -L_2 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ -x'_n(1+r_n) & -y'_n(1+r_n) & \dots & Z - z'_n(1+r_n) & -L_n \\ q_x & q_y & \vdots & q_z & q_L \end{bmatrix} \begin{bmatrix} P_x \\ P_y \\ \vdots \\ P_z \\ W \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \\ G \end{bmatrix}$$

In a more compact form:

$$\begin{bmatrix} \hat{\mathbf{q}}(\mathbf{I} - (\mathbf{I} + \hat{\mathbf{r}})\mathbf{C}^T - \boldsymbol{l}) & \boldsymbol{l} \\ q_x ... q_z & q_L \end{bmatrix} \begin{bmatrix} \mathbf{p} \\ W \end{bmatrix} = \mathbf{g}$$

Where $\mathbf{g}$ is the vector of known terms. Now, we have a square matrix $[(n+1)\times(n+1)]$ and two vectors $\mathbf{p}$ e $\mathbf{g}$ $[(n+1)\times(1)]$, and prices could be determined as following:

$$\begin{bmatrix} \mathbf{p} \\ W \end{bmatrix} = \begin{bmatrix} \hat{\mathbf{q}}(\mathbf{I} - (\mathbf{I} + \hat{\mathbf{r}})\mathbf{C}^T - \boldsymbol{l}) & \boldsymbol{l} \\ q_x ... q_z & q_L \end{bmatrix}^{-1} \mathbf{g} \tag{3.4}$$

The solution vector identifies both all prices in an economic system and the level of total payroll, once fixed the rate of profits. The property of this system is that it finds the equilibrium prices for each industry, depending on the level of income distribution, that is just what our paper would test.

In practice, statistics offices evaluate nominal Input-Output tables for n sectors and the total amount of wages, so that, indirectly, the rates of profit may be calculated for each sector. However, we cannot observe the matrix **C** because databases provide only nominal I-O tables. Furthermore, it is impossible to find the prices of sectors' products with equation (4). Even though it is impossible to accomplish anything by using a single matrix, with a time series of nominal I-O tables at constant prices, we have developed a way to evaluate the variation in prices with an approach similar to (4).

The main problem to employ our approach is to separate prices from quantities. If we knew a time series of physical I-O tables, we could test if prices depend on income distribution among firms and workers, within each sector. To manage this issue, we firstly adopt a time series of nominal I-O tables in constant prices, so that we are certain that variations in intermediate inputs over time are only due to changes in the technology of the system. Afterwords, we build up the classical intermediate coefficients matrix **A** by dividing each column of intermediate inputs in nominal I-O tables $(x'_i, y'_i, ..., z'_i)$ by the nominal gross value of each sector's product $(P_1X, P_2Y, ..., P_nZ)$. These nominal I-O tables are in constant prices (we indicate it by $\mathbf{A}_{\overline{p}}$), therefore, matrix $\mathbf{A}_{\overline{p}}$ coefficients change over time only because of $(x'_i, y'_i, ..., z'_i)$.

$$\mathbf{A}_{\overline{p}} = \begin{bmatrix} x_1 & \frac{P_1}{P_2}x_2 & \cdots & \frac{P_1}{P_n}x_n \\ \frac{P_2}{P_1}y_1 & y_2 & \cdots & \frac{P_2}{P_n}y_n \\ \vdots & \vdots & \vdots & \vdots \\ \frac{P_n}{P_1}z_1 & \frac{P_n}{P_2}z_2 & \cdots & z_n \end{bmatrix}$$

Where, for example, the elements of first column x_1, x_2,...,x_n are equal to $\frac{x'_1}{X}, \frac{y'_1}{X}, ..., \frac{z'_1}{X}$.

We do not know the real matrix of intermediate coefficients as we can only configure a $\mathbf{A}_{\overline{p}}$ matrix, whose elements consist in the inseparable product of the intermediate coefficients $(x_1, ..., x_n; ...; z_1, ..., z_n)$ and the prices ratio $(\frac{P_1}{P_2}, ..., \frac{P_1}{P_n}; ...; \frac{P_n}{P_1}, ..., \frac{P_n}{P_{n-1}})$. We image to gather separately all the prices ratio in a new matrix that we call *Shadow Matrix Prices Ratio*. If we could separate the real intermediate coefficients in matrix $\mathbf{A}_{\overline{p}}$ from the Shadow Matrix Prices Ratio, getting the canonical matrix **C** in physical data, we could use **C** to find physical intermediate quantities. By **C**, indeed, it would be possible to set-up a homogeneous linear system of equations by which (knowing only the gross quantity of one of the n sector's product of the system) getting quantities $X, Y, ..., Z$; at that point we could apply (4) and find prices. Unfortunately, there does not seem to be any way to carry out the Shadow Matrix Prices Ratio from $\mathbf{A}_{\overline{p}}$ matrix, nevertheless, as we are going to show, if our goal is to know the percentage variations in prices, we do not need of **C**; we can indeed substitute **C** with $\mathbf{A}_{\overline{p}}$, the nominal I-O table at constant prices.[4].

[4] The problem would occur if we wanted to know the absolute value of prices industry by industry, but this is not the goal of our paper.

Now, we show how to find the correct prices variations without knowing the real intermediate coefficients matrix. Let us imagine that $\mathbf{A}_{\overline{p}}$ matrix represents the real intermediate coefficients matrix of another economic system. In this case, for finding prices, we should start by determining the gross products $X, Y, ..., Z$. We need to set-up a linear system of equations which includes $\mathbf{A}_{\overline{p}}$. The horizontal sum of $\mathbf{A}_{\overline{p}}$ matrix rows are the total intermediate consumption of sector's i product (let us call them C); the ratio $\phi = \frac{D-C}{D}$, where D is the generic gross product, is expressed by quantities of the same good, i.e. it is independent from the price of D. By construction, it holds:

$$(\mathbf{I} - \mathbf{A}_{\overline{p}} - \hat{\phi})\mathbf{q} = \vec{\mathbf{0}} \tag{3.5}$$

Where I is the identity matrix; $\hat{\phi}$ is the diagonal matrix whose diagonal elements are the vector ϕ; q is the vector of unknown gross products and $\vec{0}$ is the null vector: this is a homogeneous linear system of equations, which admits non-trivial solutions (different from $X_i = 0$ for any i) since its determinant is always 0; moreover, the solution vector is never negative since 1 is always the maximum eigenvalue of B^{T}. Therefore, this system finds the gross products that guarantee the surplus value objective is exactly ϕ for any i. By using this system to solve the problem, we find infinite solutions which depend on the value assumed by the sector's product chosen to represent a measurement value $\tilde{Z}$ (the "numeraire"). We assume to chose the sector's product z as the numeraire, therefore we get this solution vector:

$$\tilde{\mathbf{q}} = \begin{bmatrix} (\mathbf{I}_{(-1)} - \mathbf{A}_{\overline{p}(-1)} - \hat{\phi}_{(-1)})^{-1} \begin{bmatrix} \frac{P_1}{P_n} x_n \tilde{Z} \\ \frac{P_2}{P_n} y_n \tilde{Z} \\ \vdots \\ \frac{P_{n-1}}{P_n} q_n \tilde{Z} \end{bmatrix} \\ \tilde{Z} \end{bmatrix} \tag{3.6}$$

Where $\mathbf{I}_{(-1)}$, $\mathbf{A}_{\overline{p}(-1)}$ and $\hat{\phi}_{(-1)}$ are the matrixes $\mathbf{I}$, $\mathbf{A}_{\overline{p}}$ and $\hat{\phi}$ reduced of their last row and column (since in this case we chose as numeraire the last sector's product of the system). The vector $\tilde{\mathbf{q}}$ coincides with the real gross output vector in physical terms only if we choose the real value for the numeraire $\tilde{Z}$. Obviously, we do not know it, however, we are gong to show that it is not necessary for our analysis; we can freely assign a random value to the numeraire. Now, if we plug (6), the gross product expressed in physical terms, in equation (4), we would get a price vector.

$$\begin{bmatrix} \tilde{\mathbf{p}} \\ W \end{bmatrix} = \begin{bmatrix} \begin{bmatrix} (\mathbf{I}_{(-1)} - \mathbf{A}_{\overline{p}(-1)} - \hat{\phi})^{-1} \begin{bmatrix} \frac{P_1}{P_n} x_n \tilde{Z} \\ \frac{P_2}{P_n} y_n \tilde{Z} \\ \vdots \\ \frac{P_{n-1}}{P_n} q_n \tilde{Z} \end{bmatrix} \\ \tilde{Z} \end{bmatrix} (\mathbf{I} - (\mathbf{I} + \hat{\mathbf{r}})\mathbf{A}^T_{\overline{p}(-1)} - \boldsymbol{l}) & \boldsymbol{l} \\ q_x \cdots q_z & q_L \end{bmatrix}^{-1} \mathbf{g} \tag{3.7}$$

With the quantities thus determined, once the last generic condition $H(q_x, q_y, ...,$

$q_z, q_L) = G$ is chosen, system (4) is defined and it is possible to evaluate prices. Naturally, the prices so found refers to an economic system whose *real* intermediate coefficient matrix is the $\mathbf{A}_{\overline{p}}$ matrix. This is not valid for our initial economic system, where matrix $\mathbf{A}_{\overline{p}}$ contains the Shadow Matrix Prices Ratio. However, we are going to show that the *variation* of prices observed is the same found in (7) through the gross products get by (6), even using the $\mathbf{A}_{\overline{p}}$ matrix with price ratios.

In order to demonstrate this, we shall consider a hypothetical economic system which contains only two sectors, for simplicity's sake (though easily applied on a general scale). We shall also assume the generic condition $H(q_x, q_y, ..., q_z, q_L) = G$ as:

$$P_1 X\theta + P_2 Y\gamma = G$$

This is a general condition, which states that a generic percentage θ of gross quantity X and a generic percentage γ of gross quantity Y is equal to a generic value G. The system in matrix form is:

$$\begin{bmatrix} X - x_1'(1+r_1) & -y_1'(1+r_1) & -L_1 \\ -x_2'(1+r_2) & Y - y_2'(1+r_2) & -L_2 \\ X\theta & Y\gamma & 0 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ GD \end{bmatrix}$$

If physical quantities are known $(X, Y, x_1, x_2, y_1, y_2)$ we can easily solve the system by (4). Prices are:

$$p(1) = \frac{G(L_1(Y - y_2' - r_2 y_2') + L_2(y_1' + r_1 y_1'))}{L_2(XY\gamma - Yx_1'\gamma + X\theta y_1' - Y\gamma r_1 x_1' + Xr_1 y_1'\theta) + L_1(XY\theta + Y\gamma x_1' - X\theta y_2' + Y\gamma r_2 x_2' - Xr_2 y_2'\theta)}$$

$$p(2) = \frac{G(L_1(x_2' + r_2 x_2') + L_2(X - x_1' - r_1 x_1'))}{L_2(XY\gamma - Yx_1'\gamma + X\theta y_1' - Y\gamma r_1 x_1' + Xr_1 y_1'\theta) + L_1(XY\theta + Y\gamma x_1' - X\theta y_2' + Y\gamma r_2 x_2' - Xr_2 y_2'\theta)}$$

However, as we noticed, prices and quantities are not separable in classical nominal I-O tables. In this path, we firstly build up the $\mathbf{A}_{\overline{p}}$ matrix and secondly, accordingly to (6), we find the quantities $\tilde{X}, \tilde{Y}, ..., \tilde{Z}$ by fixing the numeraire at a randomly value k. In this example the system is:

$$\begin{bmatrix} 1 - x_1 - \phi_1 & -\frac{P_1}{P_2} x_2 \\ -\frac{P_2}{P_1} y_1 & 1 - y_2 - \phi_2 \end{bmatrix} \begin{bmatrix} X \\ Y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

We fix $Y = k$ and we get $\tilde{X}$ recalling that $\phi_1 = \frac{X - x_1' - x_2'}{X}$ and that $Xx_1 = x_1'$. Solving by the first equation we get:

$$X - Xx_1 - X\phi_1 - \frac{P_1}{P_2} x_2 K = 0$$
$$X - Xx_1 - X + x_1' + x_2' - \frac{P_1}{P_2} x_2 k = 0$$
$$X = \frac{P_1 x_2'}{P_2 Y} \frac{X}{x_2'} k$$

Therefore, the gross quantities are the vector $\mathbf{q} = \left[\frac{P_1 x_2'}{P_2 Y} \frac{X}{x_2'} k; k \right]$. We call $\frac{x_2'}{Y} \frac{X}{x_2'} = \overline{x}_2$. At this point, by multiplying the $\mathbf{A}_{\overline{p}}$ matrix by $\mathbf{q}$ vector of gross quantities we get

$\tilde{x}_1, \tilde{x}_2, \tilde{y}_1, \tilde{y}_2$. Now we can build up the system (6), and finding the price vector:

$$\begin{bmatrix} k\overline{x}_2 \frac{P_1}{P_2}(1-x_1)(1+r_1) & -k\overline{x}_2 y_1(1+r_1) & -L_1 \\ \frac{P_1}{P_2} x_2 k(1+r_2) & k(1-y_2)(1+r_2) & -L_2 \\ \frac{P_1}{P_2}\overline{x}_2 k\theta & k\gamma & 0 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ G \end{bmatrix}$$

The prices are:

$$\tilde{p}(1) = \frac{G[L_1(1+r_2+y_2+r_2y_2)+L_2(\overline{x}_2y_1+\overline{x}_2r_1y_1)]}{k\frac{P_1}{P_2}[L_2(\overline{x}_2\gamma+\overline{x}_2^2y_1\theta+\overline{x}_2r_1\gamma-\overline{x}_2x_1\gamma-\overline{x}_2r_1x_1\gamma+r_1y_1\overline{x}_2^2\theta)+L_1(\overline{x}_2\theta-x_2\gamma+r_2\overline{x}_2\theta-r_2x_2\gamma+y_2\overline{x}_2\theta+r_2y_2\overline{x}_2\theta)]}$$

$$\tilde{p}(2) = \frac{G[L_2(\overline{x}_2+\overline{x}_2r_1-\overline{x}_2x_1-\overline{x}_2r_1x_1)-L_1(x_2+r_2x_2)]}{k\frac{P_1}{P_2}[L_2(\overline{x}_2\gamma+\overline{x}_2^2y_1\theta+\overline{x}_2r_1\gamma-\overline{x}_2x_1\gamma-\overline{x}_2r_1x_1\gamma+r_1y_1\overline{x}_2^2\theta)+L_1(\overline{x}_2\theta-x_2\gamma+r_2\overline{x}_2\theta-r_2x_2\gamma+y_2\overline{x}_2\theta+r_2y_2\overline{x}_2\theta)]}$$

Recall that we know the value of $\overline{x}_2$ but that we cannot decompose it since we do not know its physical components separately. However, if we substitute $\overline{x}_2$ with its components $(\frac{x'_2}{Y}\frac{X}{x'_2})$ in $\tilde{p}(1)$ and $\tilde{p}(2)$, we discover that these equations are very similar to $p(1)$ and $p(2)$.

$$\tilde{p}(1) = \frac{GY(L_1(Y-y'_2-r_2y'_2)+L_2(y'_1+r_1y'_1)}{k\frac{P_1}{P_2}(L_2(XY\gamma-Yx'_1\gamma+X\theta y'_1-Y\gamma r_1x'_1+Xr_1y'_1\theta)+L_1(XY\theta+Y\gamma x'_1-X\theta y'_2+Y\gamma r_2x'_2-Xr_2y'_2\theta))}$$

$$\tilde{p}(2) = \frac{GY(L_1(x'_2+r_2x'_2)+L_2(X-x'_1-r_1x'_1)}{k(L_2(XY\gamma-Yx'_1\gamma+X\theta y'_1-Y\gamma r_1x'_1+Xr_1y'_1\theta)+L_1(XY\theta+Y\gamma x'_1-X\theta y'_2+Y\gamma r_2x'_2-Xr_2y'_2\theta))}$$

Now we shall compare $p(1), p(2), \tilde{p}(1), \tilde{p}(2)$ through their ratios.

$$\begin{aligned} \frac{p(1)}{\tilde{p}(1)} &= \frac{P_1}{P_2}\frac{k}{Y} \\ \frac{p(2)}{\tilde{p}(2)} &= \frac{k}{Y} \end{aligned} \tag{3.8}$$

From these equations, it is possible to state that they differ only for variables k, Y, P_1, P_2, but these variables do not affect price variations over time due to income distribution (r_1, r_2, L_1, L_2) and technology (x_1, x_2, y_1, y_2) changes; this finding also holds in the case with n sectors[5]. k, indeed, is randomly fixed at an initial value and after the first period it varies according to the real percentage variations of Y over time[6]; Y varies according to the evolution of the system over time, however, as just observed, k moves in the same percentage of Y therefore, their ratio is always constant, i.e. they together do not affect price percentage variations; P_1, P_2 are fixed since we consider I-O tables in constant prices. Of course, the absolute value of prices is different: $p(1) \neq \tilde{p}(1)$ and $p(2) \neq \tilde{p}(2)$). However, their equations are identical except for factors that remain constant ($\frac{P_1}{P_2}\frac{k}{Y}$ and $\frac{k}{Y}$), thus percentage variations in

[5]In case of n sectors the $\mathbf{q}$ of solutions for real gross productions is:

$$q^T = [\tfrac{P_1}{P_n}\overline{x}_1k; \tfrac{P_2}{P_n}\overline{x}_2k; ....; \tfrac{P_{n-1}}{P_n}\overline{x}_{n-1}k; k]$$

Where, as before, k is the randomly chosen real gross quantity of the numeraire and $\overline{x}_1, \overline{x}_2, ..., \overline{x}_{n-1}$ are respectively $\frac{x'_n}{Z}\frac{X}{x'_2}, \frac{x'_n}{Z}\frac{Y}{y'_2}, ..., \frac{x'_n}{Z}\frac{V}{x'_{n-1}}$.

[6]Even if we cannot know Y because I-O tables provide only P_2Y, Through I-O tables in constant prices we can get the real percentage variation of Y over time since P_2 is fixed.

prices due to $r_1, r_2, L_1, L_2, x_1, x_2, y_1, y_2$ are identical[7]. Moreover, this study indicates price percentage variations do not depend on θ and γ, and this means that we can constrain the system with whatever relationship exists between X and Y. Through this demonstration we identified a procedure which allows the researcher to choose the final relationship of the system completely freely, according to his/her needs.

Finally, we need to specify the generic condition $H(q_x, q_y, ..., q_z, q_L) = G$, that is the last equation of the system, necessary to solve it. Recall that in this paper we investigate the relationship between income distribution and prices. Therefore, the generic condition should be an equation which fixes exogenously the total payroll of the economy. In this way the system lets us know the economy's price level in correspondence to wages (or profits) variations, *ceteris paribus*. Furthermore, the last condition of the system should define the total wage W with an equation expressed in gross productions $X, Y, ..., Z$.
The total wage may be determined by the difference between the total revenue coming from selling the gross production of each sector (nominal gross value) and the total cost of production plus their profit rates.

$$X - \sum_{i=1}^{n} x'_i(1 + r_i) + Y - \sum_{i=1}^{n} y'_i(1 + r_i) + ... + Z - \sum_{i=1}^{n} z'_i(1 + r_i) = W \qquad (3.9)$$

In matricidal form the equation can be inserted as following:

$$\begin{bmatrix} \tilde{\mathbf{p}} \\ W \end{bmatrix} = \begin{bmatrix} \hat{\tilde{\mathbf{q}}}(\mathbf{I} - (\mathbf{I} + \hat{\mathbf{r}})\mathbf{A}^T_{\tilde{p}(-1)} - \boldsymbol{l}) & \boldsymbol{l} \\ (\mathbf{e}^T - \mathbf{r}^T \mathbf{A}^T_{\tilde{p}})\hat{\tilde{\mathbf{q}}} & 0 \end{bmatrix}^{-1} \begin{bmatrix} \vec{0} \\ W \end{bmatrix} \qquad (3.10)$$

Where $\mathbf{e}$ is the unitary vector and the vector on the right hand is $\mathbf{g}$. By plugging $\hat{\tilde{\mathbf{q}}}$ found in the equation (6) in the equation (10), we get the vector of prices $\tilde{\mathbf{p}}$. This system, by the algebraic point of view, has $n+1$ unknown variables and $n+1$ equations, therefore it is determinable. However, the system has only n unknown variables (the prices), since the last 'unknown' variable, W, is the known term of the last equation of the system[8]. This choice is intentional; by this way both the rate of profits and the total payroll become exogenous and so we are able to simulate how prices vary, freely changing the rate of profits $(r_1, r_2, ..., r_n)$, the percentage of total payroll in the production of each commodity $(L_1, L_2, ..., L_n)$ and the nominal level of total payroll (W). In other words, we can determine how the price system moves according to the income distribution among firms and workers[9].

[7] $\frac{p(1)_{t+1} - p(1)_t}{p(1)_t} = \frac{\tilde{p}(1)_{t+1} - \tilde{p}(1)_t}{\tilde{p}(1)_t}$ and $\frac{p(2)_{t+1} - p(2)_t}{p(2)_t} = \frac{\tilde{p}(2)_{t+1} - \tilde{p}(2)_t}{\tilde{p}(2)_t}$

[8] By the algebraic point of view, there are really $n+1$ unknown variable, and the system determines the n prices and the nominal level of wage W; theoretically, the nominal wage found by the system should be equal to the one chosen for the known term equation (9). We have checked it in the empirical application.

[9] On the opposite, if we chosen whatever other equation different from (9), we could not study movements in prices caused by income distribution. For example, if we specified an equation for the nominal current GDP which sums up the added value of each sector, we would surely find the current level of prices, but we could not simulate what happens if nominal wages increase since we could only move $(r_1, r_2, ..., r_n)$, $(L_1, L_2, ..., L_n)$ and the GDP value.

3.3 Estimating Bargaining, Technological and Fiscal Effects on Inflation

For the empirical analysis, we prefer long-run I-O tables since it is possible to test our inflation definition with better accuracy. During the 70s and 80s, indeed, in quite all industrialized countries there was high inflation and high bargaining among unions and firms; in the 90s this trend reversed. If our theoretical model is correct it should holds both in times of high and low inflation, thus we should test it on the long-run. However, the most common I-O tables database collect data only from 1990/95 (see WIOD database, OECD-ICIO, EORA-MRIO or EU-Eurostat)[10]. Therefore we used the I-O tables in constant price elaborated by Rampa (2001) for the case of Italy[11]. These tables, indeed, contains 42 sectors at constant purchaser prices (base year 1978), from 1970 to 2000. The branch and primary input codes the usual ESA1979 and for 1997-2000 they were adjusted by Rampa starting from ESA95. The sectors are the following:

ESA cl.	**Products**
01.	Agricultural, forestry and fishery products
03.	Coal and lignite
05.	Products of coking
07.	Crude petroleum, natural gas and petroleum products
09.	Electric power, gas, steam and water
11.	Production and processing of radio-active materials and ores
13.	Ferrous and non-ferrous ores and metals
15.	Non-metallic mineral products
17.	Chemical products
19.	Metal products except machinery and transport equipment
21.	Agricultural and industrial machinery
23.	Office and data processing machines, precision and optical instruments
25.	Electric goods
27.	Motor vehicles
29.	Other transport equipment
31.	Meats, meat preparation and preserves
33.	Milk and dairy products
35.	Other food products
37.	Beverages
39.	Tobacco products
41.	Textiles and clothing
43.	Leather, leather and skin goods, footwear
45.	Timber, wooden products and furniture
47.	Paper and printing products

[10]WIOD: http://www.wiod.org/home OECD-ICIO: http://www.oecd.org/sti/ind/inter-country-input-output-tables.htm EORA-MRIO: http://worldmrio.com/ EU-Eurostat: http://ec.europa.eu/eurostat/web/esa-supply-use-input-tables

[11]Data are free available at this link: http://economia.unipv.it/pagp/pagine_personali/grampa/iotables/Data.html

49.	Rubber and plastic products
51.	Other manufacturing products
53.	Building and construction
55.	Recovery and repair services
57.	Wholesale and retail trade
59.	Lodging and catering services
61.	Inland transport services
63.	Maritime and air transport services
65.	Auxiliary transport services
67.	Communication services
69.	Services of credit and insurance institutions
71.	Business services provided to enterprises
73.	Services of renting of immovable goods
75.	Market services of education and research
77.	Market services of health
79.	Other market services
81.	Non-market services provided by general government
93.	Domestic services and other non-market services

Table 3.1: Productions I-O tables

Sector 93$^{\text{th}}$ of the table is not consumed as an input for any other sector, therefore it can be eliminated since it has the only effect of consumption: i.e. it consumes inputs from the other sectors but it is not consumed in turn. Consequently, the wages paid by this sector are diverted from the total[12]. Sector 11$^{\text{th}}$ is not used as means of production of other goods but it uses a few sectors' products as means of production. However quite all years it is not produced inside the economy, but only imported, and in those years when it is involved, it requires, to be produced, only a very few quantities of the other sectors' products. For this reason, we eliminated it from my calculations, expecting to observe only a very slight reduction in final GDP (for only a few years). Without the elimination of sector 11$^{\text{th}}$ and 93$^{\text{th}}$, we would have one (and sometimes two) lines of zeros for each year, which would prevent us from inverting matrix $\mathbf{A}_{\overline{p}}$ since the determinant of every square matrix with a single row or column of zeros, is zero.

In addition to I-O tables, our database provides data regarding total wages paid in each sector every year; thus, indirectly, it is possible to calculate rates of profits[13]. Finally, we chose the last commodity on the list (i.e. number 81$^{\text{th}}$) as the numeraire good and we fixed its value held in 1978, equal to 100000, and then we adjusted it

[12]The final outcome in terms of price variation is the same, while we can expect the GDP to be reduced by the added value of 93

[13]The rate of profit is:

$$\frac{R-C-W}{C}$$

Where R is the total revenue of a generic sector (i.e. its nominal gross product), C is the total cost in terms of means of production consumed in order to produce said good, and W the total payroll paid in that sector.

for its real growth over the period, using price tables indexes. With this last device, using I-O tables in constant prices, we can be sure that any changes in I-O table values over the years are due exclusively to real modification in means of production and gross productions. Furthermore, I-O tables built up in this way do not have any connection with their current vector of prices.
Determination of the inflationary trend from 1970 to 2000 was calculated using Matlab software, without any distributive hypothesis, but only by applying the equation (10) for all 31 corresponding I-O real matrixes. We recall that by construction, our system is not linked in any way to the inflation observed. Indeed:

1) I-O tables are considered in constant prices, so any variations of their coefficients over time can be explained only by technological changes.

2) profit rates are exogenous

3) Total payroll of the economy W and its shares within sectors are exogenous

Therefore, if we inserted the values observed of $(r_1, r_2, ..., r_n)$, $(L_1, L_2, ..., L_n)$ and W into the system (10) and if doing so, we found price vectors equal to the inflation rate observed, this would mean that price levels are a consequence of income distribution among income groups (point 2) and 3)) and changes in technology (point 1)).

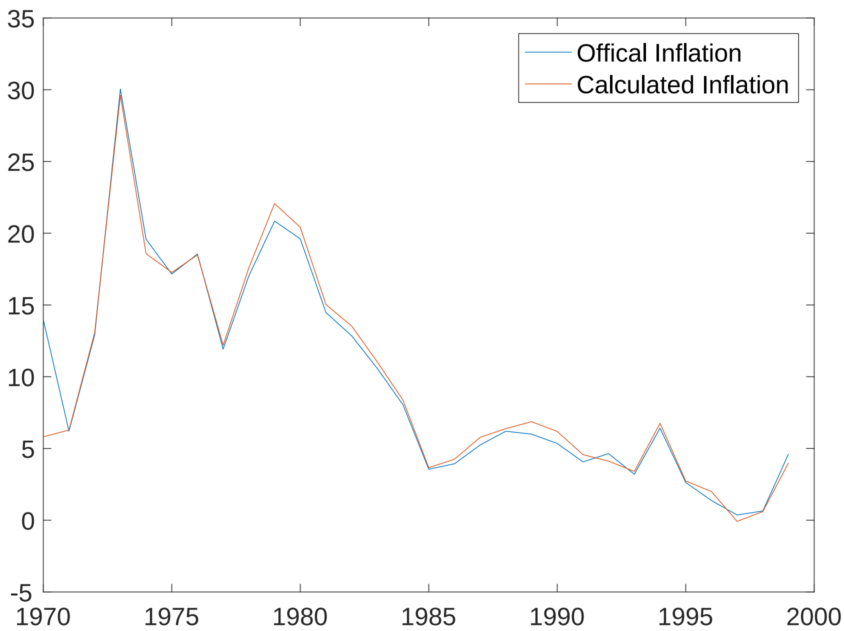


Figure 3.1: Observed Inflation (blue) vs Inflation Defined by Equation 10 (red)

The graph is extremely accurate. This is not an estimation, but a definition. This model, in fact, is not aimed at estimating inflation, but at finding a formula to define it. Along the period 1970-2000, in Italy, as in a lot of other Western countries, there have been a lot of shocks which affected inflation. Between 1970-1985 there have been a highly conflicting bargaining among companies and workers which surely was reflected on price level. Moreover, in 1973 and in 1979 happened the two oil picks which also lead the World in an inflation crisis. Our definition of inflation take into account of all these factors since the system of equation (10) depends on these three exogenous variables recalled above: the technology employed, the nominal profit rates $(r_1, r_2, ..., r_n)$, the nominal total payroll W and its shares within sectors $(L_1, L_2, ..., L_n)$.

The point 1) recalls for shortages in raw materials like petroleum or other lack due to wars; the last two point recall for bargaining outcome. Therefore, our model can also be used to separate the bargaining effects from the technology shocks effects on inflation. Keeping constant the intermediate input matrix $\mathbf{A}_{\overline{p}}$ (i.e. the technology) and plugging in (10) only the level of wages and profits of the next period it is possible to evaluate the weight of income distribution in the formation of inflation, year by year. On the opposite, keeping constant the current profits, wages and the numeraire $\tilde{Z}$ and plugging in (10) the matrix $\mathbf{A}_{\overline{p}}$ of the next period (i.e. the technology of the system in the new period), we find the weight of technology shock in the determination of inflation, year by year.

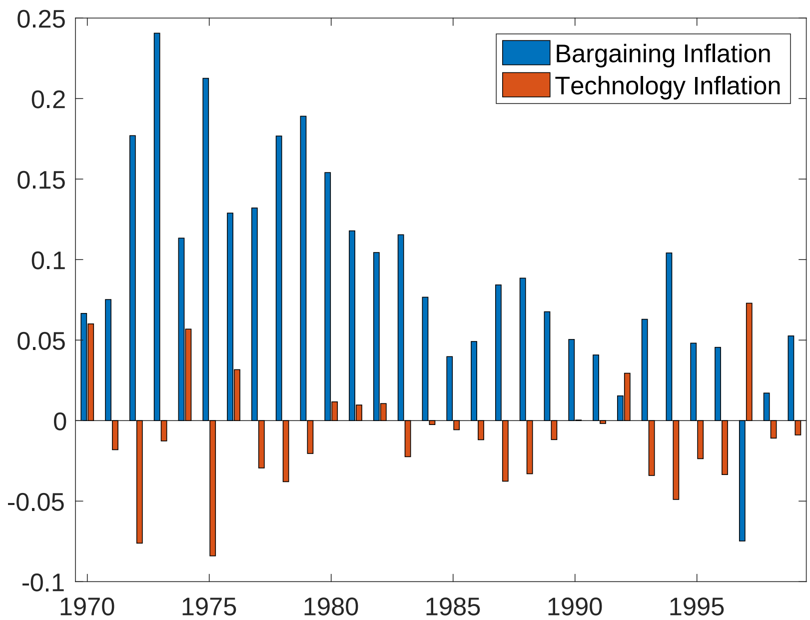


Figure 3.2: Inflation Share due to Bargaining (blue) vs Inflation Share due to technology Shocks (red)

We did it for the case of Italy. Figure 2 shows a bar chart which split the effect of bargaining (in blue) and the effects of technology shocks (in red) on prices. Overall, the effect of technology over time, tends to reduce the price level. This outcome is consistency to the economic theory If we assume that the technology employed in the system improves year by year, thanks to innovation. Improvements in technology, indeed, lead to produce more with less raw materials; if nominal wages and the profit rates remain constant, the final effect is a price reduction. However, even if technology shocks have generally a reducing effects on inflation, there are also some years when this rule does not holds. In 1974 and from 1980 for the three consecutive years, technology shocks increase inflation. This occurs, by the theoretical point of view, when there is a shortage in raw material. Indeed, we recall that in 1973 and in 1979 there have been the two oil crises; this shortage reduced also the availability of oil for all the other sectors and in the end, less goods could have been realized in the years next these shocks. Within this scenario, nominal wages and profit rates did not change, therefore the final outcome was a negative technology shocks which contributed to make price grow. Our estimations find an increment of approximately 6% due to technology; considering that the oil price passed in 1973 from 2.7$ to 11$ in a single year (+307.4%) this seems to be consistent with the estimations of LeBlanc and Chinn (2004), Cologni and Manera (2008) and Choi et al. (2018) who forecast an increment between 0.1-0.8% of general price index for a 10% of oil price growth. Moreover, Figure 2 shows a positive technology shock also in 1992; we could relate it to the conclusion of 'mani pulite', the nationwide judicial investigation into political corruption and the end of the so-called 'First Republic' in Italy. Between 1990-1992 Italy re-structured its economy through great privatizations, the pension reform, the strong devaluation of Lira in 1992, the elimination of the so-called "scala mobile" (costof-living adjustment of wages) always in 1992 and experienced institution innovations with the introduction of majoritarian representation system; this could have de-stabilized the economy with negative short-run technological effects as noted by Miniaci and Weber (1999). Indeed, we can observe that the technology shocks on inflation in 1990-1991 were close to 0 and even positive in 1992. We finally found a relevant positive technology shock on inflation in 1997, that could be related to the Asian financial crisis which contributed to decrease the availability of a lot of raw materials or primary goods that Western economies were used to import as shown in Blalock and Roy (2007).

We finally try to estimate the weight of 'fiscal inflation' on the total price growth over time. When studying the evolution of inflation and output over the past sixty years, the role of fiscal policy has often been neglected (Bianchi and Ilut, 2017). However, economists such as Cochrane (1998, 2011) and Sims (1994) conjectured that the original sin that led to the rise of inflation in the 70s should be sought out in the conduct of fiscal policy during those years. The fiscal theory of inflation is based upon a seminal paper by Sargent and Wallace (1981), who argued that the rate of inflation is dependent upon the coordination between monetary and fiscal authorities. When the fiscal authority is dominant over the Central Bank (like in the decades 60s-90s in Europe) it sets the current and future budget balances and determines the amount of seigniorage income required from the monetary authority. Therefore, the monetary authority may create extra money in order to respond to the requirements of the government, weakening, by this way, its control over price stability. In the literature, this version is named as the weak-form of fiscal theory (Carlstrom and Fuerst 2000) and is accepted largely as the correct way of interpreting the fiscal-monetary interrelations in the determination of inflation. No mention of fiscal inflation is present in Sraffian and post-Ricardian Literature.

Fiscal policy modifies the income distribution, indeed it is just a redistribution of total added value of the economy among wages and profits. Knowing the trend of fiscal balances over time, our model theoretically allows to split the effect of fiscal policy on inflation by the effect of bargaining among unions and firms. We should only know, exactly, the share of fiscal imbalance devoted to increase labor income and the residual part spent in favor of profits. This data is not directly available, however we show the procedure with the following example, assuming that the total fiscal imbalances have been spent in order to increase the labor income (W). What is more, it is not an assumption too hard: the great part of fiscal imbalance is generally directed to increase the number of people hired by the public sector, social assurances and pensions; i.e., invoices for W, the total national payroll. furthermore, in general, only a residual part of fiscal imbalance is moved to increase profits. In the following example, we only need to subtract the current fiscal deficit to the total payroll observed, year by year, and than replugging these new values in the equation (10). In doing so, we use the official data of the Central Bank of Italy which provides yearly fiscal deficits and surplus over quite two centuries. Moreover, we recall that the Italian fiscal deficit have been mainly covered by the creation of new money over the period analyzed; furthermore, the outcome we are going to get, recalls the above quoted literature on the impact of monetary financing of a fiscal deficit, i.e. the price effects of money creation for the government expenditures. Our findings confirm part of the literature. The first outcome is that fiscal deficit affect inflation in a considerable way; the second one is that fiscal deficits are not the only cause of price growth. As for the first finding we observe by the Figure 3 that over the period 1970-1992 fiscal deficit contributed to the total inflation for approximately 7-8 percentage points. This effects has considerably reduced in the last 90s, but this is due to the decrement of fiscal imbalances.

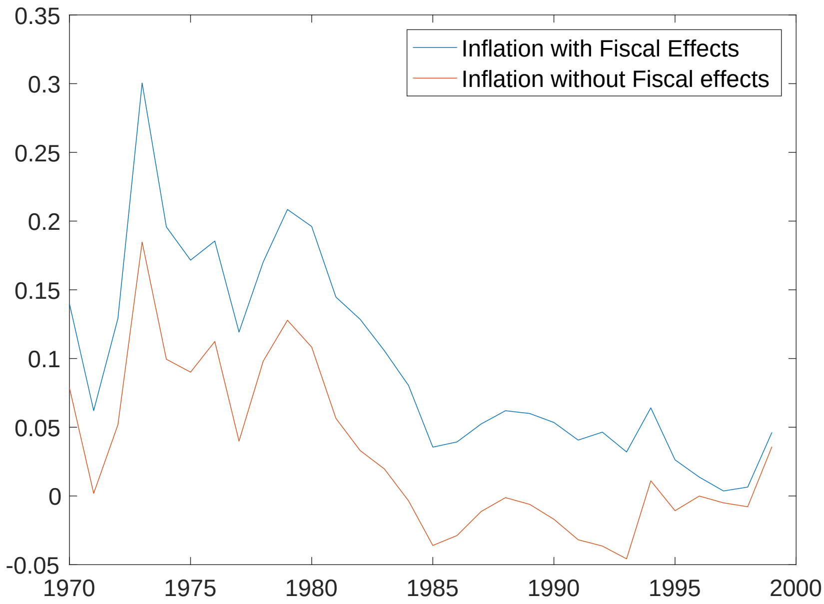


Figure 3.3: Total Inflation (blue) vs Inflation without Fiscal Effects (red)

As for the second finding, we observe that even without fiscal deficits, inflation would have been nevertheless high until 1983, and then it would have been stabilized around zero mean. Over the period 1970-1983 Italian workers were highly unionized (OECD statistics), every year there were thousands of strike hours (OECD statistics) and workers representatives in the Italian parliament exerted a strong influence (Lombardini, 2017). Therefore, the high inflation found for this period, after deducting the fiscal effects, implies that the direct bargaining among unions and firms can heavily affects the price level. More precisely, strong bargaining lead to high inflation meanwhile feeble bargaining do not produce any effect on the price level. However, as we are going to show better in the next sections, fiscal policy could also be interpreted as a bargaining outcome among firms and unions. In the end, the accuracy of our theoretical model, proved empirically and shown in Figure 1, suggests that our approach is an effective way to define inflation. Furthermore, we can now deduct from the model some theoretical economic implication on inflation.

3.4 Theoretical Implications

This way of proceeding may seem valid from an empirical point of view, but the consequences of this model on economic theory are even more interesting since they affect the economic debate on inflation and its origins. We have managed to describe inflationary long-term trend by merely noting income distribution between wages and profits, government monetary expenditure (implicit in wages and profit rates) and real production variations among all economic sectors. Doing this and achieving an accurate estimate may suggest that prices are a consequence of income distribution. Therefore, their trends may depend primarily on social bargaining and its outcome, and, last but not least, on the effect of productivity growth, which gives rise to variations in inter-sectorial interdependencies.

We have studied six different scenarios. The exogenous variables to freely vary are: the total payroll W, the vector of rates of profits $\mathbf{r}$ and the value of numeraire, i.e. the technology shock. We are going to study what would happen, from a theoretical point of view, to the price index trend over time, when these three variables separately increase and decrease, *ceteris paribus*. We will use the same I-O table from 1970 (but it really does not matter which we choose among the 31 analyzed in this study) for all the simulation periods. In the aggregate data of total nominal wage and profit rates, "government monetary intervention" is included. By this expression we mean a policy of public expenditure which creates (or destroys) new money through direct seigniorage or by bonds sold to the Central Bank. This policy may increase/decrease wages of workers in the public sector, public pensions, enhance/lower unemployment subsides or extend their duration, affect patronage policies or direct/indirect subsidies to private firms. All these items are included in the total value of wages and rates of profit, since both are expressed as gross values, comprehensive of social contributions, i.e. of the redistributive effect of State intervention.

3.4.1 Case 1: wage increase

The graph below refers only to the I-O table of 1970, so price index variations are not due to any change in real quantities inside matrix $\mathbf{A}_{\overline{p}}$, nor to a movement of numeraire good whose quantity remains fixed for all 30 steps. This is a way to keep constant the technology in order to study the net effect on prices lead by bargaining among workers and entrepreneurs. From this graph, as from all the subsequent graphs, it is possible to see how income distribution may affect price trends, if everything else remains constant. In this particular simulation, we made the total wage in 1970 increase at a constant spread (50,000 million lire) at each step[14]. The outcome shows that if wages increase but the rate of profits and the level of production remain the same, the price index will grow. This kind of inflation is neither monetary in origin nor it is linked to the Central Bank's interest rate expectations as stated by Burton (1972). This is consistent with classical economic theory: with the same goods produced, if workers obtain an increase in the nominal level of wages, in the face of constant profit rates (i.e. increased proportionally in absolute), there is no other mathematical possibility that a prices increase. From a bargaining point of view, this situation means that workers, perhaps through trade unions and political parties, may have tried to increase their nominal wages, but companies managed to pass wage increases onto prices, maintaining a constant rate of profit. This is the classic issue of 'wage inflation' (Milner 2018, Burton, 1972). The final effect is neutral, from the perspective of real distribution. In fact, when nominal wages increased, prices also increased proportionally, while profit rates were stable. Every socio-economic group may have earned more money, but prices all increased, so there was no real final effect. Finally, this situation may also occur not only at high bargaining levels, but also

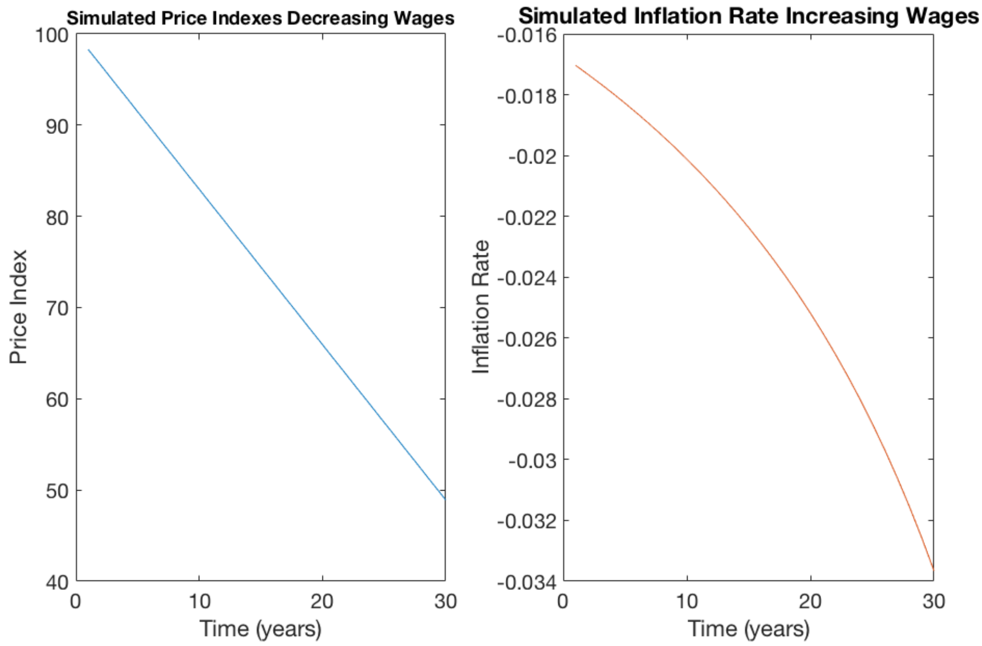
[14]The amount chosen does not change the theoretical final result.

when government intervention is heavy and not directed to productive investments, but to finance unproductive expenses by creating new money. For example, the government could start paying high subsides to unemployed people, or hiring workers unnecessarily, or increasing public pensions, or providing greater public subsidies to firms as a result of clientelism. If the state does so with a considerable and continuative financial effort, the final effect, *ceteris paribus* (i.e. fixed production and augmented expenses financed not by taxes or other forms of compensations), will only be a rise in prices, as noted in Faria (2001), Davig and Leeper (2011). I call this 'workers patronage inflation'.

3.4.2 Case 2: wage decrease

In this simulation the total wage decreases at each step at the same rate while profit rates remain constant. [15]. *Ceteris paribus*, prices will drop, at an increasing rate. This is because the real total national output stays stable, as do profit rates. Thus, national income does not shift from one socio-economic group to another, but remains in the hands of the same people, with the difference that nominal level of income has been reduced. On the other hand, price indexes also decrease proportionally, so the ratio between individual nominal income and prices remains constant.

[15] Simulation is built in a way that however wage are decreasing, they remain positive until the last step.

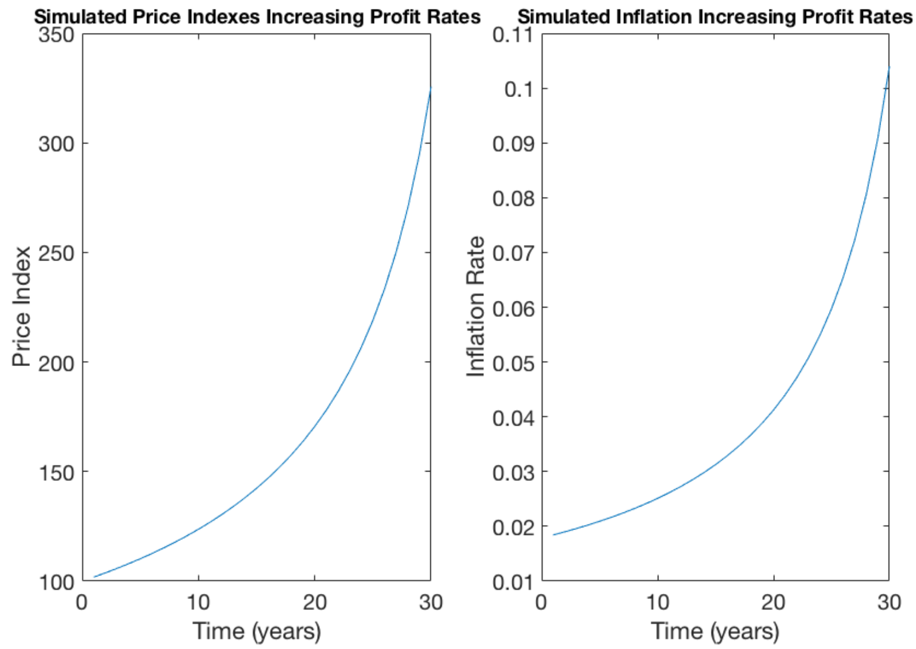


This situation may occur on the bargaining side, when a company's management and other employers are making cuts in payrolls thanks to their increased bargaining power. This may be achieved by a combination of layoffs and decreased wages, or by substituting the labor force with people coming from other socio-economic groups who have less bargaining power, such as immigrates and people who have long been unemployed, or by substituting labor with machines. On the other hand, while wages are decreasing, profit rates remain stable. This happens, for example, when enterprises decide to be more competitive by taking advantage of lower payrolls to reduce prices of goods. This drop in wage is not necessary linked to unemployment, but mainly to the outcome of bargaining between workers and employers. Moreover, certain external factors may force employers to reduce their purchasing prices. In either case, profit rates remain stable, wages decrease, but prices also fall proportionally, so in the end income distribution is not affected, but nominal GDP is reduced. One of the possible external factors which may force firms to lower prices may be caused by the reduced purchasing power of society as a whole as a consequence of increased unemployment or reduced wages. This is a typical post-crisis scenario, like the aftermath of the crash of 1929 or the most recent financial crisis in 2008. In the months following these events, prices as well as wages decreased in the nations most severely struck by the crisis (Stock and Watson 2010). Of course, such situations create a mixture of the kinds of effects we have observed in the cases we have been studying here separately. In these crisis scenarios, a decreasing wage level is often also followed by a reduction in real production and consequently of profit rates. In this scenario, however, employees are ineffectual: their trade union and political activity is quite absent; indeed, they are subjected to pressure from the companies that employ them and suffer from the general negative effect of the business cycle induced by this wage policy (Giordano 2001).

Finally, from the perspective of government expenditure, this scenario may reflect a policy of strict budget constraints which meanwhile may lead government to fire its employees, to extend retirement age, to lower pensions, or to diminish other forms of unproductive expenditure like subsides to efficient enterprises, or other form of investments. These policies have the same effect, in the end, of reducing the nominal income of all socio-economic groups, and may refer to a government which wants to pay off its debts, as studied by Edgell and Duke (1982). But here, all other variables being constant, real production does not drop, and so these policies only affect prices. This could happen if, for example, cuts in public spending focus on unnecessary costs, which, being unproductive by definition, would not cause any reduction in real production. Conversely, by cutting these useless expenses, it is possible to gain competitiveness by reducing the general prices of goods in the economic system.

3.4.3 Case 3: profit rates increase

Here I generate a cycle where all profit rates (for the sake of simplicity) are increased by 1% at each step. All the other variables, as always, remain constant. Here the model shows us that prices would rise at increasing rates. It is reasonable to assume that since gross production remains steady, total wages will also remain the same. In this case, how can profit rates increase? The only mathematical solution is that prices will rise. This may occur following a long period of intensive bargaining which results in profit rate increments that are out of proportion compared to wages, the well-known 'profit inflation' effect (David 1956). The simulation reveals what effect different ranges of profit rate increases have on final prices. The final upshot here is not neutral. While prices are rising, wages remain fixed, causing a loss in workers' purchasing power. On the other hand, absolute profits are increasing, but so are the rates of profits, and, since wages are fixed, the profit growth margin is more than sufficient to compensate price increments. From the perspective of public spending, this scenario refers to an increment in state subsidies to private firms, which are not covered by taxes but by the means of bonds or seigniorage (anyway, money creation). Another possibility is that the government agrees to pay higher prices for services furnished by private companies. Also, other forms of patronage may collect rent from new government sources which in turn will make profit rates increase and thus raise prices, as recently reported by Barkan (2011). We would call this 'capitalist patronage inflation'.



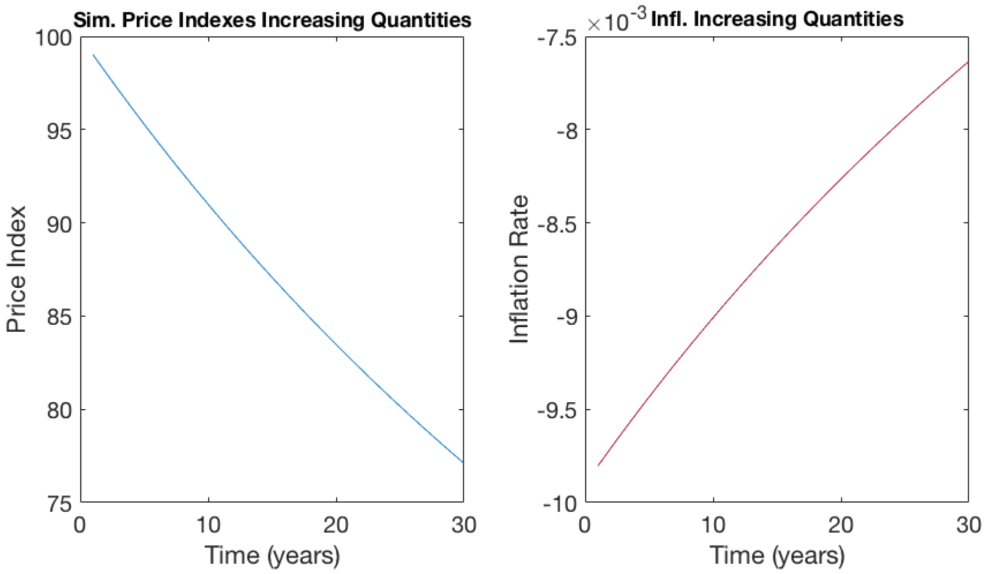
3.4.4 Case 4: profit rates decrease

For this simulation, we let profit rates decrease at the same speed as in the previous example: 1% per each simulation step, making the two studies comparable[16]. In this case, when profit rates decrease systematically, *ceteris paribus*, the price index drops at decreasing rates. If profit rates decrease while both real production and nominal wage remain stable, prices will also have to drop to balance the only other variable that has changed. This is not a neutral situation: during the process real wages grow, while profits in absolute drop at a higher rate than prices, i.e. their real value is reduced. From a bargaining point of view, this scenario describes an economic system where workers do not demand better economic conditions, but where there is increased competition between companies. The bargaining between new entrants and incumbents and in general among all companies leads to a reduction in profit rates, as described by Martin and Worz (2012). Finally, from the perspective of public expenditure, to the contrary of what was stated in the previous section, the government would have to end the patronage of some private companies, or start paying lower prices for the same goods and services purchased from private producers. In the end, the state may reduce its subsides to private firms or end its patronage policies.

[16]Simulation are built in a way that profit rates decrease without becoming negative.

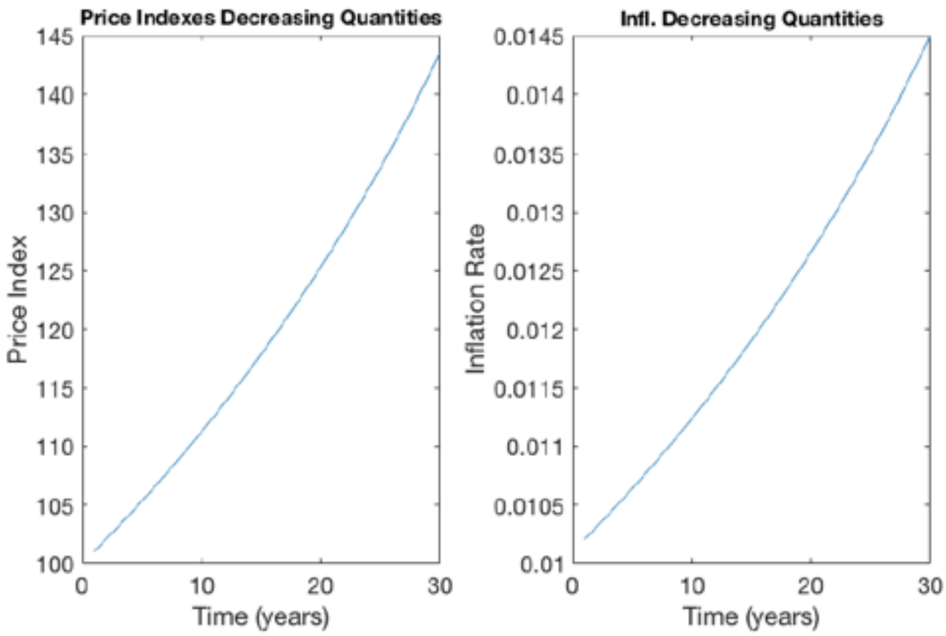
3.4.5 Case 5: real gross quantities increase

In the following case the real gross quantity of the numeraire, rises at 1% at each step of the simulation. This implies that all the other real gross product quantities will also increase at the same rate, since they represent a proportion of the numeraire, by definition. So real production in general is increasing at 1% at each step of simulation; so, *ceteris paribus* (i.e. income distribution does not change), this means that prices must decline. This simulation also shows that inflation rates are negative but their absolute value is decreasing. The final effect on income distribution is neutral: in fact, profit rates remain stable as do nominal total wages, while at the same time prices are declining. Both social categories, private enterprises and workers, receive a higher real income, but the proportions between them have not changed. This is consistent since at each step, each person should be richer than before, as real production has increased. Therefore, even though each social category is earning the same nominal income, i.e. profits and wages are increasing, prices are decreasing, which means that distribution remains the same. In terms of bargaining, this situation may occur when the same number of workers produce more goods with more raw materials. This is possible primarily thanks to new technologies which increase productivity. Companies, in this scenario, choose to maintain the same rates of profit and to take advantage of this increase in productivity by reducing prices, thus improving their competitiveness. This is a real possibility which was evidenced by Sangho et. al (2013) in the recent case of South Korea. Public expenditure plays no role, since the variable of real production is the only one which changes in this scenario, and so no monetary variations implemented by the government are assumed.



3.4.6 Case 6: real gross quantities decrease

In the final case we are going to consider, the real gross quantity of the numeraire declines at a fixed rate of 1% for each step of simulation. As in the previous section, all the other real gross quantities, expressed in terms of the numeraire, will follow the same trend at the same rate by definition. Here prices rise at increasingly faster rates. Indeed, if nominal total payroll and profit rates are fixed, but real production is decreasing, prices, mathematically, must rise. Companies have to face a drop in real production, but they also want to earn the same nominal amount of profit, while workers will not accept lower nominal wages; this leaves no other solution than selling the smaller quantity of products at higher prices, in order to assure that final revenue and nominal incomes remain constant. This scenario is neutral in terms of distribution, but since the real income of both socio-economic groups drops, while nominal wages and profits remain constant, prices will necessarily increase. This kind of situation may arise during a crisis when productivity is reduced and/or the availability of raw materials is limited (due to external factors like shortages - e.g. of petroleum - or war) , while workers and business owners try to maintain the same (nominal) income level, as described extensively by Roeger (2005) and Trehan (2005) with regard to OECD countries. Public expenditure, at least theoretically, plays no role in this situation, since the only variable modified in the simulation is real production. This scenery could recall, for example, to the two petroleum shocks occurred in 1973 and in 1979. The shortage of petroleum, so deeply linked to all the other industrial sectors, lead to an increases in prices recorded in all Western countries. Our model, indeed, applied for the case of Italy, finds two peaks in prices just for the year 1973 and 1979.


Price Indexes Decreasing Quantities
Price Index
Time (years)
Infl. Decreasing Quantities
Inflation Rate
Time (years)

3.5 Theoretical Considerations

As a result of these scenarios, we may know the following:
Inflation may be caused by intense bargaining between workers and companies. If real production does not grow sufficiently to compensate nominal income increases in wages, profit or both, due to this allocative competition, there will be inflation. But inflation may also be caused by a sudden shortage of raw materials within a context of fixed wages and rates of profit, or during and just after a war, when governments try to legislate in order to maintain a constant level of wages, and the capitalists attempt to keep profit rates steady. If a crisis due to a shortage of raw materials intensifies bargaining between workers and employers, the effect on inflation will be empowered. Finally, inflation may also be caused by a corrupt government which indulges patronage requirements of enterprises or by a demagogic government which raises wages, pensions, subsides, without corresponding real economic growth.

Price levels are stable, according to the model's results, when for example wages and profits grow while real production is increasing just enough to compensate for the incremented nominal income of workers and business owners. But wages and profits may not necessarily both increase. Prices also remain fixed in a scenario where nominal wages grow while profit rates decrease: in this setting, real production does not change but wealth distribution among social groups does. When profit rates decrease, and the increase in total wages is greater than the drop in profits, real production raises consistently. The opposite scenario may happen with prices remaining stable when real production increases but wages remain fixed and the excess production is attributed to profits. Or, in another scenario, real production does not change, but wages decrease as a result of a raise in profit rates: prices are stable, and only a redistribution among social groups happens. Finally, prices could be also stable if a government increases the total wage value by reducing profit rates, for example with taxes, or, on the contrary, may increase subsidies to and update patronage policies for private firms, thus recovering resources from total wage.

Finally, government monetary intervention, by the definition of inflation described in this paper, may be thought as a form of income bargaining between workers and firms. This is an extension of Sraffian and post-Ricardian literature, which does not assign any role to the government in their I-O model. On the opposite, in this paper, as shown by our example estimation in Figure 3.3, we theorized that monetary fiscal policy has an effects on prices through the channel of wages and profits. Indeed, if workers are strong, i.e. have powerful trade unions, control a lot of newspapers and media and millions of electors flow in the same political parties, the government, in a perfect representative democracy, would be a representation mainly of the working class. In that case, the government could help workers by raising wages, hiring unemployed people, increasing pensions etc., perhaps also trying to reduce profit rates or planning productive public investments, or simply by letting prices increase while wages increase more than proportionally, so that profit rates decrease (workers' patronage inflation). On the contrary, if workers' political and trade union activity is quiet, companies and other employers may take advantage of their weakness by reducing nominal wages, or increasing their profit rates, absorbing all the productivity improvements by keeping wages constant. If the government is a representation mainly of private firms, it will mainly try to reduce taxes, subsidies, public pensions and public employees or increase profit rates more than proportionally to inflation through capitalist patronage inflation. Through public monetary expenditure (i.e. non-productive expenditure creating money), the state redistributes income among social classes, consistently with the social class that it represents at any given time.

3.6 Conclusions

In this paper we have presented a way to describe the inflationary trends components with great accuracy. This process highlights how income distribution, government monetary intervention and productivity growth are all interrelated. The model can be used to forecast future inflation through the mixed use of the six different possible *ceteris paribus* scenarios shown. The model shows that inflation depends exclusively on nominal wage levels, rates of profits and productivity variations among the sectors of the economy. Productivity variations are able to affect inflation in a significant way, however, they only occur in rare scenarios: wars and sudden shortages of raw materials. This means that inflation is mainly due to the level of profits and wages at any given level of real production.

The monetarist approach explains inflation as a consequence of money creation by the government and not of bargaining between workers and business owners. However, as we discussed in the previous section, government monetary intervention affects the final level of wages and profits (and so, indirectly, prices), but it is itself a form of bargaining (capitalist patronage and workers patronage). This special form of bargaining does not operate alone, but it takes place alongside of classical bargaining activities between trade unions and enterprises. In subsequent studies, this model could be used to separate the component of inflation due to government bargaining (government monetary intervention) from that caused by collective bargaining (between companies and trade unions).

In conclusion, inflation seems to be mainly a political phenomenon of income bargaining. It merges as a mix of trade-union contention on wage determination between entrepreneurs/workers and political competition for government control (which means control on fiscal monetary expenditure). In free-market economies, high inflation rate periods suggest that there is a profound level of social contention between income groups, evident both in government and business, while periods of relative stability in prices, hint low political and trade union activity of workers with a reduction of their economic influence on the government. A condition which recalls Europe (and not only) in the last two decades.

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Chapter 4

Health inequalities for elderly in Europe

4.1 Theoretical framework. Health inequalities in Europe: the place matter

Our health is inextricably related to our geographies (Gatrell and Elliot, 2009): place is a "mileux that exercises a mediating role on physical, social and economic processes and which effects how such process operates" (Agnew, 2011). Nevertheless, places are nodes of social, economic and political networks (Cummins et al., 2007) and spatial inequalities in health are the final outcome of complex economic, social, environmental and political processes. As argued by Bambra (2016), "places can be health-promoting (salutogenic) or health-damaging (pathogenic)".

The literature identifies two main explanations concerning geographical inequalities in health: compositional and contextual (Macintyre et al. 2002). According to the compositional approach the health of a specific place is the result of the individual behavior of people living in that area, while for the contextual explanation health inequalities are related to economic, social and physical environmental of the area.

According to the compositional approach, the behaviours and socioeconomic characteristics of people living in a particular area determine the health of the population in such place. The main risky health behaviours (smoking, alchohol, physical activity, diet and drugs) play a crucial role in health outcome. Smoking is related to cancer and cardiovascular disease, being the more relevant preventable cause of mortality in European member states (Jarvis and Wardle, 2006). On the other hand, socioeconomic status is the second key element in term of occupational class, income or educational level (Bambra, 2011). Literature has well developed the concept of social gradient in health according to which people in higher social class have a better health than those in the class below (Marmot, 2010). Our study focuses on the contextual explanation for the health of a specific place, recalling individual behavior only in the final section, dedicated to econometric estimations, where they are considered as independent variables together to contextual variables.

The relationship between socioeconomic status and health conditions has been investigated according to three main interpretative approaches: materialist, psychosocial and behavioural/cultural (Bartley, 2016). Materialistic theory considers income as key elements in favouring access to goods and services and protecting by risk factors such as unhealthy diet, deprived housing conditions, exposition to environmental and job physical condition risks. Psychosocial theory mainly concerns the impact of domination/subordination and social support/control feelings on health. While behavioural approach argues that unhealthy behaviours are psychologically and culturally determined according to socioeconomic groups. Health, in fact, is strongly affected by social, economic and physical environment and "place acts as a health ecosystem" (Bambra, 2019). In this analytical approach the focus is therefore not on the individual socioeconomic condition, but on the area-economic factors including employment conditions, poverty rates, income level. The socioeconomic characteristics of a place affect health of the people living in that place according to several different mechanisms: the job that people can have access to, as well as the services available within a perverse circle mainly driven by economic interests (poor food available in poor neighbourhoods; healthy food and physical activity opportunities may be not present in deprived areas for example). Poverty as one of the main area-level economic factors is a key predictor of health (Macintyre, 2007). Moreover, social elements such as the possibility to access health care services, child care, the quality of schools, and housing strongly affect health conditions, as well as the possibility to implement healthy or unhealthy behaviours. The absence of safe and walkable outside space as well as of affordable fresh food market are some of the elements contributing to an obesogenic environment (Pearce et al., 2007). Places also shape the context of social capital, in terms of trust, norms and networks (Putnam, 1993) mediating between the socioeconomic conditions of people and the health outcomes (Hawe and Shiell, 2000): higher social capital is related to better health conditions. The quality of places as physical environment is another aspect strongly affecting the health of the population: the negative effect of air pollution, as well as contaminated land, is well documented by literature (WHO, 2008; Bambra, 2016; Walton et al., 2015); on the reverse the positive influence of natural and green space (Maas et al., 2005; Abraham et al., 2010). Researchers developed the concept of environmental deprivation associated with higher mortality rate and the related concept of environmental justice (Pearce et al., 2010).

Contextual and compositional theoretical approaches have to be considered as strongly intertwined, and both reinforcing each other in the so called "deprivation amplification" highlighting that individual deprivation is amplified by area deprivation (Macintyre, 2007). People and places are strongly reciprocally influencing, outlining a specific ecosystem affected by micro, meso and macro elements that are each other related, producing health geographical inequalities. Contextual and compositional explanations support the analysis at micro and meso levels, while another part of the studies focused on macro level investigating the role of social, political and economic structures and therefore of the political choices. From this point of view, political choices, being outside the control of individuals or local areas, have been considered "the causes of the causes of the causes of geographical inequalities" (Bambra, 2016). Policy matters because poverty level as well as employment and environmental conditions are determined by wider political actions by national an over national level: "politics can make us sick or healthy" (Schrecker and Bambra, 2015).

Economic recession is associated with increasing in mental illness (Gili et al., 2013; Economou et al., 2011), and health inequalities (Bambra, 2019), nevertheless the impact of the "great recession" of 2007 on health inequalities has been limited studied also because its effect will be more evident in the next years. In comparative perspective, in Western countries, the previous economic downturns had different impact on the population, and therefore inequalities have increased but not according the same path in all countries (Valkonen et al., 2000; Kondo et al., 2008). More in general, inequality characterizes western societies in neoliberal era. We refer to neoliberalism as "a politically guided intensification of market rule and commodification" (Brenner, et al. 2010). It has been marked by promoting competition in the provision of public services and introducing private sector management techniques to increase efficiency and to reduce costs (Saltman et al. 2007; Harvey, 2007; Labonté, Stuckler, 2016). Such policy context has "increased inequality" (Schrecker, Bambra, 2015) concerning economic, social and health conditions. Income inequality is related to higher infant mortality and lower life expectancy (Wilkinson and Pickett, 2008). Recent studies have put the attention on the long-term health implications of the economic crisis in 2007 and the related austerity policy within the neoliberal policy framework dominating European countries (Bambra, 2019). Austerity measures (cuts to central and local governments and therefore to welfare services) have been related to an increasing in mortality rate at older ages (Hiam et al 2018). Health inequalities has been considered as one of the "neoliberal epidemics" (Schrecker, Bambra, 2015).

The literature has usually studied income inequalities linked to mortality rate, however in this paper we would shift our attention on Healthy Life Years (HLY). We are going to investigate health inequalities in European countries focusing on HLY for elderly in comparative perspective. The first paragraph outlines the theoretical framework on health inequalities according to the main literature, stressing the relationship between health of the population and places, outlining the main research questions. The second part investigates data concerning changes in healthy life years for elderly in European member states in relationship with differences in income distribution (Gini Coefficient) and welfare regime. In the last part we run econometric estimations whose outcomes suggest some comments on HLY65+ trend in Europe in relationship with income inequalities, social public expenditure, welfare policies and individual health behavioral variables in the neoliberal context. The study is led by the following research questions: 1) Within each member state, has HLY65+ changed? 2) is there a correlation between differences in income distribution (Gini index) and differences in HLY65+? 3) Are such differences caused by income inequalities growth?

4.2 Data and Analysis: HLY65+

Healthy life years (Eurostat), also called disability-free life expectancy, is defined as the number of years that a person is expected to continue to live in a healthy condition (Gold et al., 2005). Data concerning HLY65+ are taken from Eurostat (Eurostat, 2018). Prevalence data were obtained by the following prompt from the annual European Statistics on Income and Living Conditions survey (EU-SILC). HLY65+ data is calculated by age categories of 5 years. To the sample interviewed it was asked: "For at least the past six months, to what extent have you been limited because of a health problem in activities people usually do?". The possible answers are:

"Would you say you have been:
a) severely limited
b) limited but not severely
c) not limited"

The first answer is used as a proxy for identifying disabled persons, and those who are limited or severely limited in their activity. The number of responders to a) are summed and than they are divided by the total number of interviewed people. However, this indicator presented by Eurostat is derived from self-reported data so it is, to a certain extent, affected by respondents' subjective perception as well as by their social and cultural background. The main limitation of the data is that EU-SILC does not cover the institutionalised population, i.e., people living in health and social care institutions who are more likely to face limitations than the population living in private households. It is therefore likely that, to some degree, this data source underestimates the share of the population facing activity limitations. However, our data analysis is already informative, even with this under-estimated index; the real health condition of population over 65 can only be worst than the one presented in this paper.

In the literature, the great part of studies have focused their attention on the mortality rate, finding recenlty, for example, that in the USA, mortality in the middle age group of the white population has unexpectedly increased, while the same rate calculated for all the other age groups and ethnicities continued to shrink (Deaton and Case, 2020). However, our study does not use data on mortality, nor on life expectancy at birth, while it focuses on healthy life expectancy after 65 years. Life expectancy at birth or mortality rate, indeed, could remain high, even in a context of increased inequalities, however, the quality of life could be severely reduced, which ultimately would decrease the healthy life years. According to the life course analytical perspective (Wadsworth, 2007; Willson, 2007; Pearlin, 2005), HLY65+ reflects the accumulation of several health determinants at individual as well as contextual level through the whole life (Lundberg, 2008). We therefore believe it would be more precise, for the purpose of our analysis, to use an indicator such as the HLY65 + which, unlike the death rate or the life expectancy at birth, is more easily capturing the long-term effects of inequalities, neoliberal policies and welfare regimes in which the individual lives.

Researches of causes of health inequalities (Beckfield, 2015) has demonstrated a complex relationship between welfare regimes (Eikemo and Bambra, 2008; Bambra, 2007) and the health of the population (Bambra and Eikemo, 2009); this work focuses on analysing HLY65+ in relationship with welfare regime in European member states, income inequality and micro-level variables such as alcohol consumption, smoking and overweight. As we highlighted in the first paragraph micro and meso levels are intertwined and both are related to macro structural economic and social neoliberal features.

This study embraces the literature conceptualising the welfare state as an institutional arrangement that distributes health (Beckeld et al., 2015). The "social determinants of health are real and they have real consequences" (Kelly and Doohan, 2012) that have to be considered in term of health of the population. Therefore, European states have been classified according to four main welfare regime types, commonly known in the literature (Leibfried, 1992; Ferrera, 1996; Bonoli, 1997; Arts and Gelissen, 2002; Bambra, 2007; Beckfield et al., 2015): Scandinavian (universalistic, strong interventionist state with generous social transfers), Bismarckian (welfare programmes related to a labour market position, and support to family), Southern (fragmented, limited and partial coverage with a reliance on the family and voluntary sector), and Eastern (formerly Communist countries that have limited welfare services).

Initially, HLY65+ data from 2004 to 2017 were studied carrying out the Dickey-Fuller (D-F) test in order to skim countries that have experienced a significant trend (both positive and negative) from those that have remained stable. The Dickey-Fuller test tests the null hypothesis that an autoregressive model follows an increasing or decreasing trend (unit root). The alternative hypothesis is that the autoregressive model moves around its fixed mean (stationarity) or around a trend (trend-stationarity) (Eurostat, 2018). The tests were conducted differentiating between men and women. For p-values greater than 0.1, the time series should be considered non-stationary. Subsequently, linear regressions were conducted to study the slope of the eventual trend and its statistical significance. Moreover, a delta analysis was run to perform variance analysis between European minimum and maximum data.

4.3 Changes in HLY65+ within each member state and welfare regimes

Data from WHO European region database include information not only about European member states but also about ex-Soviet Union Republic countries. Comparative analysis shows that in 2015 the lowest estimated life expectancy at birth was 62,2 for male in Turkmenistan, while the highest was 85,4 for female in Spain: a gap of 23,2 years. Within European member states the gap for male was of 12,6 years: between 68,1 in Lithuania and 80,7 in Sweden; while for female the gap was 7,5:

between 78 in Bulgaria and 85,4 in Spain[1]. Observing the female and male values, no series of HLY65+ for any country is stationary, with the exception of Spain, Portugal, Greece, and Italy (Yes=p-value>0.1, significant trend; No=p-value<0.1, non-significant trend). Nevertheless, Greece and Italy appear stationary according to the D-F test since they dropped dramatically in the first years (and before 2004) and then remained stable.

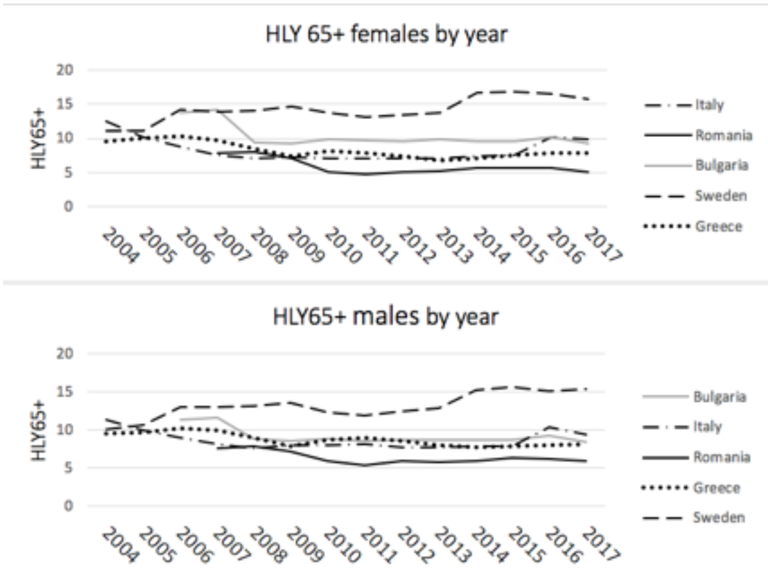
Comparative analysis of the relationship between changes in HLY65+ and welfare regime shows that there is no common trend for the four main welfare regimes. They have been differently affected by changes in HLY65+, but for the Southern welfare regime the negative trend is more evident. The European average for HLY65+ remained stable in the period 2004-2015. The trend is minimal (0.008) and not statistically significant, both in females (slightly decreasing) and in males (slightly increasing). Nevertheless, many countries exhibit large variations; 11 countries have worsened their HLY65+ in the last 12 years, 5 of them in a statistically significant way, among them in descending order of severity are Bulgaria, Italy, and Greece. This trend has also affected Denmark, a Scandinavian welfare regime, and the Netherlands, a Bismarckian welfare regime.

On the other hand, 17 countries have improved their HLY65+ and 13 of them in a statistically significant way (95% and 99%). Scandinavian welfare regime countries (Sweden, Norway and Finland) mainly present positive and statistically significant trend. Finally, 7 countries did not present a statistically significant trend.

In all countries, both the female and male trends are consistent; however, where it is positive, it is less positive for women (except for Sweden, Cyprus, Czech Republic, and Estonia), and where it is negative, it is worse for women (except for Denmark). Finally, while at the European level the maximum values per year have grown at a statistically significant rate, the minimum values have not experienced a statistically significant trend.
The chart shows the countries ordered from the higher variation in terms of improvement of the trend in HLY65+. The first glance at the table reveals immediately the high inequality among EU countries: 8 nations have worsened their HLY65+; 8 nations have not exhibited any significant trend and 13 countries have improved their HLY65+. This outcome reflects the absence of a common health policy in EU; each country competes each other and the final outcome, as usual, is that there are some winners on the one hand, and some looser on the other one. Countries which deteriorated their HLY65+ most are Bulgaria, Romania, Italy and Greece. Their trends are showed in the following chart, in comparison with EU country which has performed best in term of HLY65+ over the period analyzed: Sweden. Data are considered from 2004 to 2017. For Italy and Greece data would be available from 1995, but this is not the case for Bulgaria and Romania, therefore we can only show the HLY65+ trend of these countries in a single common graphic starting from 2004.

[1] Source: European Health for All database (WHO): $https://dw.euro.who.int/api/v3/export?code=HFA\_70$

Figure 4.1: The worst countries ad HLY65+ trend against the best one, 2004-2017, Source: Eurostat



In 2017, the HLY65+ for a Swedish female was 15.8, while for Greek female was 7.8; and for Swedish male 15,4 while 8.1 for Greece males. As the chart shows, the worst countries in Europe, as for HLY65+, aggravate their index between 2004 and 2010; after that, they remain approximately steady. On the opposite, Sweden trend increase over the whole period except for a brief pause between 2010-2013 where it suspended its growth. This general trend between worse countries and the better one, applies to both males and females.

It is interesting to note that Bulgaria, Romania, Greece and Italy, which performed worst, have been severely affected by changes in the demographic composition, due to young population migration outflows and elderly of staying population. For example, in Italy the total migration outflow passed from 9.121 people in 2000 to 40.551 in 2017, while Greece increased its outflow mainly after the economic crisis in 2008 passing in a single year, from 2009 to 2010, from 15.732 to 47.125 people. In general, the people who emigrate from these countries are not compensated by immigration flows, except for Italy, but also in this case the problem is that the new immigrant in general earn lower pays, and in turn pay less taxes, i.e. less resources are available to take care of old people. On the other hand, there is the permanent problem of residential population ageing, that in general characterizes the Western industrialized countries. In Italy, according to OECD statistics, the percentage of people 65 years old and more was 16.5% in 1995 but 22.3% in 2017; in Greece was 15.3% and 16.2% in 2017; in Romania was 17.6% in 1995 but 25.9% in 2017 and finally, in Bulgaria the percentage was 22.2% in 1995 and in 2017 was 31.1% (Source: European Core Health Indicators). The population ageing implies that health systems need of more resources to work well; on the other hand, however, the problem is that the percentage of workforce on total population decreases, therefore, *ceteris paribus*, there are less tax receipts and then less resources. The bad performance of these four countries is explained not only by institutional reforms (neoliberal policies) but also by demographic dynamics.

The table above, shows that on the one hand the maximum value increased for both

Table 4.1: Maximum and minimum HLY65+, sex disaggregated data, 2004, 2017 and Delta

	2004	2017	Delta absolute value	Delta %
Male Max	13.3 (Denmark)	15.4 (Sweden)		
Male Min	4.6 (Estonia)	4.1 (Latvia)		
Male Gap	8.7	11.6	2.9	33
Female Max	13.5 (Denmark)	15.8 (Sweden)		
Female Min	3.8 (Portugal)	4.1 (Slovakia)		
Female Gap	9.9	13	3.1	31

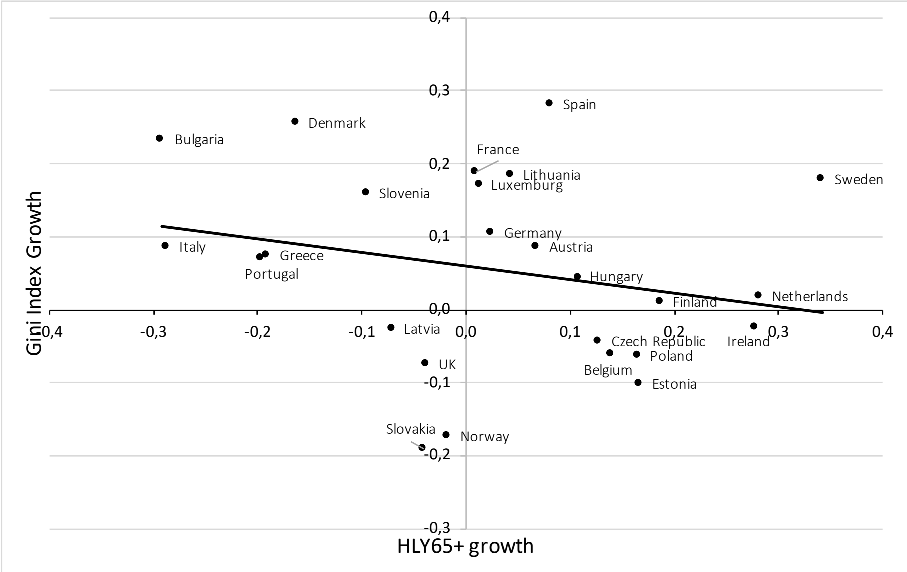
the female (from 13.7 to 16.8) and male population (from 13.3 to 15.7); on the other hand, the minimum value decreased for males (from 4.6 to 4.1) and it is stationary for females (3.8). Nevertheless, the male minimum data is still above the female level, showing that part of the female European population has worsened HLY65+ compared to the male one. Moreover, the gap between maximum and minimum values in Europe (Delta%) increased for both the male (33%) and female population (31%), and it is wider for females (13 years against 11.6 for males). The absolute difference (delta absolute value) between male and female gap increased too, respectively of 2.9 and 3.1.

4.4 Income inequality and HLY65+

In this section we link the trend in HLY65+ of EU countries with an index of income inequality. Economic inequality, indeed, is a typical characteristic of neo-liberal era and it is linked, as Literature has already stated, to health inequalities. The huge inequality in health conditions among countries that we have just studied in the previous chapters, is also reflected in income distribution. The empirical evidence, is that high level of income inequality is associated to low level of public health.

To find this relationship we adopt, as proxy of income distribution, the well-known Gini index. The Gini index varies from 0 to 1 (0 perfect distribution, 1 a single person earns all the income of the country) so that the higher the index is, the higher the income inequality is. The idea is to compare the Gini index average trend (from 2004 to 1995) with the average trend of HLY65+ (from 2004 to 2017), for all of the 28 EU countries (plus Norway). By this way, we will not simply compare HLY65+/Gini index for a single year. On the opposite, we are comparing how a long-term trend (positive or negative) in Gini Index is associated to a long-term trend (positive or negative) in HLY65+. We estimated the average trend in Gini index with a simple OLS model (Data are in table A1 of Appendix). Income inequality was measured with the Gini index provided from the Standardized World Income Inequality Database (SWIID). The SWIID is based on the Luxembourg Income Study (LIS) and offers comparable high-quality data.

Figure 4.2: HLY65+ average growth vs Gini index average growth, 2004-2017, Source: Eurostat



The chart shows the evidence of a negative link between Gini index and HLY65+. Indeed, in that countries where the income distribution has concentrated most over the period observed, the expectance of healthy life after 65 years has followed (on average) a declining trend. An outlier is Sweden: it is the first country in Europe as HLY65+ increment meanwhile it exhibits one of the highest Gini index increments. Other countries which do not perfectly fit the general trend are Slovakia and Poland, where inequalities have strongly reduced while HLY65+ has remained quite stable (a slight decline). The other countries, on the other hand, respect the general trend. By the graph the countries which perform best (i.e. high HLY65+ increment joint to high Gini index decrement) are Finland, Belgium, Portugal, Estonia and Czech Republic. On the other part, the countries which perform worst (i.e. High HLY65+ decrease joint to high Gini index increase) are Bulgaria, Denmark, Slovenia, Italy, Greece and Romania.

Now we want to test if this correlation between income inequality and HLY 65+ is also a causation. Until now, indeed, we only found a negative correlation between Gini index and HLY65+, but correlation does not mean causation. In order di conclude our study about the linkage inequality-HLY65+ we need to do an econometric estimation. We consider 27 countries of European Union (except Croatia because of the lack of data) plus Norway, over a period of 23 years (1995-2017). The last year is 2017 since it is the last available for HLY65+ while Croatia has excluded as Eurostat provides HLY65+ data only for a few years. We used Eurostat data for HLY65+, SWIID database for Gini Index and the World Health Organization database for the other control variables. We get a large panel database, complete of all European countries (except Croatia), that we used to set-up our estimations. We initially run a Pool OLS regression in order to test which regression model would be the best. The Breusch-Pagan statistical test rejects the hypothesis that the pooled OLS model is adeguate (p-value = $1.18e-195$) in favor of Random Effects and Fixed Effects model. The Hausman test rejects the null hypothesis, therefore the Fixed Effects model is adeguate (p-value = 0.0002).

According to compositional approach, both behaviors and socioeconomic characteristics of people living in a particular area affect the health of the population in such place. As for behavior variables, we plug in the model the percentage of population overweight (Bmi index, Bmi> 30). The International Obesity Task Force (IOTF) and the WHO have raised awareness of the magnitude of obesity and its impact on morbidity and mortality, quality of life, and cost of healthcare (2000) and a WHO report (2003) on diet and health recognizes the impact of obesity on the development of some of the most widespread chronic diseases, namely, type 2 diabetes, cardiovascular disease, skeletal-muscle pathology, and several types of cancer. The three main key behavioural variable are therefore alcohol consumption, overweight rate and tobacco consumption.

As for socioeconomic characteristics we plug in the model the income inequality measured by the Gini index, the per-capita social expenditure of the State, the per-capita GDP and the percentage of Migrated people over the population. Gini index is the most common inequality index, therefore, to test our hypothesis (income inequalities affect healthy life), we plug it in the estimating equation of the panel model. We add a cross product variable of Gini index and per-capita GDP in order to test how the effect of inequality on HLY65+ changes according to the level of income. We also regress HLY65+ on an other income inequalities index as a robustness check of our findings. As other measures of income inequality we use the ratio of the average income of the 20% richest to the 20% poorest (S80/S20). Both of them are provided by Eurostat. The social public expenditure count for elements such as the possibility to access health care services, child care, the quality of schools and housing; the higher the quality and the accessibility of these services is, healthier the life is (Bambra, 2019). Together to social public expenditure it is important to consider the Migration effects on HLY65+. We finally distinguish HLY65+ for males and females. The estimation equation is:

$$\begin{aligned} HLY65+_{i,t} = \alpha_i + \beta_1 INQ_{i,t} + \beta_2 gdp_{i,t} + \beta_3 INQ_{i,t} \times GDP_{i,t} + \\ + \beta_4 SOEX_{i,t} + \beta_5 OVW_{i,t} + \beta_6 MIG_{i,t} + \epsilon_{i,t} \end{aligned} \tag{4.1}$$

Table 4.2: Panel Model: HAC (Robust SE), dependent variable HLY65+

	Total (Gini)	Male (Gini)	Female (Gini)	Male (S20/S80)	Female (S20/S80)
INQ	3.7072	3.0255	4.3867	4.5036	6.3043
	(0.6583)***	(0.5856)***	(0.7594)***	(1.5135)***	(2.0080)***
INQ×GDP	−0.3774	−0.3067	−0.4449	−0.4557	−0.6248
	(0.0664)***	(0.0593)***	(0.0766)***	(0.1543)***	(0.2047)***
gdp	9.3267	7.4038	11.1555	0.8758	1.4404
	(1.9923)***	(1.7800)***	(2.2979)***	(0.8748)	(0.1620)
SOEX	9.28e-4	8.57e-4	9.55e-4	7.68e-4	8.95e-4
	(1.38e-4)***	(1.21e-4)***	(1.59e-4)***	(1.26e-4)***	(1.70e-4)***
OVW	−0.1135	−0.0516	−0.1776	−0.0595	−0.2051
	(0.0478)**	(0.0426)	(0.0551)***	(0.0425)	(0.0566)***
MIG	0.0646	0.0594	0.0683	0.0671	0.0785
	(0.0168)***	(0.0151)***	(0.0194)***	(0.0151)***	(0.0200)***
Const	− 82.9373	−67.4523	−97.8595	−2.0807	−0.8236
	(20.1028)***	(2.1589)***	(1.3188)***	(8.7334)	(11.6153)
F-Test	5.3e-128***	5.7e-139***	7.4e-116***	2.7e-137***	2.6e-110***
Observations	441	449	441	437	429
$R-Squared$	0.8152	0.8314	0.7875	0.8368	0.7831

*Significance Level: * 10%, ** 5% and ***1%

Where α_i is the ith-country fixed-effect; INQ is the inequality index; gdp is the logarithm of per-capita GDP; $SOEX$ is the social expenditure of the government; OVW is the percentage of overweight population and MIG is the percentage of migrated people over population. The Wald joint test on the dummy-time variables states that there are no temporal effects (p-value = 0.2684).

In all the five models the inequality the indexes of income inequality are all statistical significative and their socioeconomic interpretation is the same: an increase in the GDP of a country rises the negative effect of income inequality on the expected life years after 65+. In the poorest European countries, income inequality has a lower effect on HLY65+ while in the richest ones it affects HLY65+ in a stronger way. For example, in Norway, one of the highest per-capita income European country, income inequality is expected to have reduced HLY65+ by 8 years from 1995 to 2017. The other control variables have consistency sign.The logarithm of GDP always affects positively the level of HLy65+ and the social public expenditure, as expected, is strongly and positively linked to the HLY65+ improving its values the higher it is. Migration affects HLY in a statistical significantly way with a positive sign; this fact could be interpreted by considering the young age that on average characterize the migrant population. These estimations suggest the inflows of foreign young people should improve the HLY65+, perhaps because they make-up for the lack of man-power concurring in paying taxes and therefore to finance the social expenditure and other social services. Finally, the model confirms the wide literature on the effect of overweight on public health. Also for the case of HLY65+, the higher the overweight population, the lower the expected healthy life is. As for the differences between males and females these estimations reveal a similar force of impact for income inequality variables, migration and social expenditure. What is more different is the impact magnitude of GDP and overweight on female population. Females health seem to be affected by the level of per-capita GDP stronger than males (11.1555 vs 7.4038). However, it is even more evident the impact of overweight on expected healthy years 65+; overweight impacts far more stronger females than males (-0.1776 vs -0.0595).

4.5 Health inequalities in Europe: policy matter in neoliberal era

The comparative analysis of an HLY65+ represents a key indicator in investigating health inequalities (Salomon et al 2013; Stiefel, 2010; Robine, 1992). This study extends, and updates some of the main results in health inequalities literature (Mackenbach, 2006; Beckfield, 2018), adding more evidence concerning the HLY65+ trend between 2004 and 2015. HLY65+ within each European member state exhibited no consistent trend: in some countries increased and others decreased, showing the presence of severe health inequalities. Findings highlight a positive performance in most of the Scandinavian (Sweden, Norway and Finland), Bismarckian (Germany, Belgium, Austria, France) and Eastern Europe (Czech Republic, Estonia Hungary) welfare regime countries, and a negative trend for Southern welfare regime (Italy and Greece). Nevertheless, the negative trend in HLY65+ had also affected a Scandinavian country (Denmark), a Bismarckian case (the Netherlands) and four Eastern Europe countries (Bulgaria, Latvia, Romania, Croatia), highlighting that none of the welfare regimes has been immune to such neoliberal epidemic, even if the Southern regime has been more vulnerable.

The sex differences in HLY65+ confirmed in this study have been observed in other studies (Crimmins and Saito, 2001; Baerlocher, 2007; Jagger et al., 2008) showing that on average, women tend to live longer than men and in better health conditions. Nevertheless, the health inequalities in HLY65+ is higher for female than for male population, showing that female are more effected by such trend. Female population, more than male population, has been more exposed to such inequality epidemic, paying the price of a decreasing in HLY65+. Sex disaggregated data usually show both similar trends and small differences by gender. The female population usually presents better HLY65+, but this was not observable in all countries. In Italy and in Greece, compared to the average of European countries, females present worse HLY65+ especially after the year 2006. Despite the decrease in HLY65+ in Denmark, the female population has been less affected by such a trend, while in Sweden, the increase has been wider than for the male population showing an advantage position for the female population in such Scandinavian countries.

Analysis on the causation between differences in income inequalities and HLY+65 push forward the debate on the role of macro elements on health of the population. We run our estimations on one of the widest and most complete database in the literature, that we built-up for the purpose of this paper. Our estimates confirm the crucial role played by income inequalities in the causation of health inequalities in a robust way, using two different indexes of economic inequalities distinguishing both for males and female. Moreover, migration seems to improve the expected healthy life years for elderly population while the overweight is a severe problem, affecting HLY65+ in a strong and negative way. Finally, our estimations reveals that the country effect is significative, i.e. the welfare regime adopted by countries matters (the country fixed-effect is statistical significative). As shown by this study, therefore, considering the wider mechanism in health inequities (Kriznik et al., 2018), place matter because policy matters: 'social welfare matter' (O'Campo et al., 2015), confirming the main literature on neoliberal welfare policy and health inequalities (Högberg, 2017), (Kwarteng et al., 2013; Kriznik, 2018; Farrants, 2017; Högberg, 2017). Inequalities in HLY65+, are a result, above all, of macro political factors, "are socially produced and therefore are potentially avoidable and widely considered unacceptable in a civilised society" (Lynch, 2017). Such inequalities being "unfair and stemming from some form of injustice" (Whitehead, 2007), "could be avoided by reasonable means" (Kawachi et al., 2002). Keeping the focus on macro neoliberal policy dimensions should avoid the risk for further neoliberal derive towards individualisation of inequalities, as victim blaming approach, and medicalisation of inequalities (Lynch, 2017).

4.6 References

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Table 4.3: Maximum and minimum HLY65+, sex disaggregated data, 2004, 2017 and Delta

Country	Welfare Regime	Presence of Trend	D-F test (Male+Female) OLS	OLS Female	OLS Male
			Positively Trend statistically significant		
1. Sweden	Scandinavian	YES	0,342***	0,359***	0,343***
2. Norway (no EU)	Scandinavian	YES	0,282***	0,248***	0,289***
3. Ireland	Bismarckian	YES	0,278***	0,278***	0,278***
4. Malta	Hybrid	YES	0,271***	0,288***	0,300***
5. Cyprus	Southern Europe	YES	0,217**	0,222**	0,137*
6. Finland	Scandinavian	YES	0,187***	0,162***	0,210***
7. Estonia	Eastern Europe	YES	0,167***	0,195***	0,139***
8. Portugal	Southern Europe	NO	0,165*	0,168*	0,163**
9. Belgium	Bismarckian	YES	0,140***	0,165***	0,115***
10. Czech Republic	Eastern Europe	YES	0,128***	0,126***	0,095**
11. Hungary	Eastern Europe	YES	0,108***	0,080***	0,127***
12. Austria	Bismarckian	YES	0,068	0,044*	0,092**
13. France	Bismarckian	YES	0,010***	0,091***	0,108***
			Trend statistically not significant		
14. Luxemburg	Bismarckian	YES	0,013	-0,07	0,096
15. Germany	Bismarckian	YES	0,0259	0,012	-0,036
16. Lithuania	Eastern Europe	YES	0,043	0,032	-0,003
17. Spain	Southern Europe	NO	0,082	0,092	0,071
18. Poland	Eastern Europe	YES	-0,017	0,004	-0,060
19. UK	Liberal	YES	-0,038	-0,019	-0.020
20. Slovakia	Eastern Europe	YES	-0,04	-0,015 0,011	
21. Slovenia	Eastern Europe	YES	-0,095	-0,177**	-0,066
			Negatively Trend statistically significant		
22. Latvia	Eastern Europe	YES	-0,071**	-0,070	-0,071**
23. Netherlands	Bismarckian	YES	-0,093**	-0,154***	-0,036
24. Denmark	Scandinavian	YES	-0,163***	-0,151***	-0,176***
25. Greece	Southern Europe	NO	-0,191***	-0,215***	-0,166***
26. Romania	Eastern Europe	YES	-0,196**	-0,232**	-0,160**
27. Italy	Southern Europe	NO	-0,287***	-0,332**	-0,237***
28. Bulgaria	Eastern Europe	YES	-0,292***	-0,295**	-0,192**
29. Croatia	Eastern Europe	YES	-0,386**	-0,407**	-0,365**
European Union	-	NO	0,047*	0,013	0,033**

Final Considerations

Income inequalities appear to be heavily influenced by ICT innovations and bargaining among social groups. In Chapter 1 we found that productivity growth over the last two decades has been indisputably driven by ICT; in turn, productivity growth over the period under review has affected the number of full-time permanent jobs, negatively and in a strongly statistically significant way. With a forecast based on the equation estimated, we easily found that in the next 30 years, it is likely that more than 60% of full-time permanent jobs will be replaced by unemployment and occasional jobs, a trend already confirmed by the OECD data since the 1980s.
These outcomes suggest that an important change in the structure of job market is taking place. In Chapter 2 we update and confirm the trend already found in the literature: we are moving towards an economy where there is less need for routinary jobs (replaced by artificial intelligence softwares) and more need of not-routinary jobs (more difficult to be replaced by machines). This revolution in the labor market has important consequences on income distribution. Indeed, the routinary jobs are traditionally associated to the middle-income professions, while not-routinary jobs involve both high-income (not-routniary and skilled) and low income professions (not-routinary and not skilled). The thinning of the middle class is a direct effect of the great improvements brought about by the fourth industrial revolution, so it can hardly be reversed, at least in the short term. The political consequences of the middle class thinning could be explosive for liberal systems, since in a *superstar economy* the median voter theorem no longer holds.
In addition to technological factors, income inequalities are also affected by social dynamics. In Chapter 3 we try to show it from a price-level perspective. We found that inflation is mainly influenced by three source of variables: the income distribution among the working class and managers/owners; what we call "the government monetary intervention" that is the creation of money to finance state spending; productivity growth. The latter has already investigated in the previous chapters and, consistently with common economic knowledge, an increment in productivity, *ceteris paribus*, reduces the price level. However, the first two variables affect inflation much more strongly. The level of profit and wages of the economy, that is a direct consequence of bargaining among firms and trade unions, is the main source of inflation trend. Furthermore, the creation of money by the government, that the monetarist approach typically associates to inflation, could be seen itself as a form o bargaining among social groups in what we call "capitalist patronage" and "workers patronage". Finally, social groups also compete for the welfare regime, which in turn affects the

final income distribution. In Chapter 4 we run a comparative analysis among European countries using HLY65+ as a key indicator in investigating health inequalities and associating it to the different welfare regimes chosen by each nation and its level of income distribution. The analysis has confirmed that Scandinavian welfare regime presents the best outcome in term of HLY65+. Individual (micro) and area (meso) deprivations are summed and affected by political-neoliberal (macro) level. Inequalities in HLY65+, as results of micro, meso, but above all macro political factors, are socially produced and therefore are potentially avoidable: only the bargaining of disadvantaged social groups could reverse this trend.