Are you NUTS? The factors of production and their long-run evolution in Europe from a regional perspective

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Are You NUTS? The Factors of Production and their Long-Run Evolution in Europe from a Regional Perspective

Ralph Hippe [*]

Abstract: *»Sind Sie NUTS? Produktionsfaktoren und ihre langfristige Entwicklung in Europa aus regionaler Perspektive«.* Standard economic growth models generally consider different factors of production such as land, capital, labour, technology and human capital. These are common in theoretical models and empirical applications but more evidence is still needed for their long-term regional evolution. Therefore, this paper traces the evolution of specific aspects of these factors in the European regions and cities by means of different proxies. The data have been collected and calculated from a wide range of diverse historical and spatial data bases. A particular feature is the definition of the European regions according to the NUTS classification by the European Union. Thus, the paper gives a rough outline of some of the most important long-term regional tendencies that should be taken into account in research directed to past and recent time periods.

Keywords: factors of production, regional development, Europe.

1. Introduction

Economic output is defined in the standard economics literature as a result of the interaction between different factors of production. The most common factors of production are land, capital, labour, technology and, more recently, human capital.[1] At least some of these factors are used in almost all theoretical economics models in this area and have been approximated by econometric applications in a variety of ways. Nevertheless, there is often a separating line between standard economics which commonly works with data from the last decades and economic history which is more concentrated in historical frameworks. In contrast, general and broad theories such as Unified Growth Theory

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[1] Other factors of production are, for example, social capital (Felice 2012), entrepreneurship and natural resources (Baumol and Blinder 1991). See Xu et al. (2009) for a brief historical overview on the theories of the factors of production.

(Galor 2005, Galor 2012) have enabled to get the full picture of economic development in the very long run.

On the other hand, economic geography theories such as New Economic Geography (e.g., Krugman 1991a, b, Fujita et al. 1999, Krugman 1999) explain the inequalities and convergence processes that characterise economic activity in space. They have also been applied to historical settings. Nevertheless, testing Unified Growth Theory models in particular needs more data for the long run, whereas New Economic Geography models rely on geographic and spatial components whose access has been progressing during the last years.[2] But there is still much more potential which has not yet been appropriately exploited.

For this reason, the aim of this paper is to give a rough descriptive outline of the various factors of production in Europe in a long-term regional perspective. Moreover, a particular feature of our approach is that we use common boundaries throughout time, enabling long-term regional comparisons. These boundaries are defined according to the Nomenclature for Territorial Units of Statistics (NUTS) that has been developed by the European Union.[3] It is the standard regional break down used for current data, often provided by the official Statistical Office of the EU, Eurostat. In addition, we exploit city data to complement the picture on the spatial evolution of the factors of production. Even though the employed data are in part standard in the literature, they have not been presented within such a common and combined framework. This feature may give new insights into the economic long-run evolution in Europe.

The paper is structured as follows: The first section gives a brief introduction to the factors of production and various economic growth models that rely on them. Afterwards, the methodology and the data are described in detail. Subsequently, we present the results of applying the methodology for the five most common factors of production: land, capital, labour, technological progress and human capital. A final conclusion sums up the paper.

2. Brief Overview of Economic Growth Models

Let us briefly take a look at the different economic growth models. Growth models may be categorised into exogenous and endogenous growth models (Schütt 2003). First, exogenous growth models do not explain growth in the

[2] In Europe, the EU has set up an initiative called Infrastructure for Spatial Information in the European Community (INSPIRE). It aims at providing more spatial data, even though primarily directed to the current time. The underlying directive was set up in 2007 and until now it is an ongoing project whose full implementation is obligatory by 2019 (European Commission 2012).

[3] The abbreviation comes from its French version, "*Nomenclature des Unités Territoriales Statistiques*".

model itself but growth is assumed to be given at an external rate. To name an example, neoclassical growth models *à la* Solow use the factors of production capital, labour and technological progress (Solow 1956). There are also varieties of these Solow models. For instance, the human capital augmented Solow model introduced explicitly human capital into the production function.[4] Second, endogenous growth models are different from exogenous growth models in the way that economic growth is not exogenously given but determined by the model. Because the rate of economic growth is very important and may be distinctive in different economies, this allows a much better understanding of the dynamics behind economic growth.

There are two major different types of endogenous growth models, focussing either on human capital accumulation or technological change. Human capital accumulation is a strand that was initiated by the seminal work of Lucas (1988). In these models, growth is dependent on the maximum growth rate in the economy and the share of time that is spent by individuals on the acquisition of skills. Moreover, the second type of endogenous growth models was founded by Romer (1990). The importance of technological change for the generation of economic growth is underlined in these models. Economic growth depends firstly on the stock of ideas which expands as the variety of goods increases. Second, the existence of knowledge spillovers is assumed because all workers (here researchers) have equal access to this (increasing) stock (Schütt 2003).

The most recent contributions in the area of economic growth come from Unified Growth Theory and New Economic Geography. Unified Growth Theory aims at explaining economic growth in the very long run since the beginning of human kind. Therefore, it is a broad and flexible framework which can be adapted to special cases (Galor 2005, Galor 2012). On the other hand, the goal of New Economic Geography is to understand why concentration of economic activity occurs in space (Krugman 1991a, b, Fujita et al. 1999). Concentration is a characteristic feature of economic activity and of human activity, which is highlighted by economic hubs such as Silicon Valley and urban centres such as Tokyo. Both theories are helpful to consider both the very long term and the spatial part of European development. Therefore, the information provided in this overview may contribute to bring together theory and facts.

[4] For more information on the link between economic growth and human capital, see Demeulemeester and Diebolt (2011).

3. Methodology and Data

We use the NUTS classification which has progressively been developed by the European Union during the last decades. This is a standard geographical break down of European space. More precisely, it includes the countries of the EU, EFTA and candidate countries of the EU.

It is defined by three basic principles which have been set up to improve comparability throughout Europe: population size, administrative divisions and geographical units (see Eurostat 2011a). What does this mean? The first principle is based on the criterion that the regions should have a similar population residing in them. For this reason, different thresholds have been defined which determine whether a region is classified as being a NUTS 1, 2 or 3 region (NUTS 3 from 150 000 to 800 000, NUTS 2 from 800 000 to 3 million and NUTS 1 from 3 to 7 million inhabitants). The second principle favours the use of already existing administrative regions. This rule makes data collection much easier because the national authorities already provide the data at the corresponding regional break down. Thus, there is no difference between the European classification and the national one, saving effort and avoiding biases and contradictions between different classification systems. Third, geographical units should not be defined according to a certain category but by general terms. This principle also improves the comparability of these regions.

In this way, Europe is categorised into several layers. The lowest level of regional aggregation is the NUTS 0 level, i.e. the country level. The second level is NUTS 1, which in most cases corresponds to the first regional level. For small countries such as Luxembourg or Malta, the NUTS 1 level remains identical to the country level. The same principles apply to NUTS 2 and NUTS 3, each time dividing more aggregated regions into their constituting subregions. This means that e.g. a NUTS 2 region is always perfectly made up by (one or) several NUTS 3 regions, allowing a smooth change from one NUTS level to the next.

Because the NUTS classification is only available for the EU, EFTA and candidate countries to the EU, we use the current regional administrative units for the other European countries (in particular in Eastern Europe).

To perform the analyses of this paper, a very broad range of sources have been used. First, we have used specialised publications that treat one (or more) particular aspect(s) in this paper. For example, we use city data by Bairoch et al. (1988) and data on universities by Rüegg (2004). These are data referring to spatial data points that is cities or locations of universities. Second, we use data on historical regional development. For instance, Coale and Watkins (1986) provide data on fertility and marital status. The historical regions were brought into correspondence with current NUTS regions as best as is possible in such exercises. Third, we used spatial data (such as raster data) whose information has been averaged for each NUTS region. An example are altitude data provid-

ed by Hijmans et al. (2005). By combining these various methods and data sources, we get insights into the evolution of regions that have constituted Europe today and in the past. Note that the purpose of this paper is only to give a rough outline of the different factors and of their evolution. Therefore, it is neither intended nor attempted to explain regional differences or their evolution which would be beyond the limits of this paper. We have to limit ourselves to highlighting some particular striking aspects of the considered variables in time and space.

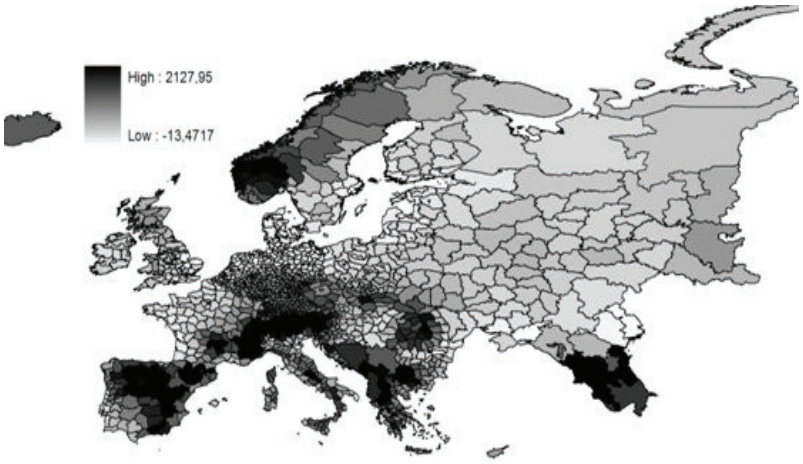
4. Results

4.1 Land

4.1.1 Altitude

Land is constituted by different aspects. One element that may be considered is altitude. Altitude affects economic actors in different ways. First, it increases the cost of transportation because it is more costly and time consuming to transport goods or people to locations that are on a higher altitude level. In this way, second, mountains may also constitute natural barriers. These barriers may define the limits of a territory (e.g., the Pyrenees for the Franco-Spanish border) and increase the likelihood of separate social, cultural and economic developments because they complicate exchange and communication between different peoples.

Figure 1: Average Annual Altitude by NUTS 3 Regions, ca. 1950-2000



Source: Own calculations, based on data provided by Hijmans et al. (2005).

A map of average altitude in the European regions at the NUTS level is presented in Figure 1. The Alps are clearly visible. The fact that Spain is Europe's second country in altitude (behind Switzerland) can be easily guessed. Important parts of Norway, the Balkans and the Caucasus region are also located on rather mountainous areas. In contrast, low altitude characterises in particular England, northern Germany, Denmark, the Netherlands and many parts of Russia.

4.1.2 Temperatures

Temperatures are also natural conditions that have been used in different publications explaining different growth patterns. Moreover, the soil of land is heavily affected by climatic conditions. Thus, temperatures have been used in the literature as instrumental variables (e.g., Galor et al. 2009) which underlines the appropriateness of considering them in the present context.

In international comparisons, temperature may be linked to the distance to the equator, the existence of deserts, tropical and subtropical weather conditions. The differences in Europe are not as high as in a worldwide perspective but still remarkable and important for shaping local culture and local economies.

Thus, the more southern a region is located, the higher are the average annual temperatures. However, the Alpine regions have lower values due to their high altitude. This observation can also be made e.g. for the Carpathian regions.

4.1.3 Precipitation

Precipitation has also been used by recent publications as an instrumental variable (e.g., Galor et al. 2009). We consider average annual precipitation between 1950 and 2000. In each case, the highest precipitation values come from different geographic areas. A first group consists of regions with a direct contact with the Gulf Stream (e.g., Iceland, Ireland, Scotland, Norway, northern parts of Spain and Portugal). Second, a further area comprises the mountains in the Alpine region down to Greece. Low precipitation characterises many regions in Spain and in the south-east of European Russia.

In sum, we show that land conditions vary quite significantly in the European regions. These differences have an important impact on regional economic and social development.

4.2 Capital and Labour

Unfortunately, there is a "lack of long-run series for capital across countries" (Prados de la Escosura and Rosés 2010, 141), in Europe and elsewhere. Recent efforts have been made for some European countries (e.g., Földvari and van

Leeuwen 2010; Prados de la Escosura and Rosés 2010). Still, if this fact is true for series across countries, this conclusion applies even more so to regions. Therefore, we are not able to directly show capital accumulation in the European regions but have to be content with much more general notions. For this reason, we put both capital and labour in the same section. First, we present the overall economic development today and in the past before considering economic proxies and labour (population) characteristics in closer terms.

4.2.1 General Regional Economic Development, Today and in the Recent Past

Important geographic disparities in economic activity have always existed in Europe and are still clearly observable. The explanation of these spatial regimes is a major challenge for academic researchers and policy makers alike. Therefore, EU policy attributes an important share of its budget to regional funds (European Regional Development Funds (ERDF), Cohesion Fund, European Social Fund (ESF)) (European Commission 2008). In total, the overall Cohesion Policy for the period 2007-2013 has a budget of € 347.4 billion. This budget is spent on the 'Convergence objective' (81.5%), the 'Regional Competitiveness and Employment' objective (16%) and the 'European Territorial Co-operation' objective (2.5%) (European Commission 2008). These funds are allocated to the regions most in need of economic progress. Globally, one can state that these funds are primarily focusing on countries that formerly constituted the Eastern Communist countries (e.g., East Germany, Poland, Romania) and on countries in Southern Europe (i.e. Greece, Southern Italy, parts of Spain and most regions in Portugal).

This general distinction between two large groups of regions is helpful but not sufficient. There are also major differences within such groups. Therefore, one should consider alternative measures. GDP per capita is an obvious candidate. A cluster including the regions with the highest GDP is located in Northern Italy, Western Austria, Southern Germany, the Benelux countries, the Greater London region and Southern Ireland. Other more dispersed regions have also high GDP levels, such as Southern Finland, the Stockholm region, the Madrid, Basque and Navarra regions, the Greater Paris region and Eastern Scotland. It is apparent that within country differences are quite important in the European countries today, which is why regional funds will also be attributed in the future.

Going a bit more back in time, the spatial concentration of GDP has evolved rather slowly but geographic concentration was still advancing in the period between 1984 and 1999 (López-Rodríguez et al. 2007; López-Rodríguez 2008). Nevertheless, there might be an overall convergence process underway when comparing the year 2008 with 2000. Most of the regions that have a low GDP per inhabitant have higher growth rates than the richer regions. However, the

current financial and debt crisis may threaten this convergence process as some countries particularly in Southern Europe have to cope with major economic fallbacks.

4.2.2 General Regional Economic Development in the Long Run

In addition, our aim is to consider the long-term evolution of economic activity in the European regions. To this end, one may refer to the concept of the Blue Banana (Brunet 2002, see also Hippe and Barmeyer 2009). This economic area has had a very import impact on economic development in Europe – and not only since a few decades. In fact, Braudel (1979) estimates that this region in Central Europe was already crucial in the 13th century. Therborn (1995) even believes that it goes back to the 9th century. In sum, "[t]he core of European industrial societies proves to be almost identical with the city belt that dominated economic development in pre-industrial Europe" (Heidenreich 1998, 315).

Where is this area located and what are its origins? Products from the Eastern Mediterranean arrived in the commercial trade cities of Northern Italy (see Brunet 2002). There were two major possibilities to transport them to the consumers of North-Western Europe: first, shipping the goods through the Mediterranean Sea all around the coasts of France and the Iberian Peninsula. The alternative was to transport them by means of rivers through Central Europe. The Rhine has constituted a natural trading route, being the second longest river in Europe and the longest in Western Europe. Subsequently, the Hanse transported these commodities to North-Eastern Europe. For these reasons, the Rhine was an important means of transport and enabled the local communities to become rich trading cities. This, in turn, attracted individuals from other areas which led to the growth of the local population. Until today, the Rhine is a major transport axis and the most important waterway for trade in Europe. This is one reason why there is a banana in population density ranging from North Italy to the British Isles. These important populations in the Blue Banana area lead today to a prominent spatial distribution of the European population.

Therefore, the Blue Banana has been the driver of economic growth in Europe. In consequence, it has also spurred innovation and technological process during the last centuries, as Zündorf states (244; translated by Heidenreich 1998, 315): "[w]herever and whenever innovations occurred in Europe, imitators soon appeared who provoked a competitive struggle resulting in a rapid diffusion of these changes. Nowhere was this diffusion of changes faster and more lasting than in the blue banana that has always had the best developed lines of communication through a dense girdle of cities".

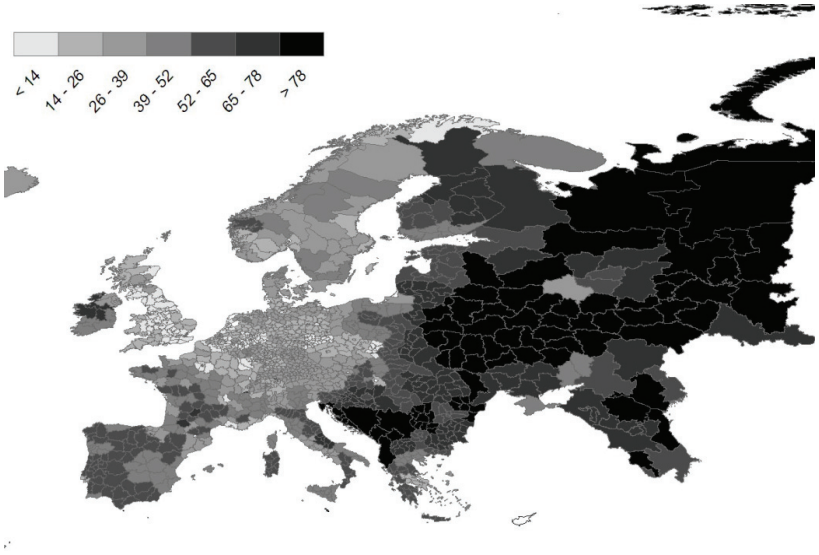
These aspects make it particularly appropriate to make reference to the Blue Banana in a long term approach. Still, estimations have been made that this area has become and will become less important in the future. The decline during the last decades of coal industries which were located close to the Rhine

has contributed to this tendency. Moreover, other geographic constructions such as the Mediterranean Arc or the Atlantic Arc have shown other geographical areas that have seen particular growth schemes due to improved European cooperation (Ministère des Affaires Etrangères 2006).

4.2.3 Measures of Regional Economic Development in the Long Run

We can get an intuition of regional economic development in the past when considering the share of individuals dependent on agriculture in 1930 (Figure 2). This variable can be taken as a rough proxy of industrialisation. More specifically, a higher share stands for a lower degree of industrialisation. However, we are not able to distinguish between the industry and service sectors which may bias the results. Still, it is evident that most British regions are highly industrialised. In other Western European countries we also find several important regions with a low share of individuals dependent on agriculture, such as in Belgium, northern France and different parts of Germany and Scandinavia. But also the Greater Athens region is an important geographic outlier. In contrast, most regions in the Balkans (in particular Yugoslavia) and the USSR are highly based on agriculture. Only Moscow as the capital is more industrialised (and based on services).

Figure 2: Share of Total Population Dependent on Agriculture, ca. 1930



Source: Own calculations, based on data by Kirk (1946).

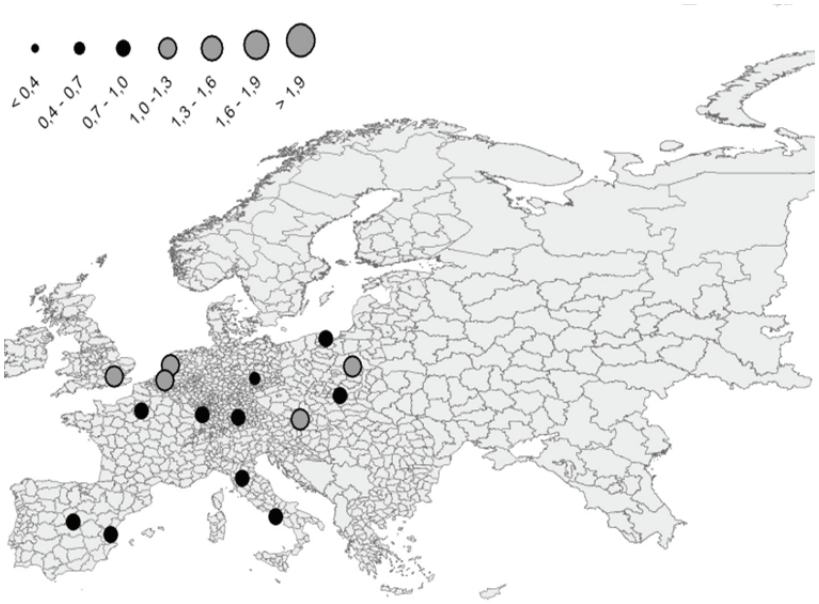
Taking a closer glance at the agricultural sector as such, it is also possible to consider its per capita productivity in 1930. In general, those regions that have a low share of individuals dependent on agriculture have also a high productivity. This result may come from the fact less individuals are employed in the agricultural sector but those are very productive because they have better technologies at their disposal. Therefore, the most productive regions in agriculture are located in the UK, the Netherlands, Denmark, southern Belgium, northern France, northern Germany and Saxony. The USSR, Yugoslavia and Albania are the most important countries with low per capita agricultural productivity.

For much longer time spans, data are available for the economic prosperity of individuals living in European cities. One standard indicator is real wages of workers. Real wages are obtained by dividing nominal wages by an index for consumer prices. Alternatively, Allen (2001) also calculates welfare ratios which are based on real wages. These welfare ratios are defined as "average annual earnings divided by the cost of a poverty line consumption bundle for a family. A welfare ratio greater than one indicates an income above the poverty line, while a ratio less than one means the family is in poverty" (Allen 2001, 425).[5] Therefore, they give an indication of the relative poverty or richness of the individuals working in a city. Allen (2012) offers data for both real wages and welfare ratios from 1300 to 1900 on two different types of workers: building labourers and craftsmen. An example of the data on building labourers can be seen in Figure 3.

The data indicate that the welfare ratios are lower in many European cities around 1500 than during the two centuries before. In most cities in the 16th century, the welfare ratios for the labourers are below the poverty line. Only in London, Anvers, Amsterdam, Warsaw and Vienna the ratios are above 1. The economic situation of building labourers does not improve during the following centuries; in fact, the contrary was often the case. The only cities above the poverty line are London, Anvers and Amsterdam during the 17th and the 18th century. Welfare ratios increase above the line in the 19th century, Paris and Warsaw joining the other three cities. However, building labourers in other cities in central Europe and southern Europe still live below the poverty line at the beginning of the 20th century.

[5] More specifically, Allen clarifies that this poverty line "is computed for a notional family of a man, a women, and two children, and the non-housing component of their poverty line income is set equal to three times [a specific] basket of goods [...] [which] provides only 1941 calories per day. [...] It was possible to get by on less [...] but this level of calories and variety of consumption mark a line between respectability and destitution" (Allen 2001, 425-6).

Figure 3: Welfare Ratios for Building Labourers in European Cities, 1500-1599



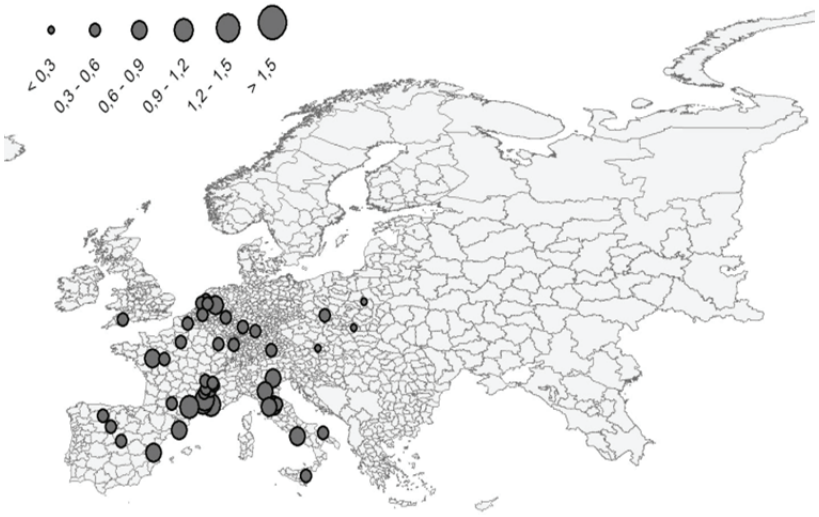
Source: Own calculations, based on data by Allen (2012).

Similar results apply to craftsmen with the difference that craftsmen have higher real wages and their welfare ratios are mostly above the poverty line. Welfare ratios are often the highest in London and Anvers throughout time. Craftsmen in different German cities and later also in Italy see their welfare ratios decrease below the line. Overall, there are striking differences in the welfare ratios of the various European cities whose evolution diverged particularly between the 16th and the 18th century. At the end of the period, i.e. the beginning of the 19th century, welfare ratios increased almost everywhere and permitted higher real wages than during the past centuries.

4.2.4 Commodity Prices (Wheat)

Commodity prices play a fundamental role in our understanding of the evolution of the European economy and trade. The commodity which has (probably) obtained the highest degree of attention is grain in general and wheat in particular. Grain was an important consumed good before the 20th century and was a key product in European trade. For these reasons, data are much more available on this good than on others, allowing to trace its long-term evolution.

Figure 4: Average Wheat Prices in European Cities, 1500-1599



Source: Own calculations, based on data by Allen and Unger (2012).
Note: Prices are in grams of silver for one litre.

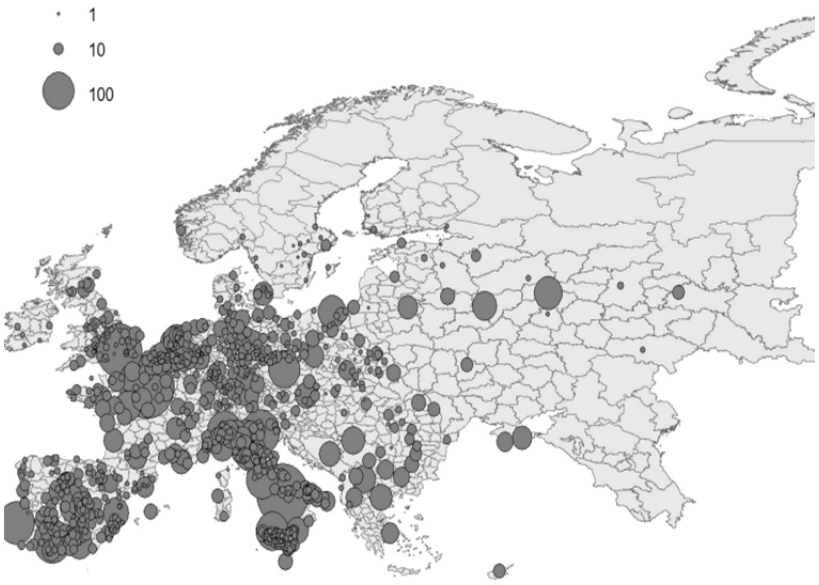
Thus, for the long run before 1800, the database by Allen and Unger (2012) provides a good starting point (see Figure 4 for the period 1500 to 1599). Note that only those cities are depicted where enough data are available for the considered time span.[6] In the 15th century, grain prices appear to be higher in Belgium and the Netherlands than in other European cities. The overall evolution from the 16th to the 17th century is one of increasing grain prices in most cities. The changes to the 18th century are much more ambiguous. In many French cities grain prices fall, whereas they remain constant in the UK and rise in cities such as Naples. Finally, the last 25 years of the 19th century are characterised by higher grain prices in several cities than in earlier centuries. Moreover, wheat prices in Eastern Europe are generally lower than in Western Europe.

[6] Data are available yearly and are averaged by larger time spans. We excluded those cities for each time span where the data are available for less than 7 years for the time span of 100 years between 1300 and 1800 and 25 years between 1800 and 1899. We took this threshold to avoid a possible bias resulting of the inclusion of only a part of a typical business cycle. Taking the assumption that a typical business cycle has a length of at least 7 years, we avoid this bias to an important part while retaining a maximum of the available data.

4.2.5 Population

We consider different characteristics of regional and spatial population distribution. The first one is urbanisation. Urbanisation rates have been used in order to approximate economic development in the long run by authors such as Acemoglu et al. (Acemoglu et al. 2002, Acemoglu et al. 2005). We present here the spatial distribution of these urbanised areas, that is the location and size of cities and agglomerations in the European space from 800 to 1990. The data stem from Bairoch et al. (1988) and Moriconi-Ebrard (1994) (Figure 5 shows an example for 1600).[7]

Figure 5: Location and Size of European Cities and Agglomerations, 1600



Source: Own graphical presentation of city data provided by Bairoch et al. (1988).
Note: City and agglomeration size in thousand inhabitants.

Let us very briefly and roughly sketch some important changes during the millennium. At the beginning of our time period (800 AD), the largest Europe-

[7] The threshold for inclusion in Bairoch et al.'s city database is a minimum of 5000 inhabitants, the threshold for inclusion in Moriconi-Ebrard's agglomerations database is a minimum 10000 inhabitants. See both authors for more details.

an city is located in the Southern part of Europe, i.e. in Spain under Muslim domination: Cordoba. By the year 1000, it is joined by another important city under Muslim rule: Palermo. This scheme remains for two centuries, until in 1200 the population of Paris is of similar size as some of its Southern counterparts. In Western Europe, the most important areas of agglomerations are located in Northern Italy, Northern France, Belgium, Western Germany and in the very South of Spain and Italy. Thus, the focal point of the European economy shifts more and more to the north, "to an axis from the Low countries to Lombardy" (De Long and Shleifer 1993, 677). The entire Eastern half of Europe (from central Germany to the east) is characterised by very few cities during the entire period which is why the urban population is mostly concentrated in Western Europe.

This general distribution remains in existence for the next centuries with the exception that the Southern agglomerations become less important and Paris grows to become the largest city of Europe. Moreover, Naples becomes an increasingly important city. London grows quickly and overtakes Paris in 1700. The dominance of London becomes more pronounced the more the Industrial Revolution advances until 1850. In Eastern Europe, many more small cities are established. In addition, the spectacular growth of St. Petersburg is particularly impressive after its creation in 1703, overtaking Moscow by 1850.

Since 1850, the general spatial pattern has remained intact but urbanisation has been progressing even further, so that most agglomerations are becoming larger and larger. The most important agglomeration becomes Moscow in 1990, overtaking the former Russian capital of St. Petersburg and other major European capitals such as London (largest agglomeration in 1950) and Paris.

Another aspect has attracted the interest of researchers in the last decades and particularly in the last years: fertility. In fact, different fertility patterns have existed in Europe in the past. In most of Europe, a particular European Marriage Pattern (EMP) prevailed. The European Marriage Pattern refers to the regions west from an imagined line going from Russian St. Petersburg to Italian Trieste – the famous Hajnal line (Hajnal 1965; Hajnal 1982). In this area, women were married not after having become fertile but often many years later. After marriage no restrictions were set on fertility (Voigtländer and Voth 2009). This peculiar way of fertility limitation did not exist in the east of Europe.

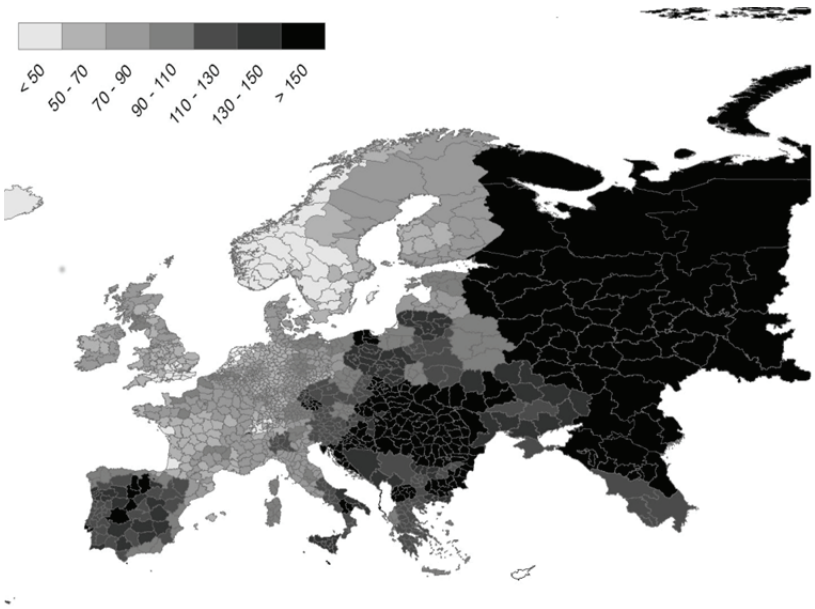
Note that there are three conditions for fertility decline (in particular marital fertility) (Coale 1973). First, fertility has to be determined by individuals voluntarily, so that they can choose the number of their children. Second, it has to appear advantageous to have fewer children than the generations before. And third, it is important that appropriate and effective techniques are available to individuals to reduce fertility.

Recent growth models also take into account fertility. Unified Growth Theory, among others, explicitly refers to the demographic transition (e.g., Galor

2005; Galor 2012). The well-known Quantity-Quality Trade-Off models a decision that parents have to take (e.g., Guinnane 2008; Bleakley and Lange 2009; Becker et al. 2010; Becker et al. 2012). Parents have to choose to invest either in the quantity (number) or the quality (education) of their children, being limited by time constraints. The increased importance of human capital for future earnings of children is seen to be an essential factor for the demographic transition and ultimately economic growth.

Related to fertility is also infant mortality. Falls in fertility are often accompanied by reductions in infant mortality, which is why there is still an ongoing discussion on the interrelatedness of these factors (see e.g., Eastwood and Lipton 2011; Galor 2012). For example, the data tell us that infant mortality was particularly high in Eastern Europe during the interwar period (see Figure 6 for data in 1930-31). But also in the Iberian Peninsula, southern Italy and parts of Bavaria it was relatively high. The most advanced regions came from Scandinavia, England, the Netherlands, Switzerland and France.

Figure 6: Infant Mortality, 1930-31

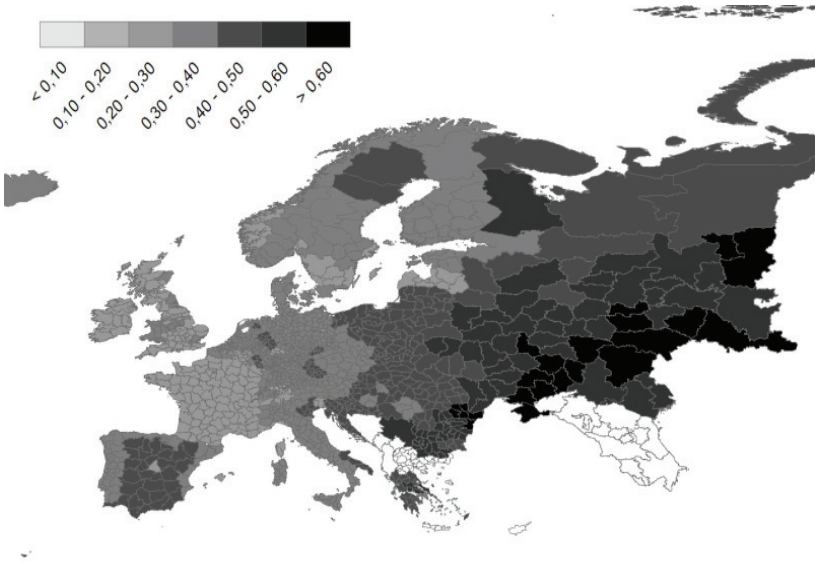


Source: Own calculations, data provided by Kirk (1946).
Note: Infant mortality is defined as "number of infant deaths per 1000 live births" (Kirk 1946, 261).

A major project on the creation of a European fertility database was the European Fertility Project (EFP) (see Coale and Watkins 1986 for more infor-

mation). It created an abundant collection of fertility data for Europe in the 19th and 20th century. We use three indicators to get an insight into the regional distribution of fertility and marriage behaviour in Europe between 1870 and 1960, the most important time span during which the European Demographic Transition took place. First, total fertility is defined as "a measure of the fertility of all women in the population; the ratio of the actual number of births to the hypothetical number if women were subject to the Hutterite fertility schedule" (Coale and Treadway 1986, 154). The same principle also applies to marital fertility, considering the fertility of married women. Second, the marital status is "the ratio of the number of births produced by married women in […] a population to the number that would be produced if all women were married" (Coale and Treadway 1986, 154). In addition, Watkins clarifies that this indicator represents "the proportions married at each age" (Watkins 1986, 315) and can thus be used as a proxy for nuptiality.

Figure 7: Total Fertility, 1900



Source: Own calculations, data provided by Coale and Watkins (1986).

We present a brief summary of the main tendencies of total fertility. The lowest fertility persisted in France, which had already known low fertility throughout the 19th century, and in Ireland, the Scottish Highlands and parts of Sweden in 1870. On the other hand, the highest fertility was calculated in Southern Russia and Romania. The other countries lay between these two extremes. In 1900 most other regions of the UK join France with lower fertility, France still pro-

gressing in low fertility levels (see Figure 7). But also in various other parts of Europe total fertility falls to similar levels (e.g., Norway, Latvia and Madrid).

The general tendency to lower fertility is clearly visible in most European countries in 1930. Nevertheless, whereas this trend continues to advance in most parts of Europe, in particular France, Germany, Austria, the UK and Norway show a pattern of increasing fertility in 1960. Total fertility is now highest in Albania.[8]

Let us further consider the fertility of married women. The lowest values for marital fertility in 1870 are again found in France. France is followed by many regions of Transleithania (the Hungarian part of Austria-Hungary), German Mecklenburg, Italy's Lazio region and several Spanish regions (Madrid, Catalonia, Baleares). Higher marital fertility dominates in particular in many regions of the Russian Empire and Scandinavia. However, the highest shares come from south and west Germany and Belgium.

In 1900, the picture remains globally the same. In most cases, marital fertility is reduced in comparison to 1870. In France, all regions have reached a similar low marital fertility index of about 0.3 to 0.45, only (historically Gaelic speaking) Bretagne stands out and, to a lesser extent, some regions in northeast and north France.

A more radical evolution shows the values for 1930. Marital fertility has further declined in most European regions. This trend is very strong in Germany, Austria and today's Czech Republic, where many regions are now on the forefront of low fertility. The shift is equally important in England and parts of Sweden. Regions of the USSR have now the highest marital fertility. Other regions in Europe characterised by relatively high marital fertility are located in particular in Ireland, the Iberian Peninsula, southern Italy and some regions of Yugoslavia.

Finally, the tendency to lower marital fertility is continued in many European regions in 1960. This is particularly true for the regions of the USSR. However, some countries are already experiencing a renewed increase in marital fertility. France is once again the leader in this trend, increasing its marital fertility in almost all its regions. Similarly are the changes in parts of Germany and Austria. The highest marital fertility remains in Catholic Ireland, Muslim Albania and Buddhist Kalmykia.

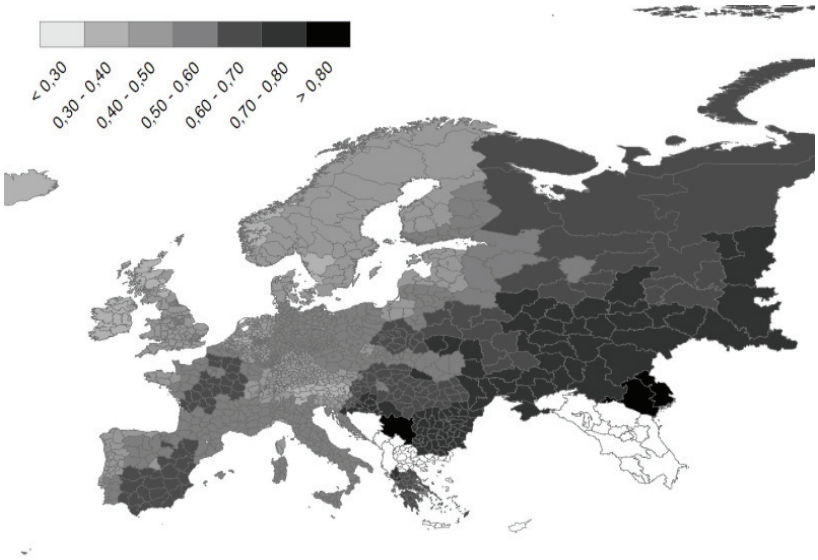
In addition, we highlight the evolution of the marital status (nuptiality) during the demographic transition. Between 1870 and 1900, a reduction in the marital status, i.e. an increase in the average age at marriage, is apparent in the British Isles, northern Spain and Transleithania (see Figure 8 for 1900). In Germany and Scandinavia, one can observe the reverse tendency in several regions. The highest marital status index is generally found in Eastern Europe.

[8] Before 1960, there is no data available on Albania. Therefore, it is possible that Albania had already high fertility rates before that time.

In 1930, the higher marital status in Eastern Europe is in most cases at the same level as French regions and some German regions. An outlier are the Balkans where a higher marital status is still common. A very low marital status is characteristic for Ireland, the Scottish Highlands, distinct regions of Norway, Sweden and Finland as well as in Alpine regions.

Contrary to what may have been expected from the earlier descriptions, the trend towards lower marital status is reversed between 1930 and 1960 and the European Marriage Pattern vanishes. Instead, in almost all Europe marital status increases, i.e. the average age at marriage falls. Particularly in Communist countries in Eastern Europe but also in many parts of Western Europe the increase is clearly visible.

Figure 8: Marital Status, 1900



Source: Own calculations, data provided by Coale and Watkins (1986).

Finally, note that the study of historical and long-term fertility trends in Europe is important to understand the current and future economic and social development in the world. As Engelen and Puschmann stress, the "marriage behavior in the present-day Arab world shows striking similarities to nuptiality patterns which have been described by Hajnal and adherents as typically Western European" (Engelen and Puschmann 2011, 387). One may also come to similar conclusions for other world regions.

4.3 Technological Progress

Technological progress is a very important factor in models that intend to explain economic growth. Clearly, there are very different ways to highlight technological progress. For example, technological progress and innovation may be measured by patent grants (e.g., Acs et al. 2002; Diebolt and Pellier 2009a, b, c; Diebolt and Pellier 2011; Diebolt and Pellier 2012). Another key factor influencing the spatial distribution of economic activity is transport of goods and labour. The Industrial Revolution brought about a revolution in transportation. An illustrative example of the advancement in transportation in Europe in the long term is given by Bretagnolle et al. (1997). The authors highlight that the average time of travelling from Ireland to the South of Italy was two months in 1500. This time was reduced to only one day by 1990. This space-time contraction has been characterising the further advancement of transportation in Europe (Janelle 1969; Juillard 1972; Bretagnolle et al. 1997).

Related to this is a key driver of transportation during the Industrial Revolution: the railway. The railway has been a quick and cost-effective means of transport. The railway network was very important in the further advancement of the Industrial Revolution. Thus, Morillas-Torné (2012) highlights its evolution. The densest networks are located in the UK, Benelux, northern France and the German Empire in 1880. Scandinavia, the Iberian Peninsula, Italy and Eastern Europe clearly lagged behind. Until 1940 the network was enlarged almost everywhere in Europe. Given the progress of alternative means of transport (car, airplane), the lines in service have been reduced in some countries until 2000.

4.4 Human Capital

4.4.1 Basic Human Capital

With the term basic human capital we refer to rather basic education, as highlighted by the ability to count or to read and write. A long-term perspective on basic human capital has been advanced by Hippe (2012a), referring also to earlier work, in particular by A'Hearn et al. (2009), Hippe (2012b) and Hippe and Baten (2012). Given the detailed illustration in earlier work, this paper will only very briefly give some rough indications of regional basic human capital distribution in Europe. The indicators used are numeracy (age heaping), literacy (ability to read and write) and educational attainment (share of a selected group with a certain level of educational attainment with regard to all individuals of the group).

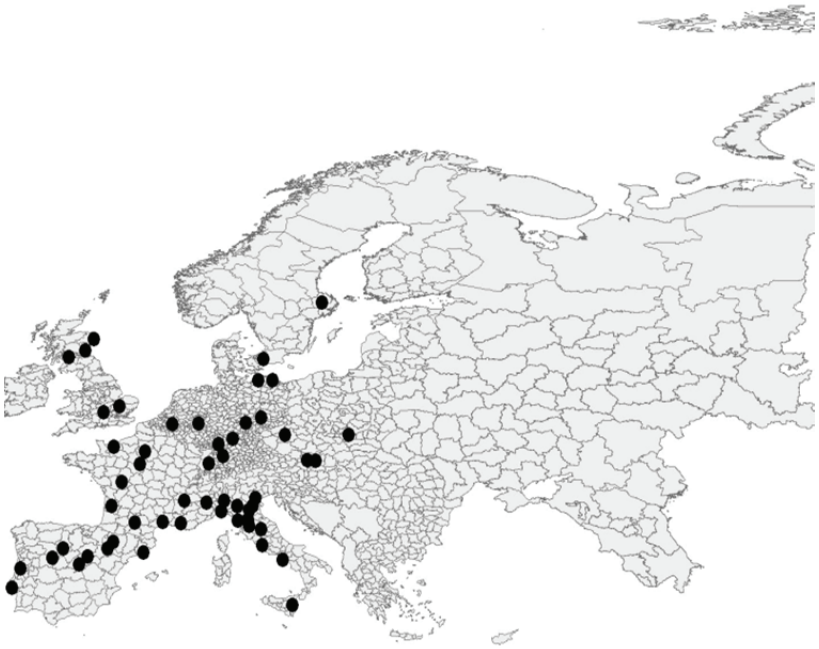
Historically, the earliest and most advanced regions in education can be found in the Germanic countries (Scandinavia, Prussia, Netherlands). In contrast, the regions which caught up only very late (if at all) are located in the European periphery, i.e. in the Iberian Peninsula (in particular Portugal), East-

ern Europe (Belarus, Russia, Ukraine, etc.) and South-East Europe (the Balkans and the Caucasus region).

4.4.2 Advanced Human Capital

More advanced human capital may refer to the study at a level of tertiary education. For this reason, we trace the evolution of the locations of enduring universities in the European space from 1300 to 1944. The original data have been categorised according to different centuries. Note that the data do not refer to all universities that existed at each particular point in time. They only include those universities that persisted at least until the first half of the 20th century, i.e. institutions of higher education which were not of temporary existence and did not close down. For this reason, the number of higher education institutions increases at each period in time. Still, it allows taking some general conclusions.

Figure 9: Location of Enduring Universities, 1500



Source: Own calculations, data provided by Rüegg (2004).

The first institutions of higher research (created before 1300) were located in Bologna, Cambridge, Lisbon, Montpellier, Naples, Orleans, Oxford, Padua,

Paris, Salamanca, Siena and Toulouse. Thus all these institutions were located in Italy, Portugal, Spain and the UK. These countries increased their number of higher education institutions during the following centuries and other countries followed their example. In particular, the Holy Roman Empire began to invest in higher education. First enduring Scandinavian universities were created between 1400 and 1500 (see Figure 9) and in today's Russia only between 1700 and 1800 (in Moscow and St. Petersburg). Only between 1900 and 1944 there was a massive increase in the number of universities in Russia, when most other parts of Europe had already a dense net of universities over their territories.

5. Conclusion

This paper has given an outline of the regional and long-term evolution of the factors of production in Europe. The factors of production are key to standard economic growth models and their applications. We have used a wide range of different sources and proxies to trace the evolution of land, capital, labour, technological progress and human capital. Nevertheless, there are evidently many other alternative ways to measure these factors proposed by theory. Given the focus of this paper, we have advanced the following aspects of land: altitude, temperature and precipitation. Second, capital and labour have been highlighted by the general economic development, real wages (i.e. welfare ratios), commodity prices (wheat), (urban) population, infant mortality, fertility and marital status. Third, the evolution of technological progress was shown by the advance of transport technologies. Last, human capital evolution was particularly demonstrated by the location of institutions of higher education.

Even though we have only outlined very roughly the regional distribution over time of these proxies, this sketch may allow a clearer overall picture of how economic activity has been evolving in space in Europe during the last centuries. In this way, it may underline the possibilities existing in this area of research and motivate more profound future analysis of the issues at stake. This will allow a much better and profound understanding of economic development in Europe at the regional level in the long run.

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