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The impact of natural geography on the economic development of European countries

Nuno Carlos Fernandes Faria

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Sandra Tavares da Silva

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Abstract

It is widely consented among the general public that recent technological endeavors have shattered natural geography blockades and shaped human interaction for years to come. The view that the world is one and profoundly unified defies the natural imposition of geography; hence dueling two seemingly contradictory statements. The main goal of this work is to investigate the influence of natural geographical determinants on the evolution of GDP *per capita* of European economies and thus investigate if natural geography still poses a challenge to economic development. Using an econometric approach and data from CEPII and the World Bank, several regressions are estimated considering as independent variables the distance, temperature, natural resources and the existence of a coastline to explain the evolution of GDP *per capita* in European countries. The pertinence of this analysis comes from the fact that the literature on economic development often neglects the study of developed countries, even if these are frequently characterized by considerable divergences within their territories. Besides, this study attempts to analyse the impact of the natural geography on the economy by looking at more than one natural geographical variable.

This study found that the impact of natural geography is insignificant when institutional characteristics are considered since they seem to reduce the importance of geographical determinants across Europe over time. Moreover, possibly due to institutional convergence during the last decades on the quality of institutions in Europe, these are also incapable, for the most part, of explaining the differences within European countries, leaving room for new explanations to what may cause differences in Europe's economic growth patterns. Constraints associated with the quality of data related to the geographical variables might also be a source of explanation for these results.

JEL codes: O44, O52, O13

Keywords: Geography and Growth, Environment, Natural Geography, Europe

Resumo

É amplamente reconhecido pelo público que os recentes desenvolvimentos tecnológicos destruíram os bloqueios de outrora da geografia natural e transformaram as interações humanas como nunca. A visão de que o mundo é um e profundamente unificado desafia as naturais imposições da geografia, fazendo chocar duas ideias antagónicas. O principal objetivo deste trabalho é investigar a influência de determinantes da geografia natural na evolução do PIB *per capita* das economias europeias e assim averiguar se a geografia natural ainda gera desafios ao desenvolvimento económico. Através de métodos econométricos e com dados do CEPII e do Banco Mundial, várias regressões são estimadas tendo como variáveis independentes a distância, temperatura, recursos naturais e a existência de costa marítima para explicar a evolução do PIB *per capita* nos países europeus. A pertinência desta análise surge num contexto em que os países desenvolvidos tendem a ser relativamente negligenciados na literatura do desenvolvimento económico, mesmo quando estes apresentam diferenças significativas quando comparados internamente. Além disso, este estudo tenta analisar o impacto da geografia natural na economia considerando várias variáveis de geografia natural.

Este estudo conclui que as variáveis de geografia natural têm um impacto insignificante quando as variáveis institucionais são consideradas, uma vez que estas últimas parecem levar a uma diminuição da importância da geografia natural na Europa ao longo do tempo. Além disso, devido à convergência da qualidade das instituições durante as últimas décadas na Europa, estes determinantes também parecem não explicar as diferenças entre países europeus, deixando espaço para novas explicações relativamente ao que causa as diferenças nos padrões de crescimento económico. As limitações na qualidade dos dados das variáveis geográficas também poderão explicar os resultados obtidos.

Códigos JEL: O44, O52, O13

Palavras-chave: Geografia e Crescimento, Ambiente; Geografia Natural, Europa

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1. Introduction

At the end of World War 2 Japan had Hiroshima and Nagasaki pulverized, each by an atomic bomb that also left radioactivity in the cities for years to come, severely jeopardizing future development in the respective cities. Miraculously, about 20 years after the bombings, Davis and Weinstein (2002) estimate, while using the population as a proxy, economic activity had converged with the pre-war estimation tendency and thus both cities had recovered from the temporary shock. This conclusion clearly favours the importance of geography (over spatial randomness) and its inevitable influence on a country's regions.

This pertinent quest emerges because times have shifted and with the rise of the internet and the continuous connectivity everywhere all the time, it is important to know if geography still matters for economic development, especially in Europe where information technologies like computers and cell phones are well established and widespread, since they are part of the developed world, and are part of everyday life.

One indicator of the persistence of the importance of geography might be the fact that regional differences, instead of more homogeneous development patterns, seem to be increasing in recent years according to Iammarino, Rodriguez-Pose and Storper (2019). Besides, Europe is divided into distinct major regional economic groups with different dynamics where, the closer to the center of Europe the richer the region (an exception is made for some conclaves and capitals such as Paris and London) and the more peripheral ones are usually the poorest (Portugal, Spain and the Balkans); a pattern that indicates geographical concentration and the prevalence of clusters. This tendency for agglomeration is confirmed when considering more technological availability by Rodríguez-Pose and Crescenzi (2008). However, this study lacks an estimation model and relies its explanation more on the economic effects of geography than actual geographical features. Besides, the developed world is more connected and technologically integrated today than it was more than a decade ago.

Other studies in recent decades have been part of a fierce debate where researchers try to prove either it's geography or institutions that fundamentally dictate economic development, putting both theories side by side. In these studies, like Ketterer and Rodríguez-Pose (2018) point out, a lot of them occur at a global scale which allows for conclusions that probably are too broad and do not consider much of the intricacies, thus the choice to be more focused in Europe. But others, like Nordhaus (2006), argue global economic activity can be

measured and explained properly by geography, claiming an astonishing 20% of the differences in output *per capita* can be explained by geography alone.

Based on the EU's political flagship on the need for achieving regional convergence across time since its creation,[1] it is expected that the institutional effect on economic development may be diminishing and the preponderance of the influence of physical regional geography is expected to rise in explaining current regional differences in economic development levels. Another benefit of using the EU as the basis for the analysis is related to the fact that it is a single market (free trade) and still enforces the Schengen agreement (free circulation of people). In the absence of all these restrictions, it is expected that people and goods are free to move to any place and so the role of geography is expected to be reinforced while the explanatory power of institutions shrinks.

The purpose of this dissertation consists, therefore, in identifying the economic importance of several natural key geographical features that influence countries' development paths and analyzing how dependent the economic development of Europe is on natural geography, and if this dependency is still relevant in modern times.

To give an updated answer to whether technological developments have bent or not the physical geographical barriers, firstly a literature review will be made to understand the state of the art. Afterward, OLS and 2SLS econometric models will be used to estimate the importance of physical geographical determinants on development patterns (using GDP *per capita* as a proxy), while controlling for institutional effects and other explanatory variables identified in the related literature. The 2SLS is used to control for endogeneity in relation to the resource rents variable, a common procedure in the literature (Badeeb, Lean and Clark, 2017), while the use of lagged temporal independent variables works as a double check on endogeneity (Ketterer and Rodríguez-Pose, 2018). As a primary database, World Bank will be used to gather information on Institutional Indicators. CEPII's databases will also be used for geographical variables.

This approach differs from the majority of studies because this work does not intend to explain spatial distribution of economic activity on the basis of economic phenomena (agglomeration, spillovers, labor mobility, etc.) as commonly appears in the literature, but rather

[1] Since the Treaty of Rome, European Structural and Investment Funds have been conceived as instruments of the EU cohesion policy. Convergence between regions is a fundamental goal (EUR Lex , 1957), https://eur-lex.europa.eu/legal-content/PT/TXT/?uri=CELEX:32019D1957 , accessed on January 2022.

to aggregate physical geographical variables and understand if and how much economies are dependent on them to prosper. Also, it is intended to refresh the analysis of Ketterer and Rodríguez-Pose (2018) for geography with new data not just in the number of countries taken into consideration (which in the mentioned study were European Union 15 member states) but also increase the length of time studied.

The rest of this work develops has follows: in section 2 a literature review will be made, where not just the state of the art is described for the related topics but also key concepts are explained, and the theoretical framework of the research question is established; section 3 briefly explains the methodology with a description of the variables used. In section 4, the main results are presented and discussed. Section 5 concludes with the findings and the main limitations of this dissertation.

2. Literature review on geography and economic development

2.1 Main concepts

It is important to recognize the meaning of economic development which is not equal to economic growth. While economic growth is usually associated with the simple growth of Gross Domestic Product (GDP), economic development is broader and more qualitative. This means that economic development studies dimensions that are beyond money and wealth creation. More crucial than the economy is how people feel about the society they live in. So, this branch of economics pays close attention to population's health, education and civil liberties like gender equality, freedom of speech and the rule of law, just to name a few examples. In short: politics, geography, education, health and institutions matter too (Todaro, 2012).

Furthermore, the concept of the expression "location matters" needs to be fully understood. Locations can be comprehended from two perspectives: spatial heterogeneity and spatial dependence. Spatial heterogeneity is objective, dealing with the physical characteristics of a region and is more concerned with the direct impact of geography in that place, accounting for features like rivers, mountains and temperature. Spatial dependence, like the expression indicates is relative, so is more focused on the interactions with surrounding areas such as: economic hubs or closeness to major trading routes (Annoni, de Dominicis and Khabirpour, 2019).

The study of geography and its relations with economics becomes particularly necessary when confronted with pivotal concerns like climate change. Even though some studies in development economics tend to disregard absolute geography (Acemoglu, Johnson and Robinson, 2001; Ketterer and Rodríguez-Pose, 2018; Bosker and Garretsen, 2009), in Schelling (1992) climate change seems a common concern so it is safe to assume that even if some economists disregard nature's effects on economics they might reconsider their views in face of what the future might reserve. Schelling (1992) defines climate change not just as a mere increase of temperatures worldwide but as an imbalance capable of creating new equilibriums that would alter average temperatures, the sea level and all of it has a cause of the greenhouse effect. The greenhouse effect consists of a denser ozone layer making the earth reflect less sunlight, thus becoming warmer while changing entire stable ecosystems in the

progress; temperature is just one consequence among many others. Therefore, it is more accurate to say that temperatures will change (can increase in some regions and decrease in others), the humidity will change, storms frequencies will change, et cetera. These changes will be slow and gradual and our capability as a species to shield from them can be questioned when considering more recent literature (Peng, She, Huang, 2020; Burke and Emerick, 2016; Colacito, Hoffmann and Phan, 2019). Taking this framework, adaptation will be inevitable.

2.2 How geography influences economic growth and development: a review

Economic development proposes different theoretical frameworks to explain why some nations succeed and others fail (Acemoglu, Johnson and Robinson, 2005). One of the most prominent paradigms is focused on the role of institutions, namely the enforcement of the law or the ability of a state to secure individuals' property rights. Other theories suggest that before the emergence of formal institutions, a specific culture already allowed similar patterns. Among the proponents of the relevance of culture to explain economic development we can find the famous instance of Max Weber (1930), according to whom "Unwillingness to work is symptomatic of the lack of grace" (pp.104-105) for the protestant diligent mind. This emphasis on work and disregard for pleasure aligns well with a capitalist mindset and explains, according to the cultural proponents, economic development. Lastly, the geographical approach, which will be emphasised in this work. This framework, followed in this work (Acemoglu, Johnson and Robinson, 2005), can be divided into three approaches: one that states that the diseases that exist in several regions are responsible for delaying economic development; another that recognizes the importance of geography for the allowance of technological advances, especially in agriculture; and a perspective focused on climate. A synthesis of the relevant variables that emerge within this framework as potential determinants of economic growth and development will now be explained.

2.2.1 Temperature

Among some of the factors plaguing many places on earth is latitude. Countries closer to the equator tend to have higher average temperatures and, therefore, a marginal increase in temperature will have a greater negative impact. According to Dell, Jones and Olken (2012), a 1ºC variation in temperature will reduce, for the same year, economic growth by 1.3 percentage points; so, it's not just the level of output that gets affected but also the potential of

the economy to grow because the variation also affects infrastructures that are determinant for economic growth. Moreover, since poor countries are most of the time more dependent on the agricultural sector and hotter than rich countries, they will feel a greater temperature impact.

Nevertheless, as Acevedo, Mrkaic, Novta, Pugacheva and Topalova (2020) recognize, the increase in temperatures does not affect countries in a linear way and a proof of that is the fact that, for countries/regions where the average temperature is relatively low, it can increase economic growth; one of such places would be Siberia. So, the implications of temperature increase are highly dependent on the starting point of average temperatures. "For the median emerging market economy, a 1ºC increase from a temperature of 22ºC lowers growth in the same year by 0.9 percentage points. For the median low-income country, with a temperature of 25ºC, the effect is even larger: growth falls by 1.2 percentage points." (pp.5).

Besides short run effects, Acevedo *et al.* (2020) also studied a possible impact on the medium run. The effects of temperature increase usually last for more than a year or so and will have consequences in the future: "Even seven years after a weather shock, per capita output is 1.4 percent lower for the median emerging market economy and 2 percent lower for the median low-income country as depicted." (pp.8). This makes sense because temperature shocks tend to decay slowly and because an increase in 1ªC often comes as a temperature shock in a steady and longer trend, which relates to prolonged higher temperatures.

The literature on temperature recognizes several ways to explain how exactly temperature influences economic activity. Dell *et al.* (2012) confirm the negative effects in poor countries of temperature increases in agriculture and industry. When it comes to agriculture, the impact is obvious but in industry not so much. They find out that, even industries that don't have agricultural inputs and are high-tech, like electronic equipment, get affected by temperature shocks. As expected, if the output of agricultural and industrial sectors is reduced, the marginal return of investments will go down and will eventually drive away investors, thus reducing investment because of the temperature evolution. Because profit margins are reduced, investors will invest in other countries/regions where the impact of temperature is less of a concern, *ceteris paribus* (Acevedo *et al.,* 2020). If temperature increases 1ºC for a country of median low-income, investment, consumption, exports and imports will be negatively affected and this becomes more obvious for investment in the medium term. "Seven years after the shock, investment is estimated to be 10 percent lower than it would have been

in the absence of the shock" (pp.15). The authors point out that impacts on the industry could come as a direct result of input shortages in agricultural output and also due to a reduction in labor productivity that ensues with higher temperatures, especially for heat exposure occupations. Several studies from this literature have proven that exposure to higher temperatures can reduce the capabilities of individuals to perform at a physical and a cognitive level, making productivity decline. Acevedo *et al.* (2020) state that, when compared to workers that are not exposed to heat, workers exposed to heat in countries with high temperatures suffer a productivity reduction if temperatures rise even further. This effect grows in the future due to food shortages and a higher impact on people's health. Albeit affects people's performance it does not end there: "A 1ºC increase in temperature raises infant mortality by 0.12 percentage points in the year of the shock" (pp.15). They also find a negative correlation between an increase in temperature in hotter countries and the Human Development Index; so it is safe to say temperature increases can and will undermine economic development.

Dell *et al.* (2012) recognize the negative effects that the presence of higher temperature can pose to institutions and economic activity in general but might be smoothened if economies can adapt to the situation. Acevedo *et al.* (2020) state that higher development is associated with lower negative effects of temperature on the economy when comparing regions that fall in the same average temperature intervals, and so they advance the hypothesis that somehow developed economies can shelter themselves from climate effects, at least to some extent. Dell *et al.* (2012) perceive a statistically significant negative relation between poor countries' economic growth and rises in temperature, something that does not happen in rich countries. So, the negative effects for a given year in poor countries persist in the medium run and there is little evidence that they can eliminate them afterward; both on level and on growth.

I. Labor productivity

One usually cited paper on this literature's branch is Seppanen, Fisk and Faulkner (2003) that conduct an experiment with buildings to assess the relationship between temperature and productivity. They indicate a 2% decrease in a worker's performance for every Celsius degree increase above 25ºC. This comes about after summarizing several studies and concluding with a parable relation between percentage performance decrements and temperature, where the null performance decrement is around 25ºC. Nevertheless, they go even further stating

that in the temperature range of 21ªC to 25ºC no significant impact on productivity exists. According to this study, productivity increases could be made in indoor environments with something as simple as night-time ventilation or air-conditioning (AC), giving an increase in productivity on hot days (0.39 h/day for the paper's experiment). Seppanen, Fisk and Lei (2006) dive further into this and in their meta-analysis relate productivity increases with temperature increases up to 21-22ªC and productivity decreases with temperature increases after 23-24ªC. This is in line with Seppanen *et al.* (2003) and reinvigorates the need for climate control indoors otherwise productivity will suffer dramatically (for instance, they estimate that at 30ºC performance is only 91.9% of what would be at 21.75ºC). It should be noted that is not just about individual optimal temperature but also the economy optimal temperature, which are not the same. Deryugina and Hsiang (2014) put it around 12ºC and 15ºC while estimating a linear decline of 1.7% productivity by each 1ºC increase after that. Burke, Hsiang and Miguel (2015) estimate an optimization of the general economic outcome at 13ºC, where poorer countries are often more affected because they tend to have larger temperatures making them more susceptible to temperature than rich countries. Hsiang (2010) finds declines in productivity after 27-29ºC, with individual thermal stress jeopardizing productivity at higher than 25ºC. Andersen, Dalgaard and Selaya (2016) propose a health hypothesis on ultra-violet radiation (UV-R) that would cause more cancer and blindness where it is more prevalent (closer to the equator); eye diseases would be the most important since would diminish returns on education (people that don't see can't read or write) and severely hamper sustained economic growth, but also malaria that predominates in some tropical regions (Gallup, Sachs and Mellinger, 1999). Heat waves can also cause infant mortality by 0.12 percentage points a year, for an average increase in temperature of 1ºC, not only creating terrible social despair as well as influencing future GDP growth through population growth (Acevedo *et al.,* 2020).

II. Agricultural Sector

The primary sector is the most affected by temperature by far and even if in some regions those effects might be mild, that might change in the future due to climate change. The countries that suffer the most are the poorest with most of the effects around agriculture (Schelling, 1992). Burke and Emerick (2016) look at the US and find that for corn a single day above 30ºC reduces yields by 0.5% at the end of a season., contradicting Schelling (1992) and backing the idea that even developed countries suffer from temperature shocks.

Deryugina and Hsiang (2014) predict crop yields steep decline after 27ºC; even when considering supply and demand effects, lower yields still represent lower income, so high temperatures mean lower agricultural revenues. For Tanzania, Letta, Montalbano and Tol (2018) say the poorest suffer the most in their consumption habits by temperature-induced short-run shocks, while the rich can surprisingly benefit from it in some cases, leaving the most vulnerable in society in a poverty trap by slowing down income convergence although not reversing it. The impact on consumption and food on the poorest (-47%) is larger than in the rich (+13%). The positive impact on richer households could derive from simple supply and demand, allowing the rich to charge higher prices when the poor lose their crops, raising concerns of inequality related to climate change. The authors' guess relies on the heavy dependence of rural subsistence farming with very little knowledge and technology for the poor and thermal stress for individual productivity, making output vulnerable to weather fluctuations (extreme temperatures above 34ºC). The rich benefit from irrigation techniques (at least some of them), generally better technology, better soil (agricultural know-how) and seeds drought-resistant; meaning wealth and technology can fend off against weather fluctuations in Tanzania. Peng *et al.* (2020) disaggregate study seasonal effects and conclude a temperature increase in winter has a significant effect on the primary industry, making its growth increase by 0.217 percentage points; but in summer, if the average temperature increases by 1ºC, economic growth will be 0.414 percentage points lower (for 1% level of significance).

Beyond the more common direct and intuitive consequences of weather on agricultural output, Burke and Emerick (2016) and Dell, Jones and Olken (2014) consider the outmigration of agriculture after suffering weather shocks as a channel through which output gets curtailed; this is in line with a more recent explanation related to investment (Acevedo *et al.,* 2020). If the return to capital is perceived to be hinder, risk increase makes investment plummet. The reduction of investment can be, with climate change, one of the most important influences in the long-run for the primary sector. Acevedo *et al.* (2020) report 10% lower investment 7 years after a shock.

III. Technology and temperature

Schelling (1992) foresees climate change impact will be negligible in developed countries if technology takes care of it. Climate change then would affect mostly underdeveloped countries, which are more dependent on agriculture and outdoor activities. On the contrary, Burke

and Emerick (2016) suggest little or even an absence of the positive long-run effects of technology capable of offsetting short run negative impacts that come with heat. In this study for the U.S., the biggest field crops (in area sown and output value) are analyzed (i.e., soy and corn) and long-run adaptations seem to have had perhaps no repercussions at all; agricultural revenues are harmed by exposure to high temperatures and farmers don't seem to do much about it. Burke and Emerick (2016) change the period of study but the results persist, emphasizing the inadaptability; expenditures on seeds, fertilizers and chemicals haven't changed significantly and US subsidies to agriculture (assuring losses) don't seem to play a role in it too. This means US farmers cannot mitigate short-run or long-run impacts on corn and soy crops.

Deryugina and Hsiang (2014) make the bold claim that temperature's effects haven't changed since 1969 in the US, leaving room for a feeble technological offset without an obvious way to mitigate costs. This is in line with Burke *et al.* (2015) for whom temperature's impact hasn't changed since the 1960s and temperature's negative effects are higher and stronger for poorer countries. In Schlenker and Roberts (2009) temperature-yield relation is the same for 1950-1977 and 1978-2005 but the average yields of the 1978-2005 sample are twice those of the first sample, supporting the hypothesis that technology can compensate for bad weather. Letta *et al.* (2018) demonstrate that in Tanzania richer people with access to irrigation systems, seeds resistant to droughts or in general better technology can thrive in agriculture, while those who do not have those capabilities are at the mercy of heat shocks. Zhao, Gerety and Kuminoff (2018) defend the idea of protection from climate change through economic development since in their estimation only 2 out of 10 temperature related coefficients are significant for rich countries, even though evidence to support this idea is relatively few. Acevedo *et al.* (2020) compare regions within the same high average temperature range (15º-20ºC), using Texas as a developed region. Developed regions like Texas are safer from hot weather than their poorer counterparts even though the authors can't find a reason why: "We cannot identify the specific ways in which these "hot" regions have adapted to their climates, but this find offers some hope for effectiveness of climate change adaptation strategies" (pp.18).

IV. Non agricultural Sector

An a priori intuition makes clear the impact of weather on agricultural output and overall

outdoor activities but this conclusion can get problematic if indoor activities are to be considered. Bloesch and Gourio (2015) find manufacturing is affected by temperature as well as the sectors of construction and hospitality. Even though these estimates are highly significant, especially for construction (1% level of significance), the precision of the estimates is not very high. In outdoor sectors like construction and hospitality, the weather will reduce demand or make work unfeasible. In their national analysis for the U.S., only outdoors activities are affected by the temperature at a large scale and even those have a quick bounce back (car sales are expected to recede 1.3 percent by a snowfall impact but in the next month recover 1.27 percent). The authors conclude weather does not cause severe long-lasting impacts, except for some outdoor activities like the ones mentioned above. In this branch of literature, the study by Cachon, Gallino and Olivares (2012) finds indoor productivity reduction for 64 automobile assembly factories in the United States of America, claiming severe weather conditions would on average hinder productivity by 1.5% weekly. Their hypothesis is outdoor temperatures may affect input delivery services to the factories by delaying or cancelling them, besides even if there is an air conditioning system indoors it may not be able to regulate the temperature in every space of the factory. This last proposition is in line with Seppanen *et al.* (2003) and Seppanen *et al.* (2006) since it considers the effect of curtailing labor productivity. Cachon *et al.* (2012) discover an average 8% impact on the automobile industry if six or more days of a week have temperatures above 90ºF (Fahrenheit) (i.e., heat waves). A further robustness check delivers coefficients with less precision and not statistically significant, namely heat. Another shortcoming is the possible acute difference in managerial practices of each car brand, which the authors cannot rule out as a factor of heterogeneity regarding plants' weather responses. Nevertheless, the most puzzling fact is the authors' conclusion that even though companies get affected by weather they not only do not recover, as they do not seem to try to recover from the short run impacts, raising the question of if the impacts were so stark as Cachon *et al.* (2012) propose. Deryugina and Hsiang (2014) look at productivity in the US and the main result is the damage to agricultural outputs, while nonagricultural output estimates are noisy and insignificant. Hsiang (2010) reports an increase in productivity losses of 2.4% by 1ºC increase in a cross-sectional study for 28 Caribbean countries. The reductions in nonagricultural output are robust and consistent for three nonagricultural industries and they came about because of temperature impacts on human labor due to workers' exposure to thermal stress. The sectors are wholesale, construction, restaurants and hotels, retail and other services. They also conclude that outdoor activities

(i.e. mainly tourism) are considerably exposed. This is further supported by the authors' conclusion that the income reductions occur mainly due to a tourist visits reduction, also influenced by cyclones.

More recent surveys on temperature's consequences have divided the temperature's impacts by seasons as is the case in Colacito, Hoffmann and Phan (2019). This way the authors can find an impact not just across different sectors but also for the entire US, capable of representing a reduction in the country's annual growth from 0.15 to 0.25 percentage points if the average temperature in the summer season increases by 1ºF. They find a positive effect on the economy if average temperatures increase by 1ºF in fall. Peng *et al.* (2020) agree that what makes this study great is the recognition that previous studies might have reduced temperature effects by only considering annual averages with a likely compensation of the seasonal effects or reduction, making temperature meaningless, even when statistically significant. This is the case for Peng *et al.* (2020) estimation for 31 Chinese cities where they find that an increase of 1ºC in the average temperature in the winter has a positive effect of 0.203 percentage points on growth for the non-primary industry, whereas the negative effect on growth in summer by the same increase is 0.209 percentage points, practically cancelling out each other on an aggregated analysis.

2.2.2 Distance and Trade

Disdier and Head (2008) developed a meta-study on bilateral trade and the puzzling persistence of the distance effect by compiling 1467 estimates for more than 100 studies. They record a mean effect of 0.9: if the distance is increased by 10% (for bilateral trade) trade will be reduced by 9%. Their most promising discovery implies the distance effect grew after the 1950s whereas before was mostly flat. It supports the argument that mere technological development is not capable of eliminating the distance effect. The authors propose three explanations for it: (i) technological progress cutting distances could be overvalued and less impactful than thought (technological developments mostly reduced distance when it comes to human interaction); (ii) greater expectation could also rise greater imposition on demand requirements: people are less willing to wait for something to be delivered; (iii) lastly, there could be a shift in trade towards more expensive to transport goods.

These authors also found a higher and positive distance effect when using a dummy for developing countries, while for developed countries the correlation was negative. This makes sense since developing countries tend to lack behind on infrastructural development and so,

costs of transportation would be higher than for developed countries, making countries in their vicinities more likely to become trade partners.

Furthermore, "distance can increase" if countries (but specially regions) have quarrels with natural geography, even if they are highly developed countries. Giordano (2017) notes Bornholm, a Danish island in the south of the Baltic Sea. The remoteness of the island makes the physical connection more expensive and in the staggering words of a local clerk: "the unit cost of transporting merchandising in container ships from Bornholm to Copenhagen is the same as the shipping cost from Bornholm to India" (pp.873-874). So, it is important not only to pay attention to natural/physical geography but also to the circumstances that can increase its influence.

I. Transport and Market Access

With trade liberalization and the reduction of tariffs worldwide, transport costs have become one of the major contributors to the cost of physical distance. These costs depend on a country's infrastructure and geography (Limão and Venables, 2001).

Transport costs are only one factor that dictates the impact of physical distance. These costs "can be measured by the c.i.f./f.o.b. ratio giving the 'carriage, insurance and freight' costs of countries' imports" (Henderson, Shalizi and Venables, 2001, p. 87). It is no secret firms pay higher transport costs in remote locations. Redding and Schott (2003) find an increase in 1% of distance reduced exports between two countries by 1.2% and 1.5% for 1970 and1990 respectively, contradicting the thesis of the death of geography. Ghemawat (2001) predicts the amount of trade between countries 5000 miles apart is 20% of what would be if they were 1000 miles away.

Redding and Schott (2003) also suggest there is a negative connection (at 1% level of confidence) between bigger distances to major centres of economic activity (these being: U.S.A., Belgium and Japan) and economic development. Surprisingly, even developed countries could do better if they were closer to thriving international markets and a good example is Australia and New Zealand. Boulhol, Serres and Molnar (2008) state these two nations have 2,5 times transport costs than North America, making them have on average a lower GDP per capita somewhere between 1.0%-4.5%. While Canada and the U.S. can save on transport costs and have an estimated higher GDP per capita somewhere between 0.5%-2.5%.

The content of what is exported can also be undermined with distance. For Bastos and Silva

(2010), export companies tend to export higher value-to-weight goods for longer distances, meaning it is more likely that higher quality products are exported. Ghemawat (2001) reinforces this idea, stating low value-to-weight goods have relatively high costs when shipped abroad for bigger distances, discouraging their exports. They also estimate doubling the distance, unit values exports would increase by 11.9%, supporting the idea that with distance the quality of the products exported increases. The increase in price also serves to cover higher transport costs.

Another issue with distance is the matching between sellers and buyers. Yue, Lai and Khachatryan (2022), while studying the distance effects in the U.S. nursery and greenhouse industry, found out that the most important effect of distance is not transport itself with its costs but the harshness of matching sellers with buyers, which drastically affects trade flows and trumps transport costs even though they still exist. So, the friction of information comes as one of the most important costs; nevertheless, the sample is for the U.S. alone and this should reduce transport costs due to national infrastructure integration.

II. Knowledge

In its seminal work, Porter (1998) perceives knowledge as one of the most fundamental reasons for the importance of geography in the formation of clusters, which are geographical places where companies from a similar sector come together as competitors and cooperatives. This builds on the idea that the outside environment of a company can bring benefits such as knowledge spillovers, a common pool of highly skilled and specialized labor force commonly needed, suppliers, buyers, firms that develop technology for the sector, and favorably institutional arrangements, et cetera. The core idea is a profound dependence upon close proximity with all sorts of agents, stimulating partnerships and competitions both of which are crucial for economic development. Competition, Porter (1998) argues, manifests itself under three forms: drives the direction of productivity and innovation in the cluster, makes competitors' efficiency increase so they produce more and, lastly, allows for scale economies, giving these companies an edge that far competitors have not. This appears to be a trend amongst multinationals with Silicon Valley and Hollywood as two examples. Wang and Zhao (2018) further develop on how knowledge and space are intertwined: firms, and more surely multinationals, don't need to be concerned with technological appropriation when in a cluster; this happens due to the often high and independent technological development capabilities of multinationals but also because they can be closer to local competition

(i.e. in the cluster) if they maintain a large technological distance along with their different locations. Another problem that comes with distance is pointed out by Morgan (2004), where different types of knowledge are to be distinguished. There is codified knowledge, which is portable, and easily accessible in terms of understanding and use, but then there is tacit knowledge that is not as transferable or codifiable as the former. Tacit knowledge depends upon personal experience and know how, while being sometimes difficult to communicate, even in words; it could be argued that it constitutes some sort of experience induced knowledge that is hardly articulable. Besides this drawback, Morgan (2004) also recognizes the face-to-face interaction that can tell if a person is trustworthy, reliable, or lying, without disregard for cyberspace information exchanges. Globalization and regionalization are therefore complements and not substitutes.

If a country is remotely distanced from major economic hubs, it will take higher transport costs. This can translate into a lower profit margin when compared to the direct competitors and depress human capital formation through a lower remuneration. By suppressing human capital accumulation, remoteness is allowing future economic divergence since manufacturing (a sector highly related to high skill jobs) will lose much of its skilled workers and the economy will specialize in low skill industries because fewer individuals will see beneficial a higher level of education (Redding and Schott, 2003). It is not just a matter of physical distance but also the absence of scale economies or industry specific hubs. These authors conclude peripheral countries are becoming more economically remote with time (from 1970 to 1995), possibly leading to economic divergence.

III. Migration

In a globalized world more and more countries search for talented workers to boost their economy or to compensate for population decreases, leading to a chronicle problem for some countries: brain drain. Deprived of human capital and human assets any country development is curtailed.

Docquier, Lohest and Marfouk (2007) show brain drain hits small and poorer countries the most (depending on the degree of openness). Interestingly enough, the degree of openness increases with OECD countries' geographical proximity. Docquier *et al.* (2007) posit thus that countries that are poor, small, closer to OECD and with a higher school gap in relation to OECD countries will have higher degrees of migration to OECD countries, *ceteris paribus*. In this study, geographical and cultural closeness seem to matter when it comes to migration,

but selective-immigration policies are also capable of explaining the phenomena. Nevertheless, the geographical proximity doesn't seem to be too important since the ones migrating usually have higher levels of education than the ones who stay, covering expenses easier. Also, a future job promise (even if only relative to the migrant origin country) compensates for the transport costs and the worst quality of life in the home country making anyone less distance sensitive. Besides, geographical proximity to OECD countries has an ambivalent meaning: on one hand increases openness to migration, making the national citizens leave for richer countries, but on the other hand reduces the schooling gap to those OECD countries, reducing migration. This geographical explanation is statistically significant but other effects seem to be more important in the moment of changing country.

One of the most important factors for world migration is the wage gap. Marchiori, Maystadt and Schumacher (2012) believe weather anomalies cause wage depression in developing countries that are mainly dependent on agriculture, like in most sub-Saharan Africa, spurring a rural-urban migration. This depresses urban wages as well as induces out-migration (i.e. international migration, especially to developed countries). The authors point out that urban agglomeration economies can play a role in mitigating this effect, even though they don't develop much on that. These weather anomalies create incentives for migration and reinforce the idea that real wages are a key determinant in explaining international migrations.

Beine, Docquier and Özden (2011) explore the power of diasporas to explain international migration. The diaspora encourages low-skill migration because it reduces the language and cultural barriers, allowing for the newcomers to use the diaspora's know how (i.e. assimilation and information). Indeed for low skilled migrants, the distance and cultural barriers are stronger. Beine *et al.* (2011) find that 71% of migration flows can be explained through diasporas, making physical distance less relevant.

The main conclusion regarding migration is the small impact of physical distance when it comes to moving to another country. In a long-term decision, it is reasonable to assume that distance costs are one of the lesser evils in what is several times a life changing decision.

2.2.3 Natural resources

Since the 20th century, there has been the view that natural resources can be used, especially for less developed countries, to increase the economies' output and stimulate general economic growth. This can come about in two ways, either by consumption or investment, i.e.,

increasing present general welfare or delaying it for the future. After the oil crisis in the 1970s, studies about natural resource rich countries and their resources' relationship with economic growth started to shake the conventional view adopted so far (Davis and Tilton, 2005).

In 1977, the Dutch discovered gas in Groningen, an event that would shape development economics forever; it was coined "The Dutch disease". The natural resource windfalls boom was responsible for high levels of inflation and appreciation of the Dutch currency. This made it nearly impossible for Dutch manufacturers to be competitive in the international markets. The rest of the economy shrunk, and with it national income, leading to unemployment. Because it is more profitable, the natural resource sector dries out other sectors from its inputs, making input prices for the rest of the economy go up. The "Dutch disease" is only one of the possible effects of the "resource course" and not an inevitable consequence of it (Davis and Tilton, 2005). Beyond policy issues, there are also political concerns, namely with corruption. Some argue institutional quality could hamper its spreading; others sustain that the paramount dependency on these resources weakens institutional performance and spurs promiscuity (Badeeb, Lean and Clark, 2017).

In recent years the pejorative view of resources is being contested. Brunnschweiler and Bulte (2008) state the endogeneity of using as a dependent variable the ratio of natural resources exports over GDP; a common approach in the literature. Their criticism hampered the consolidation of the curse hypothesis and focuses on the distinction between natural resource dependent economies and natural resource abundant economies. The first, rather than the last, seems to have a higher propensity in falling in the resources' course.

I. Dutch Disease

Since the first steps of this branch of literature in the 1980s, it was clear a counter intuitive idea was gaining traction: developing countries that export mineral resources are worst off. Auty and Warhurts (1993) offer a good example of this when analyzing for feeble responses and hard blows these economies suffered during the oil crisis in the 1970s, whereas poorer resource countries like Taiwan and South Korea were doing better. Sachs and Warner (2001) systematize the problem very easily: the natural resources activity, through a crowding-out mechanism, harms the sector that is mostly responsible for economic growth (usually considered to be the industry sector), making the country reliant mainly on international prices of the natural resource to sustain the national economy.

Corden and Neary (1982) approach this issue in a purely theoretical way and start by identifying two main mechanisms through which the Dutch disease makes itself felt: the resource movement effect and the spending effect. However, before these effects can be felt, there must be a boom in the natural resource sector, i.e. an increase in revenues generated by this sector. In Corden (1984), three main explanations are pointed out: an exogenous technological shock that boosts the resource extractions permanently, the discovery of more deposits of the natural good, and an exogenous increase in the price of the good in foreign markets when considering that the country sells at least some amount of the good.

The resource movement effect happens when the extractive sector, after a production boom, becomes more profitable, due to the increase in the marginal productivity of labor, and attracts resources from other sectors of the economy (i.e. labor and other inputs); draining the rest of the economy (industry and non-tradable sectors) from useful assets that allow for sustained economic growth. Corden (1984) further divides this effect into two. The first is the exit of labor directly from the industry sector to the booming sector, which decreases directly the output of the industry ("direct de-industrialization"). The second has to do with the exit of labor from the non-tradeable goods sector to the booming sector. This will reduce the supply of non-tradable goods and create a relative excess of demand since the output is reduced for the same demand. As a consequence, the price of these goods will rise, making the marginal productivity of labor increase in the non-tradable goods sector when compared to the industry sector, reinforcing once more the labor exodus from the industry sector ("indirect de-industrialization"). So, the resource movement effect unequivocally spurs de-industrializations.

The spending effect relates to the spending in the economy, usually made by the government directly or indirectly through tax collection after the huge profits collected in the extractive sector from the production boom are spent. This procedure is overwhelmingly associated with inflation and real currency appreciation. If the income elasticity for non-tradable goods is positive, its relative price, when compared to tradable goods, must rise and so there is a real appreciation of the currency.

In the first model presented by Corden and Neary (1982), only labor is considered a mobile factor, making it more like a short-term societal arrangement, and de-industrialization follows suit. This occurs since, after the boom of the extractive sector, wages rise and labor is drained from the industrial sector and the non-tradable goods sector. The non-tradable

goods sector increases prices to compensate for the lack of manpower to the same demand. The industry sector will need to increase wages (keep the same level of production) or prices (keep the same level of profits) and, either way, will lose competitiveness in foreign markets. If we add to this effect (resource movement effect) the spending effect, then inflation will rise and real currency appreciation will happen, making exports even less viable. As the authors point out this is not an inevitable outcome special regarding the spending effects, but this reasoning is a cornerstone in explaining the Dutch disease process.

Regarding empirical evidence to back up the natural resource curse, Sachs and Warner (2001) show that during the 1970s resource abundant countries had, as explained, higher average prices than other economies, especially due to the rise in non-tradable goods prices. This conclusion is enhanced by its consequence: these countries had a hard time, for the same period, in pursuing an export-led economic policy for manufacturers; a negative correlation between the growth of exports for manufacturers and natural resource exports as share of GDP sustains this trend. Iimi (2007) studies one of the few exceptions to this sub-Saharan African trend: Botswana. Despite being resource rich, Botswana was able to take-off and outperform its regional counterparts for the simple reason that this country had better institutions. In a literature review paper, Badeeb *et al.* (2017) also accept the presence of exceptions to the resource course even though they make undeniable a major trend between countries that have resource abundance: they also present poor economic growth.

II. Economic mismanagement and inequality

When a country finds natural resources in its territory, there are inequality concerns that should be addressed. Ross (2007) identifies horizontal inequality and vertical inequality as problems to be solved.

Vertical inequality relates to the social distribution of wealth as it is typically assumed: the rich richer and the poor poorer. With the spread of the Dutch disease, many people in the agricultural and manufacturer sectors might lose their jobs and flock to unemployment, while a small fringe minority benefits from the boom. The effects of inequality could be smoothened not just by promoting the sectors affected by the boom, i.e. agriculture and industry, and its displaced workers but also by adopting policies that attempt to take more people out of poverty. Indonesia seems to be a good example of this while contrasting with Nigeria. An interesting alternative could also be to directly give a portion of the windfalls to locals; a successful practice in developed countries such as Canada (Alberta) and the USA (Alaska)

requires solid institutions, frequently an issue in developing countries.

Horizontal inequality deals with the differences within regions regarding wealth distribution. Ethnical and cultural tensions in underdeveloped countries can be inflated if one group takes all the benefits while others remain helpless, to the point where armed conflicts may break out. So, if the region that has natural resources is poor, the central government should be concerned with closing the gap relative to other regions, but if it is richer, the government should distribute income among the poorest regions. To solve these concerns, direct distribution of windfalls can occur as suggested above and decentralize the revenues while transparency measures take place.

The problem with the resource course is it can potentially cripple the economy. Having good economic management, not just of the resources, but of the economy to counterbalance the potential impacts of the foreseeable issues might be the difference between a thriving economy and a crippled one, that hampers the non-resource-based economy. Iimi (2007) also seems to agree on the only way to overcome these drawbacks is a strong institutional framework, more precisely: anticorruption laws, the capability to regulate and its quality, how effective a government can be and if people have a voice at the political and institutional matters while holding public officials accountable for their deeds. Good economic management is not impossible if there are sound institutions.

III. Price and Market Volatility

Natural resources are often used as inputs in industries, which makes their consumption align with the economic and business cycles, so that when the international economy is thriving the country that extracts them can sell more and/or at a higher price since demand tends to go up (ceteris paribus). The exposure to market turbulence undermines development projects and the economic prosperity of the nation by making unreliable finance projects, subsidize constructions or other kinds of investments. The common solution is to smooth the cycles of prices and economic activity by cautious revenue management: money is accumulated when GDP is above natural GDP and the reserves created are used when GDP is below the natural GDP. The experience has not been great, leading to mixed results. Developing nations struggle the most in having good managerial practices owning it to feeble institutional development. For Davis and Tilton (2005), the problem is more an institutional one than related to the volatility of markets and prices.

2.2.4 Landlocked Countries

Landlocked countries can attribute their lack of development to some extent to the lack of coast. The scarce access to ports not only reduces economic development but also increases costs of international trade and so there is no denial, like Limao and Venables (2001) state, landlocked countries have higher costs of transportation; 50% higher to be precise, putting a big pressure in infrastructural development. Nonetheless, Kashiha, Thill and Depken (2016) estimated that developments in a country's infrastructure to support shipping from the 25th to the median percentile is similar to a decrease of the distance of 151 km for a shipper on average, for a landlocked country (32 km for coastal countries). So, infrastructural development, according to the authors, might be able to bend natural geography in an even more critical way than for coastal countries.

While taking so many struggles by landlocked countries into consideration, a question comes to mind: "How are foreign ports chosen for trade?". Langen (2007) proposes three parameters: the location and distance to the ports of trade (even though this is not an irrefutable condition as he shows for the case of Austria that trades preferably with ports in Germany, Belgium and the Netherlands, instead of their Mediterranean counterparts); the characteristics of the port (meaning if it has good infrastructure and can accommodate specific cargo); and lastly the business of the port which relates to the importance of the routes.

I. Transport and Infrastructure

For Henderson *et al.* (2001), the high transport costs with which landlocked countries need to deal not only consume scarce resources but choke trade, which can be quite large, and reduce competitiveness and so the infrastructure is seen as a vital way to reduce this continuous struggle for landlocked countries. They are over-represented in poor countries and have been growing on average 1.5% slower for 1960-92 than countries with coastal access (MacKellar, Wörgötter and Wörtz, 2000). Limao and Venables (2001), in their seminal work, find out that poor infrastructure represents 40% of the transport associated costs for coastal countries, and a staggering 60% in landlocked countries. In the case of landlocked countries, if the transit country (i.e. the country through which the goods need to go through so they get to shore and are traded across the world) improves its infrastructure from the least 25th percentile to the 75th percentile, costs concerning landlockedness would drop to half. This means landlocked countries can reduce the impact of their condition but they can't avoid it since the cost of transport by land is much higher than by sea, as Limao and Venables (2001)

estimate. They predict 1000 km by sea has an additional cost of 190$ compared to 1380$ by land. Distance, however, cannot be the only to blame because higher coordination is needed with the transit country and insurance companies tend to charge higher costs. For the landlocked country, the dependency of the transit country is also considerable since this country's infrastructure explains 24% of its transport costs, whereas its infrastructure explains 36%, making the above total of 60%. They also estimate that the median landlocked country has around 55% of the transport costs that the median coastal country has, making infrastructural improvements in landlocked countries have a more significant impact when cutting transport costs than in the median coastal country. This is why distance alone cannot explain much, making only 10% of all transport costs variations. Carrere and Grigoriou (2011) put a bigger emphasis on the transit countries, suggesting landlocked countries are hostages of their neighbors with sea access. According to them, an improvement in central Asia transit countries' infrastructure to other landlocked countries would increase exports in the region by 49%, whereas the same improvement in the landlocked country would mean an increase of just 2.4%.

Limao and Venables (2001) also recognize that Africa's poor performance can be mostly explained by its long distance to other countries and its poor infrastructural development. If countries are underdeveloped and institutions are weak, landlocked countries might have a hard time coordinating administrative procedures and investments in infrastructures with the transit country (Gallup *et al.*, 1999). High quality institutions are the common denominator to salvage developing countries from their dire situation and landlockness is no exception, with Miao and Wörgötter (2021) affirming trade openness and institutional quality are the pattern in high-income countries to be followed. This is aligned with Arvis, Raballand and Marteau (2007) for whom the major concern is not transport costs per se but rents that are extracted from administrative and political offices from customs, the reliability of bureaucracy and the time taken during these procedures.

II. Politics and International Relations

In Faye, McArthur, Sachs and Snow (2004) view there is the need of a more descriptive and qualitative explanation for why being landlocked is a problem. The main issues at the core of this setback for these authors are political relations with the transit countries, the dependence on their infrastructure and administrative procedures.

If a country wants to trade internationally and isn't connected to an ocean it needs to bargain

with surrounding countries; trading exclusively through air transportation is not an option since the costs are not competitive. If the transit country has bad roads or malfunctioning trading ports, the landlocked country will suffer and even more if it is a developing country, which usually exports low value goods. Burundi is an example of how it is possible to have a relatively good road network but if the country that connects it to the sea doesn't have it, its trade will suffer. Other countries like Botswana are blessed in the sense that their main exports are diamonds; being easy to put on a plane with high value relative to the transport costs, making the country a bit less dependent on its neighbours.

When a nation is unlucky enough to depend on the surrounding nations much, needs to spur good relations or the transit country might increase bureaucracy, tariff costs or even deny the landlocked country complete access to its ports and roads, making the fixed cost of all the infrastructures that are connected with that country useless; being the only option building more with other countries, something that entails enormous costs. The war between Ethiopia and Eritrea made Eritrea deny Ethiopia its ports; as a consequence, 75% of Ethiopia's trade that went through this transit country stopped in 1997. But it does not need to be a matter of war, India used this kind of pressure in 2001 and 2002 to exert influence over bilateral trade with Nepal. This means landlocked countries need to rely on peace and diplomatic solutions to be afloat.

Faye *et al.* (2004) also highlight the role of administrative burdens landlocked countries must face, not just as a political manoeuvre by the countries of which they are dependent but also as real and inevitable increases in trading costs. For Faye *et al.* (2004), these costs make up the bulk of shipping expenses. Beyond tariffs and formal payments, there is also the time spent with paperwork, delaying cargo and increasing costs. Cargo delays are also a disincentive for future contracts with landlocked companies. Burundi cargo, before it gets shipped passes through Rwanda, Uganda and Kenya, and in all of them, there are fees to pay. However, examples of good coordination can be seen between India and Bhutan that can dampen these concerns. The customs agency of Bhutan deals with administrative transit trade within India and it is as if it is not a landlocked country; this status comes as a result of good relations between the two countries.

3. Methodology

3.1 The Model

To understand if there is any influence by geographical variables in European differences in economic development, this study will use a balanced dataset since for every individual country at any period there is data, comprising 37 European countries for the period between 2004 and 2019.

Since the dataset has cross-sectional and time-series information, it is used panel data so that it can be understood if different countries in the same period behave differently from each other due to specific and unchangeable conditions (Verbeek, 2008).

It will be used the same approach as Ketterer and Rodríguez-Pose (2018), where the estimation is made with Pooled Regression first and then with the 2 stage least squares (2SLS). According to Greene (2003), the Pooled Regression is an efficient and consistent estimator if the assumptions of the classical ordinary least squares model are met. But, because endogeneity concerns are to be expected since, for example natural resource rents in percentage of GDP are endogenous (Brunnsschweiler and Bulte, 2008), it is used the 2SLS to counter it.

The econometric model to be used is the following:

$$\mathbf{Y_{it}} = \boldsymbol{\beta_1}\mathbf{X_{it-1}} + \boldsymbol{\beta_2}\mathbf{C_{it-1}} + \mathbf{u_{it}}$$

where $\boldsymbol{i}$ represents a European country ($\boldsymbol{i}$=1,…,37)[2] and $\boldsymbol{t}$ stands for time ($\boldsymbol{t}$=2004,…,2019). The dependent variable $\boldsymbol{Y_{it}}$ represents the growth rate in GDP *per capita* in PPP (current international $) for country *i* at time $\boldsymbol{t}$; the vector $\boldsymbol{X_{it-1}}$ incorporates explanatory variables related to geography that include distance, landlockedness, temperature and natural resources; the vector $\boldsymbol{C_{it-1}}$ includes the six institutional variables that will be used as a control for overall government and administrative performance; and $\boldsymbol{u_{it}}$corresponds to the random term. $\boldsymbol{\beta_1}$ and $\boldsymbol{\beta_2}$ correspond to the vector of coefficients of the respective variables (i.e. $\boldsymbol{X_{it-1}}$ and $\boldsymbol{C_{it-1}}$ respectively). The time variant institutional and explanatory variables are lagged to assure a reduction in endogeneity in accordance with Ketterer and Rodríguez-Pose (2018). The panel data is balanced since every country in the sample has the same number of observations with data for all variables. All regressions are run in Stata 16.

[2]A complete list of the countries used in the study can be found in the appendix.

3.2 The Data

3.2.1 Dependent variable

The dependent variable is the growth rate of GDP *per capita*. This variable, an indicator commonly used in the literature to represent economic development due to the high correlation between the two variables (despite several critics on this reductionist approach that are not discussed in this dissertation), is represented by *grate* (e.g. Ketterer and Rodríguez-Pose, 2018; Basker and Garretsen, 2009). The variable is calculated as differences of the logarithm of GDP *per capita* in parity power purchase. The variable that served as a basis for this was GDP *per capita* PPP (current international $) and was retrieved from the World Bank.

3.2.2 Independent variables

The majority of independent variables are geography-related. The complete list is below with the name of the variable in parenthesis:

- GDP *per capita*, PPP (current international $): Gross domestic product (GDP) *per capita* is presented in international dollars while considering parity power purchase (PPP). GDP is the yearly wealth created in a country and the fact that is *per* person serves to control for population and size differences. Parity power purchase allows a more reasonable comparison between the real quality of life differences not only because it eliminates exchange rates differences that tend to give high income countries higher prices but also accounts for inflation. It is with this indicator that the dependent variable is computed (*grate*) accounting for the difference between the logarithm at two consecutive periods ($\ln(X_1) - \ln(X_0)$). GDP *per capita* PPP, is also used to control for levels of GDP so that growth differences are not biased towards countries starting poorer in the dataset. This variable can be found in the World Bank database (World Bank, 2022).

- Total natural resources rents (% of GDP): Represents a total sum for coal, oil, natural gas, minerals and forest rents; for some countries these rents (i.e. revenues higher than the cost of extracting the resources) are a significant component of national finances. These estimates represent the difference between the price of the natural good and the average cost of extraction; afterwards the values are multiplied by the

produced quantity. Undeniably, this is a relevant indicator and often used in the literature, yet endogeneity problems oblige the use of instrumental variables (World Bank, 2022). This variable is used by several authors (Ross, 2001; Bhattacharyya and Hodler, 2014; Auty, 2007; Boos and Holm-Müller, 2013; Bhattacharyya and Collier, 2013; Collier and Hoeffler, 2009).

- Landlocked: CEPII's *Geodist* database presents a dummy where if equals one a country is considered landlocked, this means it does not have a coastline contiguous to a sea or ocean; this comes has a problem for economic development once one of the cheapest ways to ship goods across the world is through ships, making them depend on transit countries (Mayer and Zignago, 2011).

- Distance: It is calculated as a simple average distance between one capital city and all other capitals of the world. This is done to understand if geographical remoteness can have an impact in economic development. The original variable appears in CEPII's *GeoDist* database calculated according to latitudinal and longitudinal coordinates (Mayer and Zignago, 2011).

- Temperature: Undoubtedly one of the most important geographical variables for economic development is annual average temperature, with one value encompassing a country. Even though this presents methodological drawbacks[3] (Nordhaus, 2006), the data from Climate Change Knowledge Portal (World Bank Group) serves the purposes of this work. To control for non-linear effects a squared version of the variable is also used.

The institutional variables serve as a control for geography explanatory power, in accordance with the literature (Ketterer and Rodríguez-Pose, 2018; Gallup *et al.*, 1999; Acemoglu *et al.,* 2001):

- Control of Corruption: This variable tries to estimate the perception of individuals regarding corruption; if people in power use power for selfish reasons or to what extent are public institutions and governments captured by private interests. Estimates vary between 0 to 100, where a higher score relates to lower levels of corruption and thus usually trustworthy institutions. The measure of control for corruption

[3] A more appropriate way to measure the temperature's economic impact would be by using cells with a 1 degree of latitude by one degree of longitude (Nordhaus, 2006). This prevents man made frontiers to intervene in the analysis (like national frontiers) and allows for region specific effects to be detected.

can be found in the World Bank database or on the Worldwide Governance Indicators (WGI) project website (Kaufmann, Kraay and Mastruzzi, 2011).

- Government Effectiveness: Evaluates the public's perception on public services; the quality as well independence from partisan pressures is taken into consideration while also controlling for the credibility of these institutions. It is measured in a percentile rank and varies from 0 (lowest) to 100 (highest). The measure of government effectiveness can be found in the World Bank database or on the Worldwide Governance Indicators (WGI) project website (Kaufmann *et al.*, 2011).

- Political Stability and Absence of Violence/Terrorism: Deals with perceptions on the possibility of war, violence and social unrest politically motivated; also includes diverse forms of terrorism, considering to what point human rights can be under attack. Measurement can oscillate from 0 to 100, with less troublesome countries ranking on the top. The measure of Political Stability and Absence of Violence/Terrorism can be found in the World Bank database or on the Worldwide Governance Indicators (WGI) project website (Kaufmann *et al.*, 2011).

- Regulatory Quality: the capability of national government to plan and put in practice its policies in such a way that promotes private interests so that social and economic development can prosper. This composite indicator ranges between 0 and the 100 percentile rank, where a higher score resonates with more regulatory quality. The measure of Regulatory Quality can be found in the World Bank database or on the Worldwide Governance Indicators (WGI) project website (Kaufmann *et al.*, 2011).

- Rule of Law: How functional a society can be is important for economic development; laws in the national constitutions must be abided by all with rigorous swift implementation. Property rights, law enforcement and court's ability to deliver are at the forefront of a civilized society. Indicator's variation goes from 0 to 100, with lower scores representing less developed societies. The measure of Rule of Law can be found in the World Bank database or on the Worldwide Governance Indicators (WGI) project website (Kaufmann *et al.*, 2011).

- Voice and Accountability: Especially in a democratic regime, a common sight in Europe, citizen's voices need to be respected from people in high office. A citizen is respected when he/she is free to express himself/herself; likewise the media. Bigger

scores reflect bigger individual freedoms being respected. The measure of Voice and Accountability can be found in the World Bank database or on the Worldwide Governance Indicators (WGI) project website (Kaufmann *et al.*, 2011).

Instrumental variables are used to counter endogeneity concerns (Badeeb *et al.,* 2017; Brunnschweiler and Bulte, 2008):

- Fuel Exports (% of merchandise exports): In World Bank's database indicators, fuel exports are a sum for the commodities of mineral fuels and lubricants. Nevertheless, a setback is in the fact that export shares may not sum up to 100 due to unclassified trade (World Bank, 2022).
- Ores and metals exports (% of merchandise exports): Comprise crude fertilizers, metalliferous ores, scrap and non-ferrous metals. As in Fuel Exports variable the sum of all export shares may not get to 100% (World Bank, 2022).

Table 1 below presents a summary of descriptive statistics for the variables to be estimated.

Table 1- Summary statistics

	Description	Mean	Median	Min	Max	Standard Deviation	Source
grate	GDPpcPPP growth rate (%)	4.997663	4.950047	-15.2093	30.07727	4.858275	Own (with World Bank data)
GDPpcPPP	GDP per capita in PPP(current international $)	31925	29610.92	4428.073	117341.9	18812.95	World Bank
RentsinGDP	Total natural resource rents (% of GDP)	1.306892	0.396561	0	18.947	2.846744	World Bank
FuelEXP	Fuel exports (% of merchandise exports)	9.368418	4.902814	0	70.55948	14.11359	World Bank
MetalEXP	Ores and Metals exports (% of merchandise exports)	6.433879	3.717541	0.773328	50.77722	8.223368	World Bank
Temp	Average yearly temperature by Country in Celsius	9.217618	9.675	-4.77	21.07	4.195535	World Bank (Climate Change Knowledge Portal)

averdistcap	average of simple distance between capitals (km)	6672.402	6624.466	6491.163	7320.908	165.2338	CEPII
landlocked	1 if a country has no coast (dummy variable)	0.216216	0	0	1	0.412012	CEPII
Corruption	Control of Corruption (0-100)	71.31696	74.03846	11.00478	100	23.76373	World Bank (Worldwide Governance Indicators)
PoliticStabil	Political Stability and Absence of Violence/Terrorism (0-100)	64.28967	67.29858	4.761905	100	24.15991	World Bank (Worldwide Governance Indicators)
RegQuality	Regulatory Quality (0-100)	78.12771	80.95195	28.43137	100	17.17711	World Bank (Worldwide Governance Indicators)
VoiceAccount	Voice and Accountability (0-100)	75.07638	80.28508	17.73399	100	21.86871	World Bank (Worldwide Governance Indicators)
Goveffective	Government Effectiveness (0-100)	75.01228	78.67299	18.71921	100	20.23272	World Bank (Worldwide Governance Indicators)
RuleofLaw	Rule of Law (0-100)	73.89479	80.28846	16.74641	100	22.09478	World Bank (Worldwide Governance Indicators)

Source: Own elaboration.

4. Main results

4.1 Correlation analysis and estimation

To understand the correlation between the variables under analysis, the Pearson's test is used (Table 2). As expected, the rents of natural resources in percentage of GDP show a high and statistically significant correlation with fuel exports. Therefore, the latter (alongside with metal exports) will be used has an instrumental variable for the former, since the literature recognizes here endogeneity (Badeeb *et al.,* 2017; Brunnschweiler and Bulte, 2008). Institutional variables are also highly correlated between themselves, something that might explain why some are statistically insignificant when estimated together.

The variables in the estimation models will be lagged, a strategy used by Ketterer and Rodriguez-Pose (2018) to reduce endogeneity issues. An example of that is the independent variable of GDPpcPPP with a one period lag (i.e. log ($\mathrm{GDPpcPPP}_{t-1}$)). To further mitigate this issue, institutional variables will be estimated separately in distinct models and only once all together.

The first regression for OLS (1) will use only geographical variables to evaluate the importance of geography. Afterward, institutional variables, one each estimation, will be added to the geographical determinants. The last estimation (8) encompasses all geography and all institutional variables. Here, autocorrelation might be a problem to the point of making some institutional variables statistically insignificant or even change the coefficient sign. The same approach is then used for estimation with the method 2SLS. It is expected that 2SLS can better handle endogeneity issues, being also used as a robustness check.

Table 2- Correlation matrix

	grate	GDPpcPPP	RentsinGDP	FuelEXP	MetalEXP	Temp	averdistcap	landlocked	Corruption	PoliticStabil	RegQuality	VoiceAccount	Goveffective	RuleofLaw
grate	1 ...													
GDPpcPPP	-0.2355 (0.0000)***	1 …												
RentsinGDP	0.1388 (0.0007)***	-0.1052 (0.0104)**	1 …											
FuelEXP	0.0124 (0.7632)	0.0301 (0.4652)	0.8155 (0.0000)***	1 …										
MetalEXP	0.0442 (0.2827)	-0.1923 (0.0000)***	0.019 (0.6454)	-0.035 (0.3956)	1 …									
Temp	-0.0866 (0.0353)**	-0.115 (0.0051)***	-0.5638 (0.0000)***	-0.4533 (0.0000)***	-0.1687 (0.0000)***	1 …								
averdistcap	-0.0241 (0.5583)	0.2136 (0.0000)***	0.1916 (0.0000)***	0.1852 (0.0000)***	0.4305 (0.0000)***	-0.5262 (0.0000)***	1 …							
landlocked	0.0074 (0.8568)	0.1588 (0.0001)***	-0.1391 (0.0007)***	-0.2383 (0.0000)***	0.042 (0.3072)	-0.0393 (0.3401)	-0.2925 (0.0000)***	1 …						
Corruption	-0.225 (0.0000)***	0.716 (0.0000)***	-0.3729 (0.0000)***	-0.156 (0.0001)***	-0.2001 (0.0000)***	-0.0363 (0.3773)	0.3017 (0.0000)***	-0.0143 (0.7286)	1 …					
PoliticStabil	-0.1561 (0.0001)***	0.663 (0.0000)***	-0.2734 (0.0000)***	-0.1121 (0.0063)***	-0.1655 (0.0001)***	-0.1542 (0.0002)***	0.2235 (0.0000)***	0.1981 (0.0000)***	0.7778 (0.0000)***	1 …				
RegQuality	-0.2043 (0.0000)***	0.6834 (0.0000)***	-0.3937 (0.0000)***	-0.1681 (0.0000)***	-0.2306 (0.0000)***	-0.0325 (0.4302)	0.2418 (0.0000)***	0.0881 (0.0320)**	0.9337 (0.0000)***	0.789 (0.0000)***	1 …			
VoiceAccount	-0.2423 (0.0000)***	0.7133 (0.0000)***	-0.3597 (0.0000)***	-0.142 (0.0005)***	-0.289 (0.0000)***	0.0116 (0.7787)	0.2221 (0.0000)***	-0.0191 (0.6428)	0.9338 (0.0000)***	0.8442 (0.0000)***	0.8993 (0.0000)***	1 …		
Goveffective	-0.2504 (0.0000)***	0.7275 (0.0000)***	-0.2885 (0.0000)***	-0.0658 (0.1097)	-0.2182 (0.0000)***	-0.1002 (0.0147)**	0.3245 (0.0000)***	0.0558 (0.1749)	0.9465 (0.0000)***	0.7917 (0.0000)***	0.9336 (0.0000)***	0.894 (0.0000)***	1 …	
RuleofLaw	-0.2556 (0.0000)***	0.7288 (0.0000)***	-0.3834 (0.0000)***	-0.1468 (0.0003)***	-0.2443 (0.0000)***	-0.029 (0.4810)***	0.2818 (0.0000)***	0.0306 (0.4577)***	0.9676 (0.0000)***	0.826 (0.0000)***	0.9453 (0.0000)***	0.9458 (0.0000)***	0.9475 (0.0000)***	1 …

Note: p-value is in parenthesis and the significance at 1% (***), 5% (**) and 10% (*).
Source: Own elaboration.

Table 3- Models estimation results

	OLS								2SLS							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
GDPpcPPP	-0.0000845 (0.0000)***	-0.0000779 (0.0000)***	-0.000082 (0.0000)***	-0.000074 (0.0000)***	-0.0000736 (0.0000)***	-0.0000659 (0.0000)***	-0.0000604 (0.0000)***	-0.0000656 (0.0000)***	-0.0000871 (0.0000)***	-0.0000743 (0.0000)***	-0.0000803 (0.0000)***	-0.0000721 (0.0000)***	-0.0000713 (0.0000)***	-0.0000647 (0.0000)***	-0.0000597 (0.0000)***	-0.0000679 (0.0000)***
Ren-tsinGDP	-0.0251898 (0.8180)	-0.0531083 (0.6590)	-0.036108 (0.7560)	-0.074711 (0.5320)	-0.061363 (0.5980)	-0.1039702 (0.3830)	-0.1279521 (0.2900)	-0.0933947 (0.4440)	-0.2018189 (0.2520)	-0.1841128 (0.3300)	-0.1956664 (0.2890)	-0.1659294 (0.3620)	-0.1696289 (0.3480)	-0.1548163 (0.3880)	-0.1492069 (0.4100)	-0.0113186 (0.9510)
Temp	-0.0828915 (0.6500)	-0.0907798 (0.6200)	-0.089245 (0.6280)	-0.100449 (0.5840)	-0.0846741 (0.6430)	-0.1413869 (0.4460)	-0.1162369 (0.5250)	-0.1701593 (0.3740)	-0.3083335 (0.2240)	-0.2358802 (0.3330)	-0.2813283 (0.2640)	-0.203708 (0.3960)	-0.2081698 (0.3870)	-0.2020967 (0.4090)	-0.1396843 (0.5520)	-0.0787616 (0.7460)
Temp2	-0.0061367 (0.4410)	-0.0060318 (0.4490)	-0.006085 (0.4450)	-0.005832 (0.4640)	-0.0063975 (0.4220)	-0.0040382 (0.6160)	-0.0054435 (0.4940)	-0.0008401 (0.9200)	0.0021273 (0.8350)	-0.0008597 (0.9300)	0.0006789 (0.9460)	-0.0021445 (0.8250)	-0.0019785 (0.8390)	-0.0018174 (0.8550)	-0.0046039 (0.6290)	-0.0040612 (0.6790)
averdistcap	-0.000497 (0.7630)	-0.0003625 (0.8270)	-0.000475 (0.7730)	-0.000319 (0.8470)	-0.0004053 (0.8060)	-0.0001005 (0.9520)	-0.0000374 (0.9820)	0.0000443 (0.9790)	-0.0015183 (0.4050)	-0.0008843 (0.6140)	-0.0012681 (0.4780)	-0.0007128 (0.6830)	-0.0009318 (0.5990)	-0.0003097 (0.8590)	-0.0001207 (0.9440)	0.0003368 (0.8440)
landlocked	0.402571 (0.4440)	0.3367851 (0.5320)	0.413769 (0.4330)	0.3696 (0.4830)	0.2799105 (0.6050)	0.3427727 (0.5140)	0.2390217 (0.6520)	0.4312816 (0.4640)	0.2411546 (0.6540)	0.1849743 (0.7420)	0.3002738 (0.5740)	0.289782 (0.5890)	0.1513145 (0.7880)	0.2975205 (0.5790)	0.2169768 (0.6910)	0.4942143 (0.4030)

Corruption		-0.0077438 (0.5740)						0.1120846 (0.0030)***		-0.0139142 (0.3640)						0.114583 (0.0020)***
PoliticStabil			-0.003329 (0.7710)					0.0239563 (0.1600)			-0.0084092 (0.4930)					0.0253944 (0.1360)
RegQuality				-0.018084 (0.2950)				0.0395808 (0.2910)				-0.0232998 (0.2170)				0.0404653 (0.2750)
VoiceAc-count					-0.013423 (0.3500)			-0.0025353 (0.9390)					-0.0178655 (0.2450)			-0.0060936 (0.8560)
Goveffec-tive						-0.0259873 (0.0930)*		-0.0580449 (0.1230)						-0.0285752 (0.0890)*		-0.0585633 (0.1150)
RuleofLaw							-0.0298298 (0.0470)**	-0.1383097 (0.0020)***							-0.0309524 (0.0610)**	-0.1348007 (0.0020)***
Constant	12.22735 (0.2950)	11.79294 (0.3130)	12.28477 (0.2930)	12.33181 (0.2910)	12.40642 (0.2880)	11.39971 (0.3280)	11.02811 (0.3440)	10.49781 (0.3720)	20.61683 (0.1220)	16.61259 (0.1940)	19.15959 (0.1450)	16.01613 (0.2130)	17.03943 (0.1910)	13.35974 (0.2920)	11.80884 (0.3480)	7.692645 (0.5390)
Model Specifications																

R-Squared	0.1139	0.1144	0.1141	0.1156	0.1153	0.1182	0.1199	0.1400	0.1100	0.1126	0.1112	0.1147	0.1139	0.1179	0.1199	0.1393
Adjusted R-Squared	0.1048	0.1038	0.1034	0.1050	0.1046	0.1076	0.1094	0.1221								
F-Statistic	12.54	10.78	10.74	10.90	10.87	11.18	11.37	7.85								
Prob(F-Statistic)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000								
Chi Square Statistic									77.04	77.08	76.99	77.73	77.60	79.31	80.20	95.67
Prob(Chi Square Statistic)									0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Number of Observations	592	592	592	592	592	592	592	592	592	592	592	592	592	592	592	592

Note: p-value is in parenthesis and the significance at 1% (***), 5% (**) and 10% (*).
Source: Own elaboration.

4.2 Estimation Results

4.2.1 Geography

Since temperature data is for national averages, it does not account for regional idiosyncratic climates (Nordhaus, 2006), a detail that can make all the difference the bigger the country. The difficulty to find data for every region in Europe created this issue. Besides, more recent studies disaggregate temperature study by seasons and find significant impacts (Peng *et al.,* 2020; Colacito *et al.*, 2019) not only in warm seasons (more common in the literature) but also a positive effect of the temperature on economic growth with cold seasons. Perhaps more interestingly, the benefit of cold seasons can compensate for the prejudice of warmer ones in a way that (Peng *et al.,* 2020) both effects cancel each other, something that could be possibly happening in our analysis. Nevertheless, the non-linear effect of temperature, which is a very important characteristic of temperature (Schlenker and Roberts, 2009; Zhao *et al.,* 2018; Burke *et al.,* 2015; Nordhaus, 2006), is controlled with the inclusion of the variable "Temp2" (i.e. the square of temperature).It could be the case that European temperatures, which are more moderate when compared to Africa (a continent that continuously confirms temperature's impact (Letta *et al.,* 2018), have lower averages with less extreme heat and, as a result, temperature's effects are not that relevant. Also, it might have to do with the lesser dependency of European countries on agriculture activities that are more exposed to climate conditions (Letta *et al.,* 2018; Dell *et al.*, 2012; Schelling, 1992; Hsiang, 2010; Andersen *et al.,* 2016; Dell *et al.,* 2014; Acevedo *et al.*, 2020; Nordhaus, 2006). It can also be the case that development *per si* insulates economies from temperature's effects (Schelling, 1992; Acevedo *et al.*, 2020).

Landlockedness insignificance comes as expected. It is not that the specific literature for landlocked countries regards it as irrelevant, but it is the general perception that countries with good relations towards their neighbors, specially transit countries (Faye *et al.,* 2004), and good infrastructures of their own but also on transit countries (Faye *et al.,* 2004; Gallup *et al.,* 1998; Carrere and Grigoriou, 2011; Miao and Wörgötter, 2021) can reduce a lot of the costs that come with being landlocked (Arvis *et al.,* 2007). It is usually accepted this can be achieved through better institutional arrangements. With a European single market, capable of abolishing internal tariffs and other related trading costs, homogenizing bureaucratic procedures

and promoting peace and a climate of geopolitical friendship, landlockness becomes no concern. Again, this does not mean being landlocked *per si* is insignificant since that can be shown in the literature (i.e. Carrere and Grigoriou, 2011), but that the proper institutional arrangement can make its effects drastically decline (Limão and Venables, 2001), especially for developed economies.

One of the most important concerns with distance is the costs it brings. When the matter is shipping goods, Arvis *et al.* (2007) sustain there are other dimensions regarding distance that can be explored, even though don't make that much of an impact, like migration. It is not that migration itself does not have an impact on a country's economy but that distance as a factor for migration does not seem important, especially when considering more important factors: diasporas (Beine *et al.*, 2011), education (Docquier *et al.,* 2007; Beine *et al.,* 2011) or real wages (Marchiori *et al.*, 2012). However, distance can take many forms of importance and clusters are one of them. Porter (1998) recognizes the need for companies for specialized clusters; in its seminal work, Portugal and USA come as examples. It is possible that distance, as it was used in our estimated regression, is just a too broad definition to explain this impact that is often recognized in the literature (Boulhol *et al.*, 2008; Porter, 1998; Wang and Zhao, 2018; Rodriguez-Pose and Crescenzi, 2008). The indicator that measures distance is a simple average from the country's capital to all other capitals in the world. To test the hypothesis of the regional periphery as important, a new indicator was used (not presented here for simplification) with no significant changes in the significance of the variable and the power of the global adjustment explanation (R^2) of the regression, which is very low.

Alongside landlockness, the natural resources curse is a problem that can only be solved with reasonable institutional frameworks (Iimi, 2007; Davis and Tilton, 2005). Although the curse of natural resources itself is somewhat to dispute (Badeeb *et al.,* 2017; Brunnschweiler and Bulte, 2008), a case study for such good management of natural resources is Norway (Badeeb *et al.,* 2017), which is part of the sample used in this research. This reinforces the belief that sound institutions can make natural resources statistically insignificant when accounting for development. It is also the case that the integration of European economies (most of which are in the sample) may reduce the dependency on natural resources by an increase of overall economic activity, avoiding the common problems highlighted by the literature such as corruption, rent seeking, price volatility and resource dependency (Badeeb *et al,* 2017).

4.2.2 Institutions

Contrary to the most common results in the related literature, the estimated coefficient for institutions is overall negative, even though some studies might also present this result (e.g. Ketterer and Rodríguez-Pose, 2018). The only exception appears when institutional variables are estimated together, which might indicate multicollinearity. This is further reinforced by the Pearson's test in Table 2, where a high correlation between institutional variables is highlighted. As a result of being estimated all together, institutional variables will, in some cases, display positive coefficients. Furthermore, the variance of the estimators can become too large, making variables, in some cases, statistically insignificant. It should also be added that the explanatory power of the regression may increase while the significance of individual effects gets blurred because it becomes difficult to distinguish the effect of each individual variable since with high autocorrelation several are competing for the same effect (Mendes de Oliveira, Santos and Fortuna, 2011).

Some caveats should be made about the negative coefficients of institutions: (i) the institutional indicators measure overall perceptions of the national populations regarding the respective institutions and so, it is possible that a deterioration of the perception of institutions is not in line with an objective deterioration of institutions, even though it could be reasonable to assume so; (ii) there is also the possibility of selection bias, i.e. the sample used for the regression goes from the year 2004 to 2019 and during this period Europe suffered a financial crisis (2008), which had long lasting effects to this day, in most countries, with budgetary cuts, tax increases and unemployment and the migrations that flooded Europe after the Arab spring, while a lot of economies were still recovering from the crisis; (iii) the growing concern with climate change and the inertia from some national governments or institutions to take action. It seems reasonable to assume political leaders' responses to these issues were not always well received and unanimously agreed upon by citizens. Again, such major events can have decreased the population's reliance on institutions, without necessarily reducing the quality of institutions, nevertheless a causal link between perceptions and objective institutional quality cannot be easily dismissed as well.

Thus, when disregarding regressions (8) and (16) due to multicollinearity, only government effectiveness and the rule of law seem to have a statistically significant effect on European economic development. No geographical variable is statistically significant even before controlling for the institutional framework. This seems to be aligned with a common conception

that institutions trump geography (Ketterer and Rodríguez-Pose, 2018; Acemoglu *et al.*, 2001; Rodrik, Subramanian and Trebbi, 2004; Acemoglu *et al.*, 2005) and since geography by itself cannot explain much, it is reasonable to assume technological developments have diluted natural geography's importance for most of the cases in Europe. This does not mean geography is not important (Annoni *et al.,* 2018; Giordano, 2017) but that its explanatory power, due to technological developments, has been shrinking, and even more when institutions are used as a control. Nevertheless, institutions' power to explain growth patterns in our analysis also seems limited. Once multicollinearity is expected to bias explanatory power, which at its highest value in the estimations is 0.1400, the real one should be lower, making institutions incapable of explaining most economic development.[4] It seems there are not many other studies that consider Europe at a national level and attempt similar estimations for this time frame. A possibility for these results may be that European Union's institutional convergence since its creation has not only promoted economic growth but also reduced the differences between institutions in Europe, and especially in the European Union and close partners[5]. Another way to put this could be: countries with similar geography and institutions will undoubtedly have the same level of economic development? European Union further institutional convergence can only increase the importance of such question. The estimations for the coefficient associated with GDP *per capita* in PPP are always negative and statistically significant, leading to the idea of convergence between European countries (Ketterer and Rodriguez-Pose, 2018), even though coefficients are too small. This could mean a complete economic convergence might not happen in the close future even with closer and closer institutional frameworks. Nonetheless, this could also be a limitation of the data used, specifically of the use of GDP per capita PPP (current international $) to measure development level or the fact that GMM was not used for a further robustness check like Ketterer and Rodriguez-Pose (2018).

[4] Other estimations were made with no temperature, landlocked, GDP pc PPP, geographical variables or lagged variables; it was also estimated a new distance variable only considering countries in the sample but coefficients remained insignificant. Overall, institutional variables kept negative coefficients and the global quality adjustment was mostly lower or seldom insignificantly superior to current estimations.

[5] The sample of countries is not limited to the European Union (see appendix).

5. Conclusion

In recent years technological development has been growing faster than ever, allowing people to be connected everywhere all the time. With new technology and economic development never seen before, aroused the idea of the insignificance of geography in nowadays economic development. The main task of this research is to understand if natural geography still poses challenges to economic development, especially in more technologically developed countries.

In this work some geographical key features are used to measure the impact of geography in European countries while using institutional variables has a control. In the regressions were used the models of OLS and 2SLS with lagged independent variables to reduce endogeneity. In a first stage geographical variables were estimated all alone, in a second stage geographical variables were estimated with institutional variables one by one and, in the end, for each model all geography variables were estimated with all institutional variables.

Even though it is possible geography still maintains important aspects economics needs to deal with, this analysis does not empirically identify such determinants. It should be added that there are other ways in which geography can impact an economy, like through institutions (Basker and Garretsen, 2009; Rodrik *et al.*, 2009), or that even if its effects are not statistically significant, they might still exist (Henderson *et al.*, 2001). It should also be noted that several geography variables can have their impacts estimated through thorough specific equations in complex one variable studies, making more over-reaching studies less accurate.

GDP *per capita*'s small estimated coefficient can mean that a convergence of economic growth is limited at the same time that institutional convergence occurs in Europe, and can keep occurring in the future, particularly in the European Union (from which most of the countries in the sample belong or are making and effort to belong too). This can represent a limitation of institutions to explain and ensure economic development when institutions tend to converge. Nevertheless, this cannot be taken as a definitive result since not all countries in the sample belong to the European Union, more complex estimations could have been used (like the GMM) and other variables could have been used for measuring economic development instead of GDP per capita in PPP (current international $). Besides, the fact that institutions' estimated coefficients are often negative can also be a cause of the period in the analysis since several events that took place may have induced a decline in people's perception of the quality and functioning of institutions. So, even though this work presents

interesting results, they should be taken with caution, since there are several limitations. These limitations could encourage further exploration of these subjects and conclusions, in particular for developed nations, which usually are not the main focus of development economics.

6. Appendices

Table 4-Geography Vs. Institutions in Development Economics

Authors	Title	Sample	Method	Dependent Variable	Independent Variables	Main Results
Ketterer and Rodríguez-Pose (2018)	Institutions vs. 'first-nature' geography: What drives economic growth in Europe's regions?	184 NUTS 1 and NUTS 2 European regions (1995-2009)	OLS, 2SLS, IV-GMM (with lagged independent variables)	regional *per capita* GDP in PPS	Several geographical variables, Institutional indexes, historical variables and GDP *per capita* in PPS	Geography does not survive to robustness tests except for latitude and lanlockedness with mild effects. This way, institutional frameworks seem more important in dictating future economic growth.
Bosker and Garretsen (2009)	Economic development and the geography of institutions	147 World countries	OLS and 2SLS	GDP *per capita* in PPP	Regional dummys, rule of law (country and neighbours), landlocked,	Absolute geography does not seem to matter much when institutions in a country and neighbouring institutions are considered. Natural geography only has an indirect impact on

					area, island, distance to equator and major trading locations (New York, Brussels, Tokyo)	economics that occurs through institutions. This means geography matters as a determinant of neighbouring countries and their institutions, because (according to the authors) usually development does not occur in isolation.
Rodrik, Subramanian and Trebbi (2004)	Institutions Rule: The Primacy of Institutions Over Geography and Integrations in Economic Development	79 and 137 countries (first and second samples respectively)	OLS, 2SLS and IV	log GDP *per capita* in 1995	rule of law, log openness, distance from equator, log European settler mortality, log constructed openness, fraction of	Some geographical dimensions might present themselves with weak significance but institutions seem to be more important to determine economic development. Nonetheless, the authors admit the possibility that geographies influence economic development through institutions.

					the population speaking other languages	
Acemoglu, Johnson na Robinson (2001)	The Colonial Origins of Comparative Development: An empirical investigation.	64 countries	OLS, 2SLS	log GDP *per capita* in 1995	Geography and institutions	Colonialism was different according to the hostility of the local climate to colonizers. If the local climate was hostile colonizers would try to extract most of the natural resources, with the intent of leaving the region afterward. If, instead, it was suited to Europeans, they would establish a society like the ones in Europe. The last case would promote the establishment of similar institutions that would last to this day, making institutions re-

						sponsible for economic development and not geography. This does not mean today's development patterns are geographically determined, but that sound institutions are the reason for differences in economic development.
Gallup, Sachs and Mellinger (1999)	Geography and Economic Development	Countries from all over the world	AK model	GDP *per capita* in 1950, 1990 and 1995	distance population, disease, public institutions, socialism, transport costs	This study conciliates the importance of institutions with geography (geography is not a destiny but is still crucial); even though the study is focused on discussing the importance of geography. Tropical regions suffer from their exposure to higher temperatures, not just by temperature itself but also from insects, diseases (malaria) and crops

						shortfalls. Landlockedness also comes has a drawback since higher costs of transport are expected to emerge and these countries are particularly vulnerable to their neighbours whims. Distance from major economic markets does not seem to matter for economic growth.
Henderson, Shalizi and Venables (2001)	Geography and Development		Literature review			Geography remains important but it is not an unmovable determinant of economic development. Remoteness can be one of the main issues and liberalization of trade and infrastructural investment can reduce transport costs, making regions more connected within a country and between

						the main economic centers, reducing geography's importance.

Table 5- Literature on geographic variables

Geographical variable	Channel of impact	Main conclusions	Authors
Temperature	Labour Productivity	Indoor temperature studies conducted to measure productivity tend to place peak productivity temperature between 21º-25ºC, but studies that try to find the optimal temperature for the economy have usually lower temperatures (12º-15ºC). Besides temperature itself, productivity can be reduced with hot temperatures in general since they are more strongly associated with malaria and higher child mortality rates.	Seppanen, Fisk and Faulkner (2003); Seppanen, Fisk and Lei (2006); Deryugina and Hsiang (2014); Burke, Hsiang and Miguel (2015); Hsiang (2010); Andersen, Dalgaard and Selaya (2016); Gallup, Sachs and Mellinger (1999); Acevedo, Mrkaic, Novta, Pugacheva and Topalova (2020)
	Agricultural Sector	The agricultural sector's exposure to weather conditions makes it susceptible to its influence, especially in hotter climates. In more recent literature, even developed countries suffer from hot temperatures and the attempt to reduce its effects seems mild at best. However, in poorer countries, it is possible for rich farmers to benefit from a reduction of supply through price increases. It is expected that climate change will increase the negative impact on the sector and, with lower revenue margins, the investment will also be reduced.	Schelling (1992); Burke and Emerick (2016); Deryugina and Hsiang (2014); Letta, Montalbano and Tol (2018); Peng, She, Huang (2020); Dell, Jones and Olken (2014); Acevedo, Mrkaic, Novta, Pugacheva and Topalova (2020)

	Technology and Temperature	The literature on this topic seems divided. On one hand, there are studies manage to assure temperature effects are present and technological improvements are of little or no effect (Burke and Emerick, 2016; Deryugina and Hsiang, 2014). While, on the other hand, some studies dispute the inefficiency of technology by showing empirical solutions that can counter the side effects of temperature with drought- resistant seeds, better irrigation systems and better overall technology (Letta *et al.*, 2018). There is also a direct territorial comparison between developed and underdeveloped territories, where even though the authors cannot explain why developed regions can better counter temperature effects, they don't deny that that is the case (Acevedo *et al.*, 2020).	Schelling (1992); Burke and Emerick (2016); Deryugina and Hsiang (2014); Burke, Hsiang and Miguel (2015); Schlenker and Roberts (2009); Letta, Montalbano and Tol (2018); Zhao, Gerety and Kuminoff (2018); Acevedo, Mrkaic, Novta, Pugacheva and Topalova (2020)
	Non Agricultural sector	Most of the temperature's effects on the economy beyond the agricultural sector occur in outdoor activities such as construction or tourism. Indoor activities are with no doubt influenced, since the impacts are seasonal and more or less compensated	Bloech and Gourio (2015); Cachon, Gallino and Olivares (2012); Deryugina and Hsiang (2014); Hsiang (2010); Colacito, Hoffmann and Phan (2019); Peng, She, Huang (2020)

		in the opposite season or, if the impact is caused by a swift impact, a quick recovery follows suit. So, even though there are non-agricultural sectors affected by temperatures, usually these effects are temporary and recoverable.	
Distance and Trade	Transport and Market Access	Several studies that calculate the impact of bilateral distances on trade agree that higher distances between two countries are in line with less trade. This comes as a consequence not just of higher transport costs but also because companies that have higher transport costs will only ship goods with a higher value-to-weight ratio. But even when transport costs are a lesser concern, distance plays a crucial role in matching sellers and buyers. So, it's not just about transport costs but also information and matching costs.	Limão and Venables (2001); Henderson, Shalizi and Venables (2001); Redding and Schott (2003); Gjemawat (2001); Bastos and Silva (2010); Yue, Lai and Kachatryan (2022); Boulhol, Serres and Molnar (2008)
	Knowledge	Geographical proximity is what makes clusters so important, but close physical distance itself is not the key feature; it is knowledge flows. When in closer proximity to one another, companies exchange ideas that can boost each other's businesses. This rapid flow of information is	Porter (1998); Wang and Zhao (2018); Morgan (2004); Redding and Schott (2003)

		only possible, in a context of geographical proximity, in a complete way because also allows tacit knowledge or "know how" that is hard to communicate to flow. Furthermore, companies further away from industries' main events will have a hard time catching up with the latest trends. In an ever changing world, this can be critical for a company's competitiveness.	
	Migration	Globalized world migration is an everyday reality and its two most important determinants are education, wage gap and diasporas. People with high levels of education can easily integrate and look for better paying jobs in a foreign country but people with basic education tend to struggle with integration. Diasporas can reduce the shock of integrating in different cultures and increase immigration of less skilled workers. Distance, even though sometimes can be statistically significant, can be overwhelmingly neglected due to the sheer size of other effects, like the ones mentioned above.	Docquier, Lohest and Marfouk (2007); Marchiori, Maystadt and Schumacher (2012); Beine, Docquer and Özden (2011)
Natural resources	Dutch Disease	After a boom in the resource sector, it's marginal labour productivity will	Auty and Warthurts (1993); Sachs and Warner (2001); Corden and Neary

		rise, creating incentives for workers in other sectors of the economy to move expecting a better salary. This will deplete sectors that are usually responsible for sustained economic growth, like industry. To compete, the industry can increase wages or reduce profits; either way the competitiveness and profitability of the businesses diminishes. To this can be added inflation and real currency appreciation, if there is an excessive spending of natural resources windfalls.	(1982); Corden (1984); Iimi (2007); Badeeb, Lean and Clark (2017)
	Economic mismanagement and inequality	The exploitation of natural resources can generate social unrest if a country's population perceives revenue distribution inequalities. It is not just about social status and avoiding that the rich get richer while the poor get poorer but also that culturally different populations are equality treated. In underdeveloped countries, where different cultures need to coexist, injustices can ultimately lead to armed conflicts. Good institutions are often the best way to deal with these issues.	Ross (2007); Iimi (2007)
	Price and Market Volatility	Commodities' prices are correlated to the economic cycle: when GDP is above its natural level, companies	Davis and Tilton (2005)

		consume more natural resources as inputs since they produce more, and natural resources are sold at higher prices and/at bigger quantities. The favourable economic cycle should be used to accumulate financial resources to use in an unfavourable period. This would help to smoothen the funding of essential development projects in developing countries, something that is only possible with good institutions.	
Landlocked Countries	Transport and Infrastructure	Transport costs are one of the drawbacks of being landlocked since transport costs by land are higher than by sea. Albeit countries and the respective exporting companies cannot escape these costs, they can decrease them and improve overall efficiency. For that to occur, it is not only the landlocked country that needs to develop its infrastructure but also the country through which the goods are going through. Institutions come as a preponderant factor in the development of these infrastructures and access to trade in international markets. It is generally agreed good institutions can have a significant impact in dealing with this issue.	Henderson, Shalizi and Venables (2001); MacKellar, Wörgötter and Wörtz (2000); Limao and Venable (2001); Carrere and Grigoriou (2011); Gallup, Sachs and Mellinger (1999); Miao and Wörgötter (2021); Arvis, Raballand and Marteau (2007)

	Politics and International Relations	In Geopolitics, often countries exert pressure on each other to get what they want. If a country is landlocked and depends on another transit country for its exports, the transit country can pressure the landlocked to comply with its will. Diplomatic tensions can make years of infrastructural investments connecting the two countries worthless and destroy the landlocked country's economy. This way, landlocked countries need to rely in good diplomatic relations with its neighbours.	Faye, McArthur, Sachs and Snow (2004)

Table 6- Countries in the sample[6] (2004-2019)

Countries in the sample (37 countries)	Armenia, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom
Countries in the sample that belong to the European Union[7] (25 countries)	Austria, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden
Countries in the sample that are candidate countries to the European Union[8] (4 countries)	Moldova, Macedonia, Turkey, Ukraine
Countries in the sample that are potential candidates to the European Union[9] (2 countries)	Bosnia and Herzegovina, Georgia
Countries in the sample that left the European Union (1 country)	United Kingdom[10]
Countries in the sample that are not in the European Union and do not classify as candidates or potential candidates (6 countries)	Armenia, Iceland, Norway, Russia, Switzerland, United Kingdom

[6] The countries presented as being in the European Union, candidates or potential candidates are so at the date of July 17th 2022 and in accordance with the respective European Union classifications for the respective designations.

[7] https://european-union.europa.eu/principles-countries-history/country-profiles_en?page=1 (consulted July 17th 2022)

[8] https://european-union.europa.eu/principles-countries-history/joining-eu_en (consulted July 17th 2022)

[9] https://european-union.europa.eu/principles-countries-history/joining-eu_en (consulted July 17th 2022)

[10] The United Kingdom officially left the Europe Union on January 31st 2020, so during the period of the sample was a member state of the European Union.

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