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Convergence of GDP per Capita Levels within the Countries of the European Union

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Abstract

The process of economic convergence in the EU has been a hotly debated issue since the formation of this organization. In fact, one of the main "operational priorities" of the EU is to "[promote] sustained convergence of the economic performance" of its Member States. This paper examines how effective the EU has been in ensuring upward economic convergence among its member countries: more specifically, the paper uses linear regression analysis to check whether poorer EU member countries, concentrated in Eastern Europe, have been growing at faster rates than their richer counterparts, which are concentrated in Western and Southern Europe.

Keywords

European Union, Upward Convergence, Macroeconomics, GDP per Capita Convergence, Economy of Europe, Western Europe, Eastern Europe

Cover Page Footnote

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Introduction

Convergence, particularly upward convergence, has been a big policy debate in the European Union in the past couple of decades. The Eurofound, the agency of the European Union responsible for the betterment of living and working conditions, defined "upward convergence" as the phenomenon of the "reduction of disparities between the levels of development of the various regions and the backwardness of the least favored regions or islands, including rural areas" (Eurofound, 2018). This paper will be particularly interested in upward economic convergence, which is defined as the "convergence of Member States towards better economic outcomes" (European Commission, 2017). I will discuss convergence in terms of real GDP per capita values in PPP terms, which is the same as real convergence, or the "convergence in economic performance in terms of real variables, [which] includes different aspects such as GDP per head and income …" (Marelli and Signorelli, 2010).

This topic is interesting for several reasons. Firstly, it is a measure of how effective of a structure the European Union really is: whether it is fulfilling its purpose or not. According to Eurofound (2018), Article 121(3) of the Treaty on the Functioning of the European Union, which is one of the two treaties forming the constitutional basis of the European Union, "states EU's commitment to '… sustained convergence of the economic performance of the Member States' as one of the main operational priorities of the EU". Thus, determining whether there has been upward economic convergence within the Member States of the European Union can help us gauge the effectiveness of this economic and political entity. Secondly, and perhaps more importantly, "lasting divergence in major outcomes should be prevented in order to maintain the promise of shared prosperity in the EU" (Eurofound, 2018). In other words, the sustainability of the Economic and Monetary Union (EMU) might be in question if most of the Member States are not benefitting and sharing in the prosperity of the wealthier Member States.

According to Eurofound (2017), "EU membership has led to an improvement in the average standard of living across all Member States". This paper will be examining the issue from a different angle. The question that I pose herein is the following: **Does GDP converge within the present countries of the European Union since 1991? Before? What determines convergence?** I define the term "present countries of the European Union" to be the set of all countries that are considered members of the European Union as of November 2021, as well as the United Kingdom, because this country has been a member of the European Union (or its predecessor, the European Communities[1]) from 1981 to 2020, the main period which I am investigating in this paper.

My analysis has led me to conclude that there was divergence in per

[1] For more on European Communities, see *Appendix*, Table 12.

capita GDP levels of this set of countries during the period 1981-1990, and that there was convergence in per capita GDP levels among them during the period 2001-2010. I partially attribute this change from divergence to convergence to the dissolution of USSR on December 26, 1991. This event resulted in the destruction of the "Iron Curtain", as it were called, which was an ideological, geopolitical, and economic barrier that persisted between the USSR and its satellite states of Eastern Europe, and between the open-market economies of the West. Gaining independence, many of these Eastern European countries, which were satellite states or members of USSR, joined the EU in large numbers (mostly in 2004 and 2007). Examples include the Baltic states of Latvia, Lithuania and Estonia, as well as Bulgaria, Croatia, Slovenia, and others.

Accession to the EU helped these economies to modernize and privatize their economies and helped them exhibit quick "catch-up" growth as they approached their Solow model equilibrium state (model discussed in the *Theory* section).

I make the claim that the destruction of USSR was a factor in convergence of GDP per capita levels observed among the present Member States of EU by looking at the growth trajectories of a subset of "Eastern" and "Western" European countries before and after 1991 in Figure 3. I take the subset of "Eastern" European countries to consist of former Soviet states and its satellites that joined the EU in 2004, whereas the subset of "Western" European countries includes the countries that were in the European Communities (EC) after the 1973 enlargement of the European Communities[2].

It is also worthwhile to mention that this paper is not trying to establish causality – the argument is not that the dissolution of USSR caused Eastern European countries to achieve their long-run steady state per capita GDP levels in a short amount of time. Rather, I am noting that the β-coefficient of regression was positive from 1981-1990 and negative from 2001-2010: thus, there was divergence in GDP per capita from 1981-1990 and convergence therein from 2001- 2010 among the present Member States of EU. As already mentioned, much of this paper derives its definitions from Eurofound (2018), which defines β-divergence as positive values of the β-coefficient, and negative values of the β-coefficient as β-convergence[3]. A comprehensive discussion of the method used to analyze the dataset is included in the *Estimation*, *Results – Part1* and *Results – Part 2* Sections of this paper.

[2] European Communities (EC) was the predecessor of the European Union. See more information on EC in Table 12in the *Appendix* Section.

[3] Refer to Section *Literature Review* to see why this is the case.

Literature Review

Convergence in general (and not only in the EU) has been studied in many publications and papers and there is much economic literature on convergence of income levels across geographic and/or political entities. Barro and Sala-i-Martin (1992) introduce a regression of the growth rate vs the logarithm of GDP per capita based on the theory that countries face diminishing returns to capital as they grow. Thus, if they have the same capital depreciation rate and the same rate of population growth, as well as the same total factor productivity and rates of technological progress, then they will converge to a fixed value of per capita income in the long run. This research is about convergence in income and product in the 48 US continental states, but the analysis can be applied to European countries because most of the aforementioned assumptions hold for them (they have the same rate of technological progress, total factor productivity, depreciation rate, etc.).

Barro and Sala-i-Martin (1991) generalize this approach to regions of Europe, including a rate of convergence β in the regression model. The neoclassical model of growth is employed in this paper to estimate the rate of convergence β for 73 regions of Europe, 11 of which are in Germany, another 11 in the UK, 20 in Italy, 21 in France, 4 in the Netherlands, 3 in Belgium, and 3 in Denmark. Barro and Sala-i-Martin (1991) analyze convergence in ten-year intervals, 1950-1960, 1960-1970, 1970-1980, and 1980-1985, and define different concepts of convergence, namely, β- and σ-convergence. The kind of convergence that this paper is concerned about is β-convergence – "the [tendency] of poorer regions to grow faster than richer regions" (Barro and Sala-i-Martin, 1991). Barro and Sala-i-Martin (1991) find remarkable similarity between rates of β-convergence between the US states and the 73 regions of Europe that they discuss: in both cases, the β-coefficient is around 2%. That is, the rate at which the US states converged in income in the 20th century (in particular, how the Southern poorer states approached the income levels of richer Northern states) was similar to the rate at which these 73 regions of Europe converged in GDP per capita levels. They thus find that poorer regions of Europe, like many in Southern Italy, "are not being left behind in the growth process".

My paper builds on the models employed in Barro and Sala-i-Martin (1991), and Barro and Sala-i-Martin (1992): it uses a regression in which the natural logarithm of GDP per capita levels is one of the regressors, and the growth rate of GDP per capita is the regressand. The focus of my paper is similar to that of the two previously mentioned ones: gaining information about the regression coefficient of the natural logarithm of GDP per capita, called the rate of convergence β, from a regression model under different specifications.

However, there are key differences between this paper, and Barro and Sala-i-Martin (1991) and Barro and Sala-i-Martin (1992). The first key difference is in

the regressors being used in the respective models: in addition to the natural logarithm of GDP per capita, this paper uses average number of years of schooling, average investment levels and average number of years since accession to the EU as regressors. On the other hand, Barro and Sala-i-Martin (1991) and Barro and Sala-i-Martin (1992) do not consider average investment levels, average number of years of schooling, or the average number of years since accession to a particular union (be it the US for US states or the EU for European regions of EU Member States), and instead incorporate aggregate shocks into their model by adding a random aggregate shock variable and a variable measuring the effect of those shocks on the economy (the aggregate disturbance).

Another key difference between my paper, and Barro and Sala-i-Martin (1991) and Barro and Sala-i-Martin (1992), is that the latter two try to give an estimate for the value of the rate of convergence β in their models. In contrast, this paper is much more general and is only concerned with determining the sign of the coefficient of convergence β, which is an indicator of whether there was convergence or divergence observed in economic outcomes, and finding out whether there is statistically significant evidence to conclude that β was different than 0.

It is also worthwhile to mention that one of the most important reports that I used before writing this paper was Eurofound (2018). This report defines what is meant by convergence of economic outcomes and what models the authors have used to estimate the coefficient of convergence β. Eurofound (2018) uses the model

$$\Delta y_{i,t} = \alpha + \beta \ln(y_{i,t}) + \gamma Z_{i,t} + \varepsilon_{i,t}\,, \qquad i = 1, \dots, n, \qquad t = 1, \dots, m\,,$$

where $Z_{i,t}$ is a vector of potential explanatory variables for country i in period t, $y_{i,t}$ is the GDP per capita level for country i in period t, $\Delta y_{i,t}$ is the growth rate in GDP per capita levels for country i in period t, β and γ are regression coefficients, and $\varepsilon_{i,t}$ is an error term. Eurofound (2018) defines "divergence of economic outcomes" as positive values of the β-coefficient, and "convergence of economic outcomes" as negative values of the β-coefficient. The rationale is as follows: if $\beta > 0$, then the relationship between GDP per capita levels and its growth rate is positive, which implies that richer countries grew faster, and thus there was a gap generated between rich and poor countries in the period, which corresponds to divergence in economic outcomes. On the other hand, if $\beta < 0$, then the relationship between GDP per capita levels and its growth rate was negative, so that poorer countries grew faster than their richer counterparts, and thus the income gap between rich and poor countries shrank in the period, which corresponds to convergence in economic outcomes.

Eurofound (2018) uses data on the EU12 Member States: Belgium, Denmark,

France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, and the United Kingdom. It reports that among these countries, there was convergence in economic outcomes in all the periods 1961-1970, 1970-1980, 1981-1990, 1991-2000 and 2001-2007, and that there was divergence in 2008-2016. My paper, in contrast, takes a much broader subset of European countries – in fact, all countries that are presently in the EU and the United Kingdom (see *Appendix*, Table 12). I find that, in fact, there was divergence in economic outcomes in 1981- 1990 in this broader subset of Member States, and that there was convergence of economic outcomes in 2001-2010. The choice of the subset has a huge impact on results, as Eurofound (2018) analyzes only the well-off members of the EU, whereas I consider the ex-Soviet countries that later joined the EU as well. These ex-Soviet countries (I also refer to them as "Eastern European" throughout the paper) had much higher growth rates after the dissolution of USSR(1991), so it is logical that including them in the analysis would drastically change the results.

Data

Data for this paper was derived from multiple sources. The main source was the IMF World Economic Outlook Database of October 2021. I used this database to get data on GDP per capita levels in constant 2017 international dollars (PPP) and on investment rates in terms of percentage of overall GDP (overall GDP also in constant 2017 international dollars (PPP)). I selected countries that are currently part of the European Union, as well as the United Kingdom, as it has been part of the EU from 1981-2020, the main period of my analysis in this paper. I used the official website of the European Union to get data on the year of accession for every country that I will be considering. I also used the website *Our World In Data* in order to get data on average years of schooling for every year from 1981-2020 for each of the countries under discussion. For a more comprehensive list of variables and the corresponding datasets I used to acquire them, please see Table 11 in the *Appendix*.

It would be useful to briefly discuss the units of measurement used for these variables. GDP per capita is given in the IMF World Economic Outlook Database in constant 2017 international dollars. "Constant" means that the measure is expressed in terms of 2017 price levels, so that inflation does not affect the final value of goods and services produced in the economy in the given time period, and thus the measure gives us a "real" and not nominal sense of how much was produced in the country for each year. International dollars are a way to equalize the purchasing power parity across countries. The value of this imaginary currency is constructed so that it can buy the same amount of goods and services that one US dollar can buy in the US in the given period. Because some goods, and especially services, cannot be traded across borders, there are inherent price

differences in each country for the same good or service, even though their quality may be the same. The nominal exchange rate does not capture these price differences: it only considers bundles of goods and services that are tradable across borders. In order to give us a better ability to compare living standards across countries, we have to use a different exchange rate, or use a "common currency" that has the same purchasing power across borders. International dollars are an example of the latter.

The units of measurement of the other variables are straightforward. See *Appendix*, Table 11 for more information.

Below are summary tables of my dataset. Tables 1 and 2 show the average GDP per capita levels of Western and Eastern European countries from 1981-2020, respectively. It is evident that most Western European countries were richer than most Eastern European countries in this period.

Table 1.

Average GDP per capita of Western European countries, 1981-2020

Country	Average GDP per capita, 1981-2020 (constant 2017 international dollars)
Austria	44960.98
Belgium	41713.51
Cyprus	30760.03
Denmark	46376.51
Finland	38502.84
France	39280.29
Germany	42780.96
Greece	28143.6
Ireland	45305.67
Italy	39462.2
Luxembourg	87760.73
Malta	28154.15
Netherlands	44703.53
Portugal	27184.45
Spain	32161.6
Sweden	41074.61
United Kingdom	36729.13

Table 2.

Average GDP per capita of Western European countries, 1981-2020

Country	Average GDP per capita, 1981-2020 (constant 2017 international dollars)
Bulgaria	16123.82
Croatia	21907.95
Czech Republic	31851.99
Estonia	25135.26
Hungary	21914.7
Latvia	19710.16
Lithuania	23765.65
Poland	18272.59
Romania	17365.13
Slovak Republic	22843.96
Slovenia	30490.35

Theory

The basis for this research paper is the neoclassical model of growth developed by Robert Solow and Trevor Swan in 1956. This model is an exogenous growth model and depends on the amount of capital, labor, and the technological level of the economy to explain its growth.

However, whereas only short-run increases in the per capita GDP levels can be generated by increases in the labor force or the amount of capital, long-run growth can only be achieved through technological advancement. This model assumes that there is an underlying capital depreciation rate, called δ, which is how much resources should be spent repairing broken-down machinery and recovering other pieces of technology, whether tangible or not. The more a society accumulates capital, the higher the capital depreciation will be, and the higher amount of resources the society will spend on repairing depreciated capital. This depreciation rate, together with a savings rate and a population growth rate determined exogenously will together determine a long-run steady-state equilibrium to which a country will converge in the long run. Thus, this model

predicts that if different countries have similar levels of savings, capital depreciation and population growth rates, then they will converge to the same steady-state equilibrium in the long run. Thus, if one country has a lower initial GDP per capita level than the other, this model predicts that the country with lower initial wealth will consistently grow at a higher rate than the wealthier country until it has a similar amount of income compared to the rich country.

This model also assumes decreasing returns to capital, that is, the more capital a country accumulates, the less productive an additional unit of capital will be on the margin. What this means is that long-run growth can only be achieved through technological advancement, not through population growth or capital accumulation. Developed countries engage in research and development so as to increase productivity: they are on the technological forefront, and thus they grow at a slower rate as developing new technologies and new ways of doing things is costly, both monetarily and in terms of time. These countries are said to be exhibiting *cutting-edge growth.* However, developing and less developed countries can incorporate technologies that are already known in the developed world, and so they do not have to engage in research and development to grow: these countries, through incorporating already-known technologies, can grow faster than their richer counterparts. They are then said to be exhibiting *catch-up growth.*

Unfortunately, it is not the case throughout the world that convergence is observed between rich and poor countries: most poor countries in Sub-Saharan Africa, for example, fail to exhibit catch-up growth, and thus their economies remain stagnant for decades with no progress in standards of living (Strauss, 2021). The goal of this paper is to argue that, in fact, after the dissolution of USSR, the poorer countries of Eastern Europe have been able to exhibit catch-up growth during the period 2001-2010, and convergence in GDP per capita levels has been observed among them and their richer counterparts in Western Europe.

Exploring Correlations

Firstly, consider a decomposition of the dataset in terms of ten-year intervals, where averages for each of the variables “GDP per capita” and “growth rates of GDP per capita” have been taken for each country over the ten-year periods, to test convergence for each of the periods 1981-1990, 1991-2000, 2001-2010 and 2011-2020.

Figure 1.

Relationship of the average growth rate and the natural logarithm of average GDP per capita levels using 10-year intervals. Individual points represent different Member States of the EU

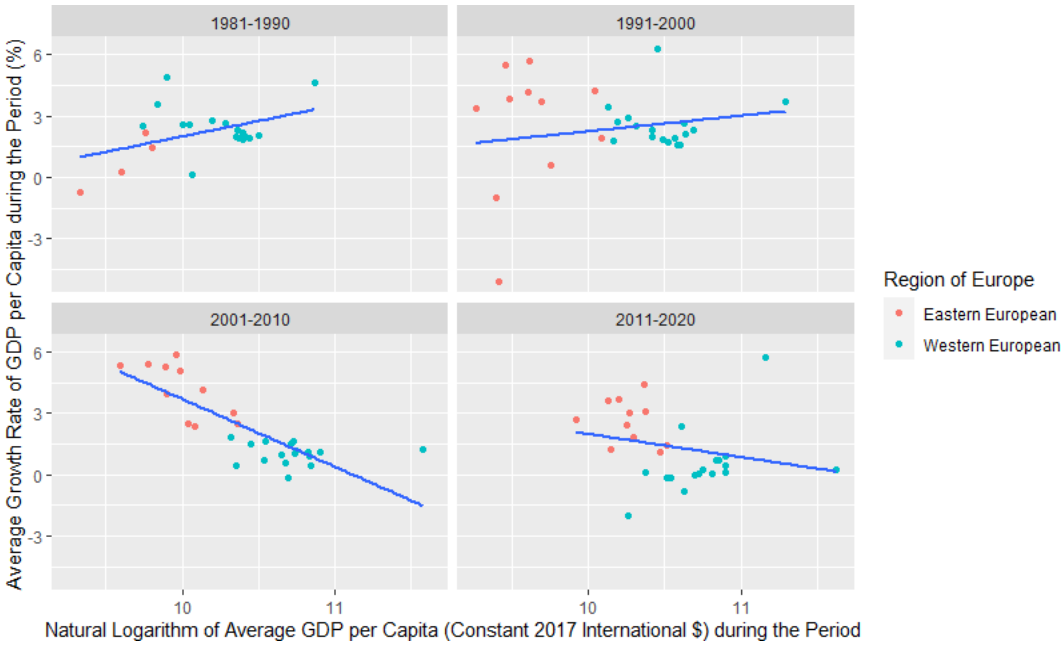


Figure 1 shows that there is clearly a negative relationship between the natural logarithm of average GDP per capita levels and the average growth rate of GDP per capita, which implies that there should have been convergence in this period. That is, poorer countries had higher growth rates, whereas richer countries had lower growth rates in this period. Also, we can notice that there was a positive relationship between the natural logarithm of average GDP per capita levels and the average growth rate of GDP per capita in 1981-1990, which hints that there might have been divergence among the countries in this period, with richer European countries growing at higher rates than their poorer counterparts. This makes sense, because during this period, the poor countries of Eastern Europe were still in the Soviet Union under a socialist centrally planned market regime: therefore, their growth rates would be comparable to that of USSR, which was meager compared to the growth rates of the advanced Western European economies. We can also notice a negative correlation from 2011-2020 implying convergence, but this is less pronounced. The reason might have been the Financial Crisis of 2008 that shook the foundations of the EU.

Another clear pattern we can see is that, in 1981-1990, red points were located

to the bottom-left of the best fit line, whereas blue points were located to the top right of it. This is consistent with the narrative of this paper: before 1990, Eastern European countries (represented by red dots on the graph), as defined by their affiliation with USSR, had less chances of growth because of the socialist centrally planned market regime that persisted there until 1991: thus, their average GDP per capita levels and their growth rates were lower compared to the advanced Western European economies. Thus, there was divergence of economic outcomes amongst the present Member States of EU, with the poorer Eastern European countries growing more slowly than their richer Western counterparts. On the other hand, in 2001-2010 and 2011-2020, the pattern is reversed: the red data points lie to the upper-left of the best-fit line, whereas the blue data points lie to the bottom-right of the best fit line. This is also consistent with my narrative, in that after 2000, when most of the ex-Soviet Eastern European countries (represented by red dots in Figure 1) joined the EU, their average growth rates were higher than those of the rich Western European countries, implying that poorer European countries were catching up with richer ones during these ten-year periods in terms of economic outcomes (by which I mean the growth rates of GDP per capita levels). Of course, this graph is far from irrevocably proving my narrative, but it is one testimony to its validity.

Next, I consider 5-year intervals to understand whether convergence has been observed during the period under discussion (1981-2020). Note that I also use the predicted GDP per capita values (constant 2017 international dollars) for the years 2021-2025 from the IMF World Economic Outlook Databases to inquire into whether convergence will be observed among the current Member States of the EU during this 5-year interval, according to the predictions of the IMF.

Figure 2.

Relationship of the average growth rate and the natural logarithm of average GDP per capita levels using 5-year intervals. Individual points represent different Member States of the EU

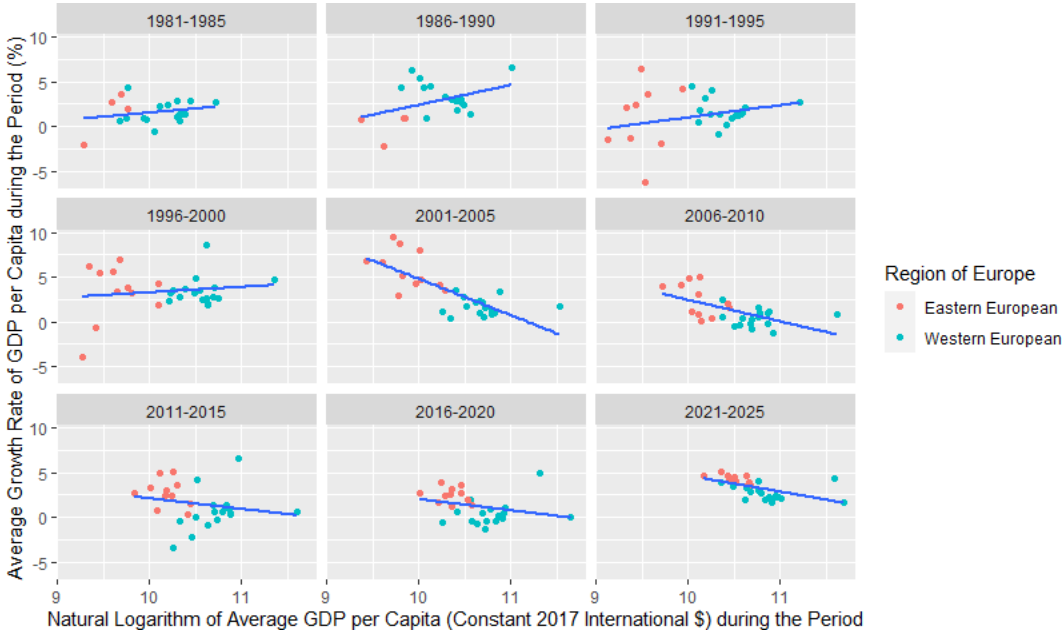


Figure 2 shows that there is a strongly positive correlation between the average GDP per capita growth rates of the Member States and the natural logarithm of their average GDP per capita levels in the period 1986-1990. As defined by the Eurofound (2018), this might imply that there was divergence in economic outcomes of the Member States in this period, as richer countries grew more rapidly during this period than their poorer counterparts. Zooming in more closely on this interval, we notice the characteristic pattern that was observed in Figure 1: poorer Eastern European countries had lower growth rates, and richer Western European countries had higher growth rates during the period 1986-1990. This is again consistent with the narrative that being in the Eastern Bloc (USSR and its satellite states in Eastern Europe) had a negative impact on the ability of poorer Eastern European countries to exhibit catch-up growth and approach the levels of GDP per capita observed in richer Western European economies (see *Appendix*, Table 12 to learn more on how I define "Eastern" and "Western" European). On the other hand, this pattern reverses dramatically in each of the 5-year periods starting from 2001-2005: here, we see that the red data points are to the upper left of the best fit line, whereas the blue data points are to

the lower right. This means that poorer Eastern European countries (red dots), on average, grew more rapidly in each of these five-year periods compared to the richer Western European countries (blue dots). Thus, the best fit line has a negative slope, indicating a negative correlation between the natural logarithm of GDP per capita levels and the average growth rates of the GDP per capita levels during the 5-year periods. This is how Eurofound (2018) defined convergence of economic outcomes: a negative correlation coefficient between GDP per capita levels (or the natural logarithm of it) and the average growth rates of GDP per capita. We can also see this same pattern for the period 2021-2025, which was derived based on the predictions of the IMF about the GDP per capita levels of the Member States during these periods. As can be seen, the correlation is negative in this case as well, indicating convergence between the Member States, with the poorer Eastern European countries exhibiting higher growth rates than their richer Western counterparts.

Finally, I will look at the average growth trajectory of a subset of Eastern European countries and compare it to the average growth trajectory of a subset of Western European countries. Refer to Table 3 for the subsets of Eastern and Western European countries used for this analysis.

Table 3.

Subsets of Eastern and Western European countries used for the construction of Figure 3

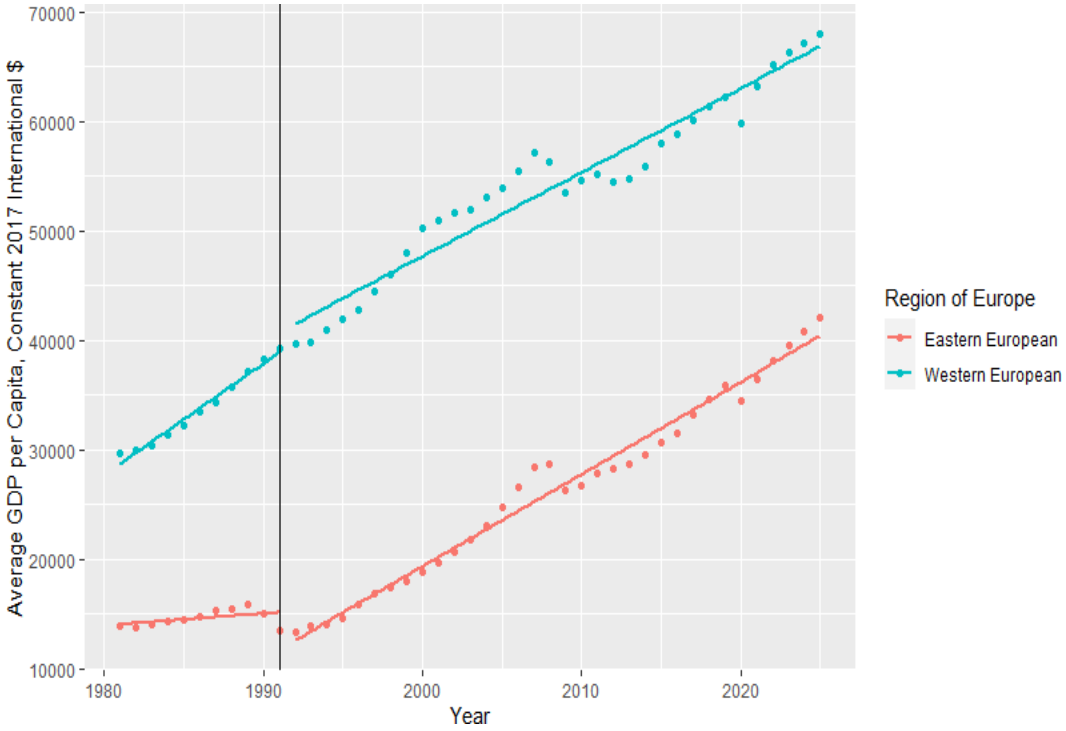
Eastern European Member States of the EU that joined the EU in 2004	**Western European Member States of the EUthat joined the European Communities[4] in 1973 or earlier**
Czech Republic	Belgium
Estonia	Italy
Hungary	France
Latvia	Luxembourg
Lithuania	Netherlands
Poland	Germany[5]
Slovak Republic	Denmark
Slovenia	Ireland
	United Kingdom

The subsets used here are not random: I chose the subset of Eastern European countries to consist of all those countries that joined the EU on May 1, 2004. I did this to control for the numberof years since accession to the EU, as there might have been a positive correlation between the number of years that a poorer developing country had been in this economic union and the gains accrued from it during those years. The subset of Western European countries is not random as well: I chose the countries that had joined the European Communities (EC) before the decade of 1980, when my data begins. This makes sense, as the countries that joined the European Communities (EC) before 1980 were the richer Western democracies that already had advanced economies and were similar in terms of GDP per capita levels and average standards of living. The last enlargement of the European Communities (EC) before the start of the eighties took place in 1973, so I take all the countries that joined the EC before and during the 1973 expansion to be the subset of Western European countries that I analyze below.

[4] European Communities was a predecessor of the European Union. See Appendix for more.
[5] I take Western Germany to represent Germany until the reunification of Germany in 1990.

Figure 3.

Average growth rates of subsets of Eastern and Western European countries, 1981-2025.Values from 2020 to 2025 are projections of the IMF



I use Figure 3 to discuss the average growth paths of these subsets of European countries from 1981 to 2020. The horizontal line on year 1991 indicates the date of the dissolution of USSR. Before and after 1991, there was not a dramatic change in the trend of the growth of Western European countries, indicated by the blue line: the trend line before 1991 and that after 1991 have approximately identical slopes. However, it is evident that there was a dramatic increase in the slope of the trend line of the growth path of Eastern European countries, indicated by the red line: in fact, before 1991 Western Europe was growing much faster, whereas after 1991 we can see that the lines are approximately parallel to each other. This figure is also consistent with the narrative that the dissolution of USSR enabled many Eastern European countries that were in the Eastern Bloc to attain sustainable growth paths comparable to those in Western Europe in the decades after gaining independence.

Estimation

As mentioned in the introduction, there are many types of convergence that different authors use. This paper is concerned with β-convergence – "the [tendency] of poorer regions to grow faster than richer regions" (Barro and Sala-i-Martin, 1991). It is important to note that this paper does not try to establish causality between GDP growth rates and GDP per capita levels: rather, I am trying to determine periods during which the correlation between these variables was positive, and periods during which it was negative.

I will use the ordinary least squares regression under different specifications to find periods in which convergence or divergence was observed. My dataset spans from 1981 to 2020, and in some cases I include the IMF projections for years 2021-2025.

According to Eurofound (2018), I will use the following model to test for convergence in a given time period:

$$\Delta y_{i,t} = \alpha + \beta \ln(y_{i,t}) + \gamma Z_{i,t} + \varepsilon_{i,t}\,, \qquad i = 1, \dots, n$$

where $y_{i,t}$ is the average GDP per capita of country i in period t (constant 2017 international dollars), $\Delta y_{i,t}$ is the average growth rate of GDP per capita of country i in period t (%), $Z_{i,t}$ is a vector of other potential explanatory variables, β is the coefficient of convergence, and $\varepsilon_{i,t}$ is an error term. We are particularly interested in the sign of the convergence coefficient β: a positive β-coefficient indicates divergence, and a negative β-coefficient indicates convergence. This is because a positive β-coefficient indicates a positive relationship between GDP per capita levels and its growth rates, so that richer countries grow faster than poorer ones, the income gap between the rich and poor countries increases, and divergence in economic outcomes is observed. Conversely, a negative β-coefficient would indicate poorer countries catching up with richer ones in terms of income, which corresponds to convergence in economic outcomes.

I will use the aforementioned model under different specifications in order to verify robustness of results obtained. More concretely, I will be using three specifications of this regression model:

$$1)\quad \Delta y_{i,t} = \alpha + \beta * \ln(y_{i,t}) + \varepsilon_{i,t}\,, \qquad i = 1, \dots, n,$$

where $y_{i,t}$ is the average GDP per capita of country i in period t (constant 2017 international dollars), $\Delta y_{i,t}$ is the average growth rate of GDP per capita of country i in period t (%), β is the coefficient of convergence, and $\varepsilon_{i,t}$ is an error term. This is the simplest possible specification with only one regressor – the natural logarithm of average GDP per capita of country i in period t (constant

2017 international dollars).

$$2)\ \Delta y_{i,t} = \alpha + \beta_1 * \ln(y_{i,t}) + \beta_2 * \mathrm{I}_{i,t} + \beta_3 * \mathrm{S}_{i,t} + \varepsilon_{i,t}, \qquad i = 1, \dots, n,$$

where $y_{i,t}$ is the average GDP per capita of country i in period t (constant 2017 international dollars), $\Delta y_{i,t}$ is the average growth rate of GDP per capita of country i in period t (%), β_1 is the coefficient of convergence, $\mathrm{I}_{i,t}$ is the average level of investment of country i in period t (% of GDP), $\mathrm{S}_{i,t}$ is the average number of years of schooling of country i in period t across all educational levels and for people 25 years and older, β_2 and β_3 are the regression coefficients of $\mathrm{I}_{i,t}$ and $\mathrm{S}_{i,t}$ respectively, and $\varepsilon_{i,t}$ is an error term.

$$3)\ \Delta y_{i,t} = \alpha + \beta_1 * \ln(y_{i,t}) + \beta_2 * \mathrm{I}_{i,t} + \beta_3 * \mathrm{S}_{i,t} + \beta_4 * A_{i,t} + \varepsilon_{i,t},$$

$$i = 1, \dots, n,$$

where $y_{i,t}$ is the average GDP per capita of country i in period t (constant 2017 international dollars), $\Delta y_{i,t}$ is the average growth rate of GDP per capita of country i in period t (%), β_1 is the coefficient of convergence, $\mathrm{I}_{i,t}$ is the average level of investment of country i in period t (% of GDP), $\mathrm{S}_{i,t}$ is the average number of years of schooling of country i in period t across all educational levels and for people 25 years and older, $A_{i,t}$ is the average number of years since accession to the EU of country i in period t, β_2, β_3 and β_4 are the regression coefficients of $\mathrm{I}_{i,t}$, $\mathrm{S}_{i,t}$ and $A_{i,t}$ respectively, and $\varepsilon_{i,t}$ is an error term.

The reader can notice that all these variables are averages across some periods of time. Firstly, I use ten-year time intervals: 1981-1990, 1991-2000, 2001-2010 and 2011-2020, such that $t = 1, 2, 3, 4$ in the regression equations. Thus, all variables are ten-year averages in these models.

Secondly, I divide the period from 1981 to 2020 into 8 subintervals of 5 years, with subintervals 1981-1985, 1986-1990, 1991-1995, and so on, such that $t = 1, 2, \dots, 8$ in these models. In the case of regression 1), I also use the IMF projections and incorporate a ninth subinterval from 2021-2025. As projections were not available for variables other than GDP per capita, regressions 2) and 3) just have 8 subintervals instead of 9. This amounts to 6 regressions, 3 with 10-year intervals and 3 with 5-year intervals, each corresponding to one of the models 1) – 3) discussed above.

I was careful in the choice of other explanatory variables. Eurofound (2018) suggests that the investment-to-GDP ratio and the year of EU accession may play a significant role in the determination of GDP per capita growth rates, and so both variables were included in at least one of the models 1) – 3). It was also discussed how average number of years of schooling might be a potential explanatory

variable for the growth rates of GDP per capita (Strauss, 2021), and thus this variable was incorporated into at least one of the models 1) – 3) as well.

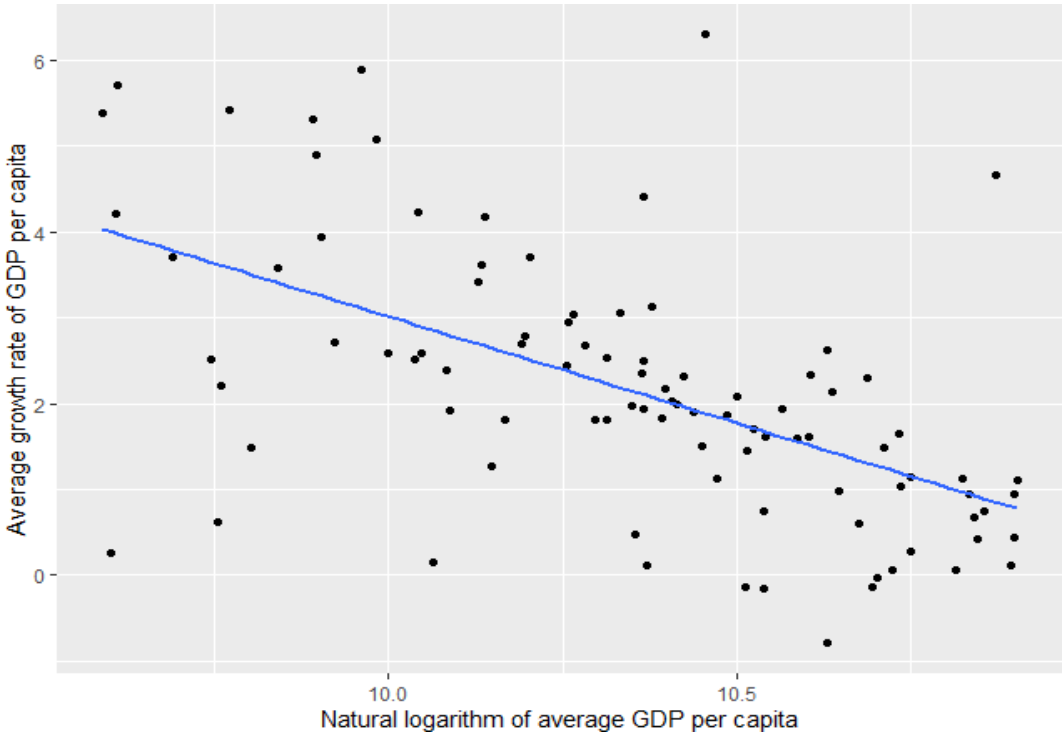
Assumptions of the OLS Model

In this section I will address each of the assumptions that need to be made for the model specified in the previous section to be reasonable.

1) Linearity – the dependent variable $\Delta y_{i,t}$ is a linear function of the independent variables, the natural logarithm of average GDP per capita $ln(y_{i,t})$, the average investment level $I_{i,t}$, the average number of years of schooling $S_{i,t}$ and the average number of years since accession to the EU, $A_{i,t}$, plus an error term $\varepsilon_{i,t.}$

Figure 4.

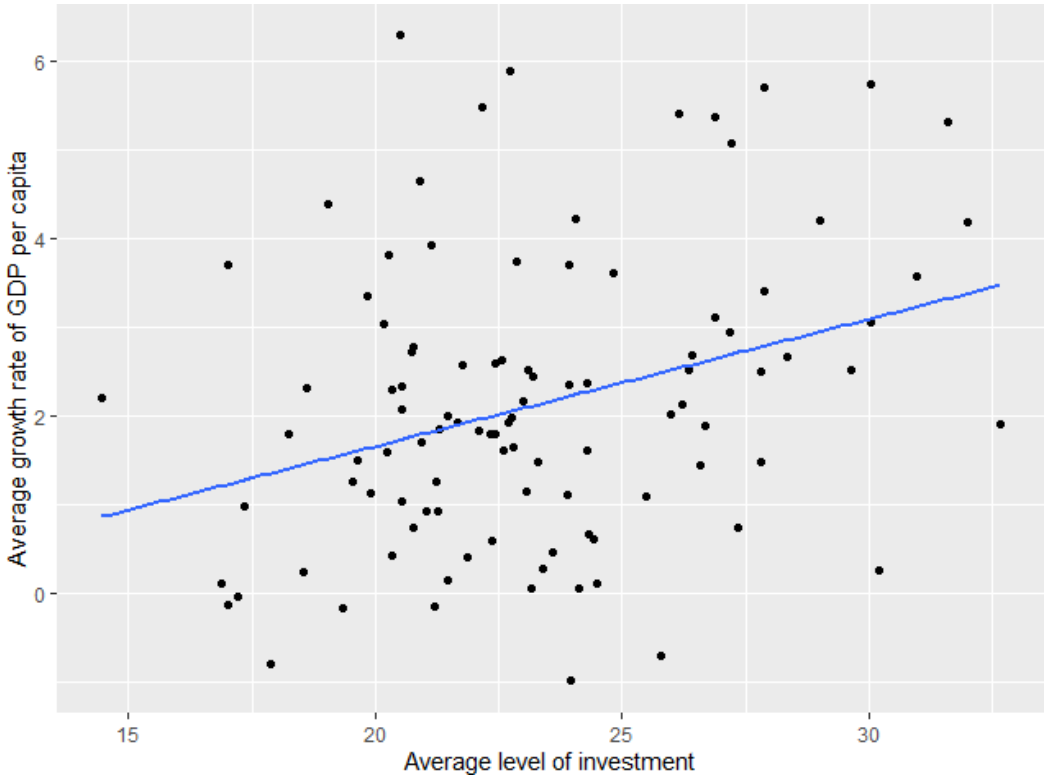
The natural logarithm of average GDP per capita vs the average growth rate of GDP per capita



Note: Some of the outliers have been omitted before generating the graph

Figure 5.

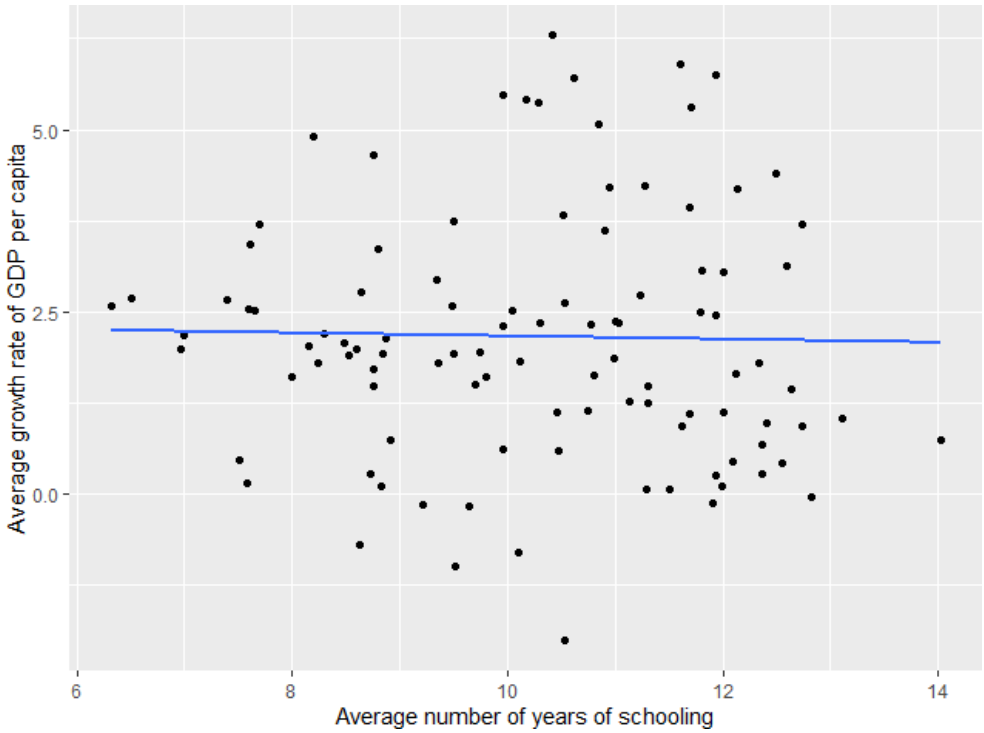
The average level of investment vs the average growth rate of GDP per capita



Note: Some of the outliers have been omitted before generating the graph

Figure 6.

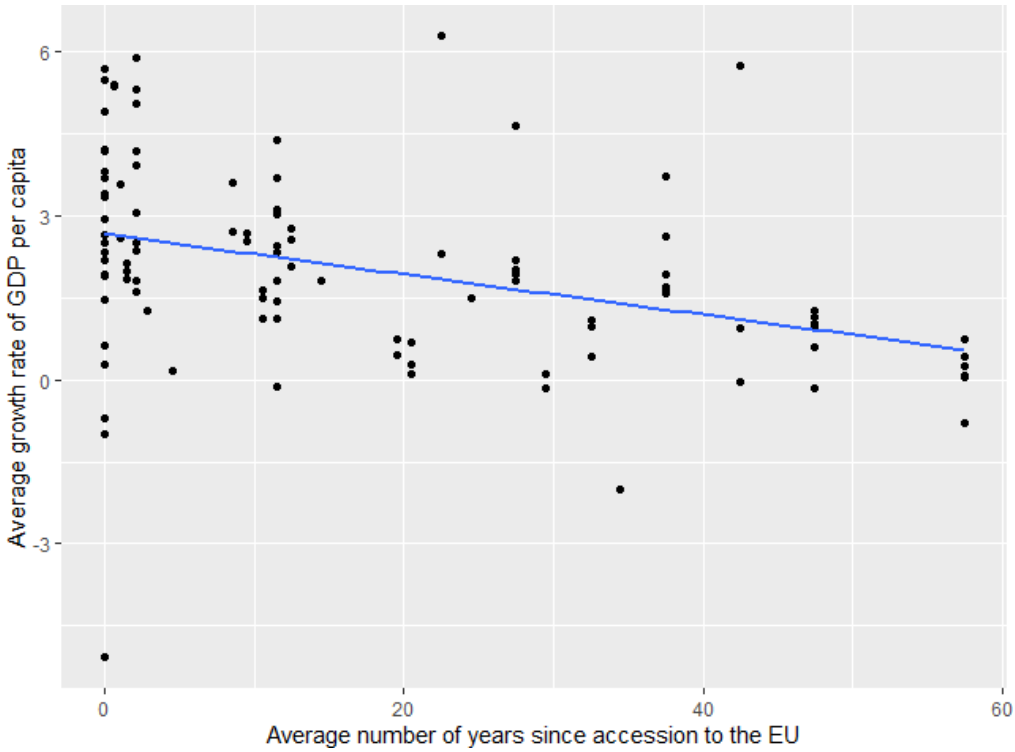
The average number of years of schooling vs the average growth rate of GDP per capita



Note: Some of the outliers have been omitted before generating the graph

Figure 7.

The average number of years since accession to the EU vs the average growth rate of GDP per capita



Figures 4-7 show a plot of each of the independent variables on the x-axis vs the dependent variable $\Delta y_{i,t}$ on the y-axis. In Figures 4, 5 and 7, we can see a linear correlation, so assumption 1) is reasonable for $ln(y_{i,t})$, $I_{i,t}$ and $A_{i,t}$. In Figure 6, there appears to be no correlation at all between $S_{i,t}$ and $\Delta y_{i,t}$. It is also true that we cannot see any other form of correlation between these two variables (for example, quadratic, exponential, etc.). The closest approximation to this set of points is a straight line.

1) No perfect multicollinearity

This condition will be breached if any two of the independent variables have a correlation coefficient of 1 or -1.

Table 4.

Correlation coefficients of each pair of independent variables.

	$ln(y_{i,t})$	$I_{i,t}$	$S_{i,t}$	$A_{i,t}$
$ln(y_{i,t})$		-0.188	0.362	0.740
$I_{i,t}$	-0.188		-0.124	-0.350
$S_{i,t}$	0.362	-0.124		0.286
$A_{i,t}$	0.740	-0.350	0.286	

Note: Diagonal blocks are shaded as only different pairs are relevant in this analysis.

Table 4 represents every possible combination of different independent variables. None of them have correlation coefficients that are close to 1 or -1, indicating that the assumption of no perfect multicollinearity is reasonable to make in this dataset. The only pair for which the correlation coefficient is close to 1 is $ln(y_{i,t})$ and $A_{i,t}$.

2) Homoskedasticity

Figure 8.

Residual plot under specification 1) of the model (see Section Estimation)

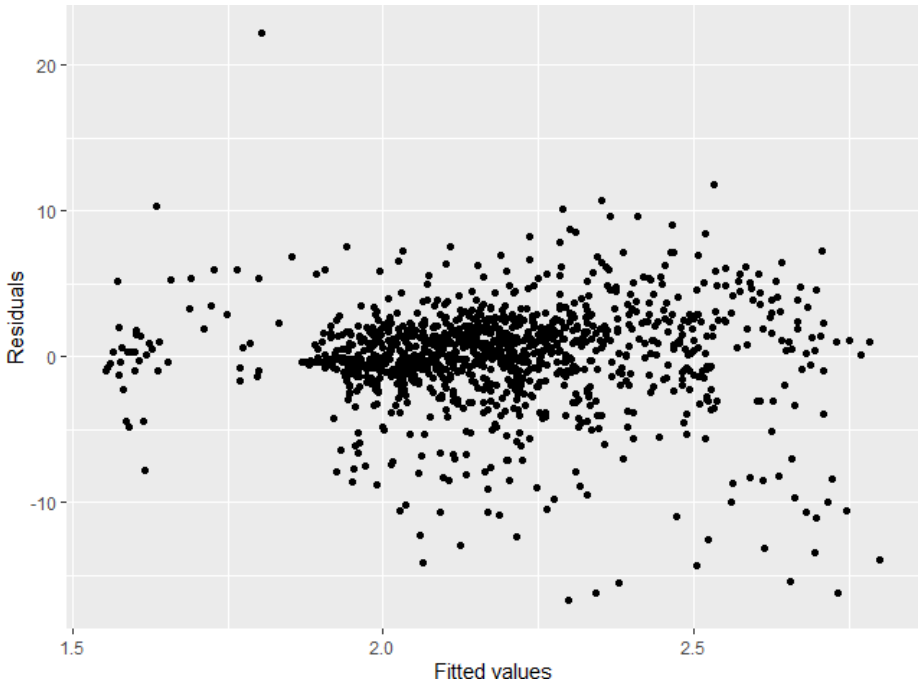


Figure 9.

Residual plot under specification 2) of the model (see Section Estimation)

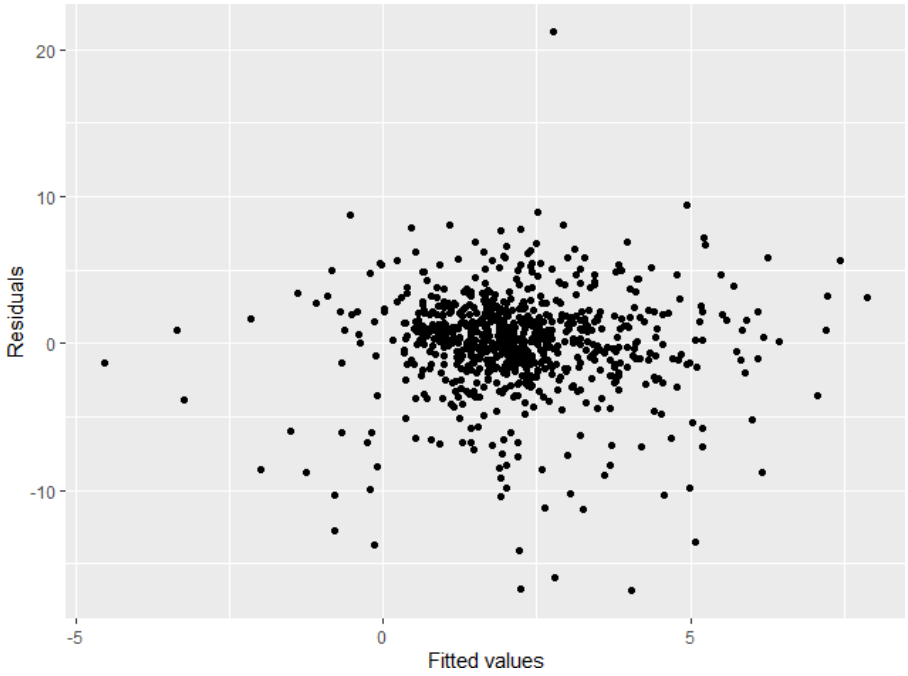
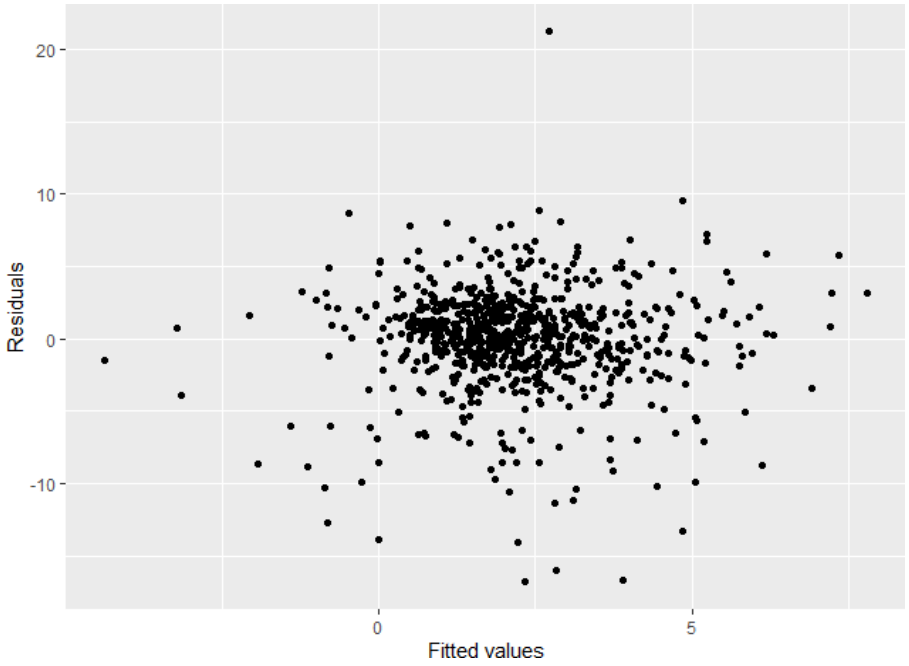


Figure 10.

Residual plot under specification 3) of the model (see Section Estimation)



Figures 8-10 demonstrate residual plots for each of the specifications 1) – 3) of the model. None of them have a cone-like structure and all of them have approximately a rectangular shape, ignoring a few outliers. Thus, homoskedasticity is a reasonable assumption to make for this dataset, given specifications 1) – 3) of the model. This is the most essential assumption for my model, as I am interested not in the particular value of the convergence coefficient β, but whether there is statistically significant evidence to assert that it is negative or positive. Negative β-values mean convergence, and positive β-values mean divergence of economic outcomes. Thus, under the assumption of homoskedasticity, I can accurately gauge statistical significance for whether the convergence coefficient is different than 0, which is the main goal of this paper.

3) Exogeneity

Finally, an important assumption of the OLS model is exogeneity. However, this is not a relevant concern for this paper: my goal in this paper is to gauge whether there is statistically significant evidence to suggest that the convergence coefficient is positive or negative. If exogeneity does not hold, this will affect the exact value of the convergence coefficient β, making it biased. However, the

goal of this paper is not to find out the exact value of the coefficient β. In fact, there may be reason to believe that there is endogeneity in this data: for example, there might be reverse causality from the growth rates of GDP per capita to the average number of years of schooling, or the average investment rates. However, as already mentioned, the goal of this paper is to gauge statistical significance in hypothesis testing, and the main concern for this is homoskedasticity, which was discussed above.

Results – Part 1

Table 5.

Regression using model 1) (see Section Estimation), with four ten-year intervals

	Average Growth Rate of GDP per Capita during the Period (%)			
	1981-1990	1991-2000	2001-2010	2011-2020
Natural Logarithm of Average GDP per Capita during the Period (Constant 2017 International Dollars)	1.516*	0.374	-3.312***	-1.131
	(0.733)	(0.822)	(0.480)	(0.926)
Constant	-13.159*	-1.281	36.824***	13.296
	(7.428)	(8.349)	(5.011)	(9.794)
N	21	28	28	28
R^2	0.184	0.008	0.647	0.054
Adjusted R^2	0.141	-0.030	0.633	0.018
Residual Std. Error	1.198 (df = 19)	2.168 (df = 26)	1.084 (df = 26)	1.731 (df = 26)
F Statistic	4.274* (df = 1; 19)	0.207 (df = 1; 26)	47.645*** (df = 1; 26)	1.493 (df = 1; 26)

Notes:

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Using model[6] 1) with ten-year intervals, we get a statistically significant (at the 10% level) and positive coefficient of convergence for the period 1981-1990 and a statistically significant (at the 1% level) and negative coefficient of convergence for the period 2001-2010. This model implies that there was a divergence of economic outcomes observed among the present Member States of the EU in 1981-1990 and a convergence of economic outcomes observed in 2001-2010. The exact values of the β-coefficient may be biased because of endogeneity, and the exact values of this coefficient is not what we are looking for: rather, we are trying to establish that the β-coefficient was different than 0, and the sign of it will inform us whether there was convergence or divergence observed among the present Member States of the EU during the given period. Thus, at the 10% significance level, Table 5 tells us that there was divergence in the period 1981-1990, and that there was convergence in 2001-2010 at the 1% significance level. Note that this model is the simplest one possible, with the response variable being

[6] In the Results section (Part 1 and Part 2), I use the terms "model" and "specification" interchangeably. They bothrefer to equations 1) – 3) in the *Estimation* Section.

the average growth rate of GDP per capita and the regressor being the natural logarithm of average GDP per capita levels during the given periods.

Table 6.

Regression using model 2) (see Section Estimation), with four ten-year intervals

	Average Growth Rate of GDP per Capita during the Period (%)			
	1981-1990	1991-2000	2001-2010	2011-2020
Natural Logarithm of Average GDP per Capita during the Period (Constant 2017 International Dollars)	2.094***	0.260	-3.185***	-1.689**
	(0.721)	(0.771)	(0.497)	(0.741)
Average Investment during the Period (% of GDP)	0.097*	0.196**	0.074	0.281***
	(0.050)	(0.089)	(0.059)	(0.076)
Average Number of Years of Schooling during the Period	-0.190	0.295	0.424***	0.259
	(0.206)	(0.323)	(0.148)	(0.264)
Constant	-19.873**	-7.353	29.062***	10.116
	(7.876)	(8.596)	(5.991)	(7.654)
N	21	28	28	28
R^2	0.379	0.205	0.754	0.476
Adjusted R^2	0.270	0.105	0.724	0.411
Residual Std. Error	1.104 (df = 17)	2.021 (df = 24)	0.941 (df = 24)	1.341 (df = 24)
F Statistic	3.466** (df = 3; 17)	2.058 (df = 3; 24)	24.574*** (df = 3; 24)	7.271*** (df = 3; 24)

Notes:

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table 6 shows the results of model 2) when it was employed with four 10-year intervals. This Table tells us that the coefficient of convergence was positive at the 1% significance level in the period 1981-1990, and that it was negative in the period 2001-2010 at the 1% significance level and negative in the period 2011-2020 at the 5% significance level. Thus, this model tells us that there is statistically significant evidence that divergence in economic outcomes was observed among the present Member States in the period 1981-1990, and convergence was observed in periods 2001-2010 and 2011-2020. The results for periods 1981-1990 and 2001-2010 coincide with those of Table 5. For the period 2011-2020, the coefficients were negative in both Table 5 and Table 6: however, Table 5 did not produce statistically significant results for this period.

Both Table 5 and Table 6 have positive coefficients of convergence for 1991-2000 that are nevertheless statistically insignificant.

Table 7.

Regression using model 3) (see Section Estimation), with four ten-year intervals

	Average Growth Rate of GDP per Capita during the Period (%)			
	1981-1990	1991-2000	2001-2010	2011-2020
Natural Logarithm of Average GDP per Capita during the Period (Constant 2017 International Dollars)	2.405**	0.113	-2.856***	-0.754
	(0.935)	(1.203)	(0.653)	(1.101)
Average Investment during the Period (% of GDP)	0.091	0.202**	0.058	0.254***
	(0.053)	(0.098)	(0.063)	(0.079)
Average Number of Years of Schooling during the Period	-0.191	0.290	0.418**	0.210
	(0.210)	(0.331)	(0.149)	(0.266)
Average Number of Years in the EU during the Period	-0.015	0.006	-0.012	-0.023
	(0.029)	(0.040)	(0.016)	(0.020)
Constant	-22.697**	-6.016	26.319***	2.014
	(9.601)	(12.053)	(6.980)	(10.403)
N	21	28	28	28
R^2	0.391	0.205	0.761	0.504
Adjusted R^2	0.238	0.067	0.719	0.418
Residual Std. Error	1.128 (df = 16)	2.063 (df = 23)	0.949 (df = 23)	1.332 (df = 23)
F Statistic	2.563* (df = 4; 16)	1.487 (df = 4; 23)	18.288*** (df = 4; 23)	5.847*** (df = 4; 23)

Notes:

***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Finally, Table 7 shows the results of regression using model 3) with four ten-year intervals. This Table indicates that there was statistically significant evidence (at the 5% significance level) that the coefficient of convergence was positive in 1981-1990 and that it was negative (at the 1% significance level) in 2001-2010. The result for the coefficient of convergence in 2011-2020 was negative but statistically insignificant using this specification of the model. In 1991-2000, the result for the coefficient of convergence was positive but statistically insignificant. This specification of the model thus tells us that there was statistically significant divergence in 1981- 1990 and convergence in 2001-2010, and thus agrees with the results in Table 5 and Table 6. It also agrees with the results in Table 5 and Table 6 in that the coefficient of convergence for 1991-2000 was positive but statistically insignificant.

Summarizing, we can see that the results for periods 1981-1990 and 2001-2010 are robust across all three specifications of the model: all three of them indicate statistically significant divergence in economic outcomes between the present Member States in 1981-1990 and convergence in 2001-2010. Additionally, we get statistically significant convergence in 2011-2020 from Table 4 at the 5% significance level: however, this result is not robust across the three specifications. It is also worthwhile to note that none of the specifications produce statistically significant results for the period 1991-2000, although all of them give a positive coefficient of convergence (which is equivalent to divergence of economic outcomes between the present Member States of the EU).

Results – Part 2

Table 8.

Regression using model 1) (see Section Estimation), with nine five-year intervals

	Average Growth Rate of GDP per Capita during the Period (%)								
	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020	2021-2025
Natural Logarithm of Average GDP per Capita during the Period (Constant 2017 International Dollars)	0.911	2.219*	0.833	0.611	-4.079***	-2.409***	-1.173	-1.255	-1.792***
	(0.893)	(1.145)	(0.967)	(0.850)	(0.700)	(0.658)	(1.140)	(0.855)	(0.505)
Constant	-7.599	-19.794	-7.026	-2.849	45.575***	26.519***	13.796	14.539	22.533***
	(8.987)	(11.674)	(9.775)	(8.680)	(7.259)	(6.914)	(11.997)	(9.090)	(5.419)
N	21	21	26	28	28	28	28	28	28
R^2	0.052	0.165	0.030	0.020	0.567	0.340	0.039	0.076	0.326
Adjusted R^2	0.002	0.121	-0.010	-0.018	0.550	0.315	0.002	0.041	0.300
Residual Std. Error	1.419 (df = 19)	1.924 (df = 19)	2.494 (df = 24)	2.313 (df = 26)	1.740 (df = 26)	1.368 (df = 26)	2.214 (df = 26)	1.557 (df = 26)	0.874 (df = 26)
F Statistic	1.042 (df = 1; 19)	3.754* (df = 1; 19)	0.744 (df = 1; 24)	0.518 (df = 1; 26)	33.980*** (df = 1; 26)	13.401*** (df = 1; 26)	1.058 (df = 1; 26)	2.154 (df = 1; 26)	12.596*** (df = 1; 26)

Notes:

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Part 2 of this section summarizes the results obtained from employing models 1) – 3) (see Section *Estimation*) using five-year intervals. Table 8 summarizes the results obtained from model 1). According to Table 8, this specification produces a statistically significant (10% significance level) positive coefficient of convergence for the period 1981-1985, and negative coefficients of convergence for periods 2001-2005 and 2006-2010 (both at the 1% significance level). Thus, Table 8 implies a divergence of economic outcomes among the Member States in 1986-1990, and convergence in 2001-2005 and 2006-2010. This Table is the only one that includes an estimate for the regression coefficient for the period 2021-2025, based on IMF predications on GDP per capita levels of these countries. It gives a negative correlation at the 1% significance level, predicting convergence of economic outcomes between the present Member States of the EU in the coming four years. This Table is consistent with results obtained from Part 1 of the *Results* Section, which argued for convergence in 2001-2010 and divergence in 1981-1990.

Table 9.

Regression using model 2) (see Section Estimation), with eight five-year intervals

	Dependent variable:							
	Average Growth Rate of GDP per Capita during the Period (%)							
	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020
Natural Logarithm of Average GDP per Capita during the Period (Constant 2017 International Dollars)	1.274	2.757**	0.412	0.703	-3.727***	-2.834***	-1.167	-2.249***
	(1.018)	(1.091)	(0.941)	(0.802)	(0.645)	(0.867)	(1.040)	(0.751)
Average Investment during the Period (% of GDP)	0.063	0.094	0.184**	0.197*	0.176**	-0.041	0.287**	0.183***
	(0.060)	(0.088)	(0.088)	(0.104)	(0.081)	(0.089)	(0.119)	(0.057)
Average Number of Years of Schooling during the Period	0.207	-0.618*	0.257	0.382	0.574**	0.275	0.346	0.317
	(0.263)	(0.334)	(0.361)	(0.353)	(0.228)	(0.218)	(0.385)	(0.253)
Constant	-14.433	-22.402*	-9.061	-12.094	31.674***	28.855***	3.752	17.256**
	(11.076)	(11.855)	(10.011)	(9.305)	(7.716)	(10.308)	(10.872)	(7.668)
Observations	21	21	26	28	28	28	28	28
R^2	0.126	0.361	0.207	0.195	0.708	0.383	0.334	0.425
Adjusted R^2	-0.028	0.248	0.099	0.095	0.672	0.306	0.250	0.354
Residual Std. Error	1.440 (df = 17)	1.780 (df = 17)	2.355 (df = 22)	2.182 (df = 24)	1.486 (df = 24)	1.377 (df = 24)	1.919 (df = 24)	1.278 (df = 24)
F Statistic	0.820 (df = 3; 17)	3.201** (df = 3; 17)	1.919 (df = 3; 22)	1.940 (df = 3; 24)	19.415*** (df = 3; 24)	4.974*** (df = 3; 24)	4.005** (df = 3; 24)	5.922*** (df = 3; 24)
Note:								*p<0.1; **p<0.05; ***p<0.01

Table 9 shows results obtained from using the second specification of the model with eight 5-year intervals. This model, as the previous one, renders statistically significant results for periods 1986-1990, 2001-2005, and 2006-2010. It argues for divergence (positive β-coefficient) in 1986-1990 at the 5% significance level and convergence in 2001-2005 and 2006-2010 at the 1% significance level. Unlike Table 8, this specification also produces a statistically significant result for 2016-2020: it argues for convergence (negative β-coefficient) during this period at the 1% significance level.

Table 10.

Regression using model 2) (see Section Estimation), with eight five-year intervals

	Dependent variable:							
	Average Growth Rate of GDP per Capita during the Period (%)							
	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015	2016-2020
Natural Logarithm of Average GDP per Capita during the Period (Constant 2017 International Dollars)	2.199*	2.465	0.276	0.874	-3.551***	-2.370**	-0.657	-0.757
	(1.249)	(1.454)	(1.408)	(1.237)	(0.923)	(1.081)	(1.566)	(1.046)
Average Investment during the Period (% of GDP)	0.052	0.103	0.187*	0.189	0.169*	-0.064	0.276**	0.146**
	(0.059)	(0.094)	(0.093)	(0.114)	(0.087)	(0.095)	(0.123)	(0.057)
Average Number of Years of Schooling during the Period	0.196	-0.623*	0.253	0.389	0.575**	0.255	0.316	0.220
	(0.259)	(0.343)	(0.370)	(0.363)	(0.232)	(0.222)	(0.397)	(0.245)
Average Number of Years in the EU during the Period	-0.048	0.014	0.006	-0.008	-0.007	-0.016	-0.013	-0.034*
	(0.039)	(0.043)	(0.048)	(0.041)	(0.025)	(0.022)	(0.030)	(0.018)
Constant	-22.979*	-19.768	-7.784	-13.628	30.127***	25.105**	-0.735	4.426
	(12.894)	(14.780)	(14.052)	(12.616)	(9.711)	(11.601)	(15.011)	(9.812)
Observations	21	21	26	28	28	28	28	28
R^2	0.203	0.365	0.208	0.196	0.709	0.397	0.339	0.506
Adjusted R^2	0.004	0.206	0.057	0.057	0.659	0.293	0.224	0.421
Residual Std. Error	1.417 (df = 16)	1.829 (df = 16)	2.409 (df = 21)	2.227 (df = 23)	1.516 (df = 23)	1.390 (df = 23)	1.952 (df = 23)	1.210 (df = 23)
F Statistic	1.020 (df = 4; 16)	2.298 (df = 4; 16)	1.380 (df = 4; 21)	1.405 (df = 4; 23)	14.018*** (df = 4; 23)	3.792** (df = 4; 23)	2.952** (df = 4; 23)	5.900*** (df = 4; 23)
Note:								*p<0.1; **p<0.05; ***p<0.01

Finally, Table 10 shows the results of regression obtained by employing model 3) with eight 5-year intervals. This model, unlike the previous two, does not produce a statistically significant result for the period 1986-1990: however, it does produce a positive coefficient of convergence for 1981-1985, significant at the 10% significance level. As Tables 8 and 9, this model also produces statistically significant negative coefficients of convergence for periods 2001-2005 and 2006-2010 at the 1% and 5% significance levels, respectively. This model, unlike that in Table 9 and like that in Table 8, does not produce statistically significant results for the period 2016- 2020.

Summarizing results obtained in Part 2, we can see that results are robust across specifications for periods 2001-2005 and 2006-2010: all three 5-year interval models agree that there was convergence in economic outcomes between present Member States of the EU during these two periods. Also, two of the specifications produce statistically significant divergence in 1986-1990, while one of them produces statistically significant divergence in 1981-1985. Combining these results with those obtained in Part 1, we see that the results agree with each other: all five-year specifications of the model produce statistically significant convergence in both 2001-2005 and 2006-2010, which agrees with all ten-year specifications from Part 1, which produced statistically significant convergence for 2001-2010 that was robust across all specifications of the model. As well, we see that the three 5-year interval specifications of the model produce divergence for at least one of the periods 1981-1985 and 1986-1990, which agrees with the result from Part 1 – that is, divergence in economic outcomes among the present Member States of the EU in 1981-1990 that was robust across all specifications of the model.

The narrative that I am trying to convey in this paper is intuitive. Before 1991, the countries in the EU (or rather, the predecessor of EU, the European Communities) were the Western European "advanced" economies, which were already at the forefront of economic frontier and were exhibiting cutting-edge growth. Thus, there was divergence between them and the countries in the East which would later join the EU (Western Europe was growing at the rates consistent with cutting-edge growth, and Eastern Europe was growing stagnantly because of socialist governments and centrally planned economies). After 1990, the dissolution of USSR enabled the poorer Eastern European countries to modernize their economies and adopt democratic institutions. Their joining the EU enabled them to access the advanced markets of Western Europe and have more exposure to modern technologies and institutions, and thus these less advanced economies were able to exhibit quick catch-up in the coming decades, and so there was convergence in income levels between the current EU countries, as predicted by the Solow Model (discussed in the *Theory* Section). Participating in the EU enabled these countries to quickly approach their long-run steady-state

Solow equilibrium during the decade 2001-2010, where all econometric models showed convergence in economic outcomes among the present Member States. Indeed, Figure 3 shows that before 1991, a subset of present Member States (all of which joined the EU in 2004) that were in the Eastern Bloc at that time exhibited stagnant growth compared to Western Europe. After 1991, however, the growth trajectory of this subset of Eastern European countries increased dramatically, leading us to believe that the dissolution of USSR had a role in convergence of economic outcomes among the present Member States of EU.

Further research would be able to concentrate on eliminating endogeneity concerns so that estimations can be given with a confidence interval about the exact value of the coefficient of convergence β. There might be reverse causality from GDP growth rates to average investment levels: investors who see an economy with high growth rates might be tempted to make investments in that specific country rather than one with lower GDP growth rates. This is one amongst many considerations that has to be taken into account to rule out endogeneity. As well, it would be interesting to extend this model with its specifications described in the *Estimation* Section to all the countries on the European continent, and not just the ones that are present membersof the EU: it is highly likely that convergence will be more evident in this extended subset of European countries, as Eastern European countries like Ukraine and Belarus (which are not present member states of EU) saw dramatic increases in standards of living after the dissolution of USSR but were not included in this study as they are not and have not ever been part of the EU.

Appendix

Table 11.

Data points of interest

Variable	Meaning of Variable	Source
GDP per capita (constant 2017 international dollars)	The real (inflation-adjusted) value of goods and services produced per person each year, adjusted for domestic prices to equalize for purchasing power (PPP), in terms of 2017 international dollars[7]	IMF World Economic Outlook Database, October2021 (By Countries) Link: https://www.imf.org/en/Publications/WEO/weo-database/2021/October/download-entire- database
Investment rate	Value of investment into a whole range of technology which increase productivity (for example, machinery), expressed as a percentage of overall GDP	IMF World Economic Outlook Database, October2021 (By Countries) Link: https://www.imf.org/en/Publications/WEO/weo-database/2021/October/download-entire-database
Year of Accession	The year in which a given current Member State ofthe EU joined the Union (or its predecessor, the European Communities)	The Official Website of the European UnionLink: https://european-union.europa.eu/principles- countries-history/country-profiles_en?page=0
Average Years of Schooling	Total number of years of schooling of citizens in a country across all education levels, for the population aged 25+, divided by the total population of the country	Our World In Data Link: https://ourworldindata.org/global-education#years-of-schooling

[7] See Data Section for more on international dollars.

Table 12.

Special terms used in this paper

Term	Description
European Communities	A set of three international institutions that were governed by the same entity. It consisted of the European Coal and Steam Community, the European Atomic Energy Community and the European Economic Community. It was dissolved in 2009 by the Treaty of Lisbon, with the European Union becoming its legal successor (European Communities, n.d.).
Present Member States	I define present Member States to be the set of all countries that were considered members of the European Union, plus the United Kingdom. I include the United Kingdom in this set because it exited the EU in 2020, and my analysis includes the period 1981-2020, so the UK was in the EU for the duration of the period of my analysis.
Eastern and Western European	I define "Eastern Europe" to refer to the set of all present Member States that were in USSR or were a satellite country of USSR prior to the collapse of the Soviet Union. This includes all the "Eastern Bloc" countries: generally, "Eastern European" countries had less advanced economies because of socialist political regimes and centrally planned economies. I define "Western European" to be the set of all present Member States that were not "Eastern", as defined above.

Term	Description
Divergence/convergence of economic outcomes	In this paper, I used an Ordinary Least Squares regression to determine the correlation between the growth rates of GDP per capita and initial GDP per capita levels. Theory predicts that poorer countries with lower GDP per capita levels should have higher growth rates. Thus, a negative β- coefficient in the regression indicates that GDP per capita and its growth rates were negatively correlated: that is, poorer countries grew faster. This indicates convergence of economic outcomes. On the other hand, if the coefficient ofconvergence β was positive, this means that poorer countries grew slower than richer ones: this indicates divergence of economic outcomes.

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