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Systems of Innovation in Central and Eastern European countries: Path of Economic Transition and Differences in Institutions

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Abstract

Against the background of the current political developments in Central and Eastern European (CEE) countries, like Ukraine, Poland, and Romania, the question arises what role the transformation of the economy and the resulting innovation linkages have played in these countries. This paper addresses this issue by exploring the impact of economic and institutional dimensions on the development of CEE countries, thereby explicitly distinguishing between European Union (EU) members and non-members. First of all, the performance development of the Gross Domestic Product (GDP) of the CEE countries and Western European countries is observed. In a further analysis step, the development of EU members is compared with that of CEE countries that are non-members of the EU. This paper estimates the impact of such factors as innovation, institutions, and political practices on the economic development of 37 European countries for the period from 2000 until 2020 by using a panel regression. The results of the analysis show that institutions matter, especially for non-EU-member CEE countries. Stable institutions—such as freedom of the press, freedom of expression, but also high levels of the Human Development Index—help countries to achieve a higher income development over time. The role of the innovative ability of countries is also decisive for a positive development.

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1. Introduction

The connection between economic growth and technological innovations has been intensively discussed in the economic literature for decades (e. g., Barro and Sala-i-Martin, 1997). The literature points to a connection between technological progress and the growth rate with a decline over time of the influence of technology on the growth rate (Barro and Sala-i-Martin, 1997). This observation is explained by the fact that the followers, instead of undergoing the resource-intensive process of developing their own technologies, catch up with the leaders by adapting to the already existing technological developments (Barro and Sala-i-Martin, 1997, Niebuhr and Schlitte, 2009). Thus, lower-income countries are steadily catching up with higher-income countries due to a higher growth rate, which is known as the convergence between countries (Barro and Sala-i-Martin, 1997). In this respect, the particular effect of innovations, institutions, and their historic development on economic growth in Central and Eastern Europe (CEE) experienced only limited research.

The CEE countries are defined according to the EuroVoc (5892) definition. They include Albania, Hungary, Poland, Romania, Belarus, Bulgaria, Bosnia and Herzegovina, Croatia, Kosovo, North Macedonia, Montenegro, Moldova, Slovakia, Czechia, Russia, Slovenia, Ukraine, and Serbia. These countries make an interesting case to study, as they have developed differently due to their historic coercion to the Soviet Union. Though, not only in contrast to Western European countries, but also within the geographic grouping CEE significant difference can be observed, as some countries remained in the sphere of influence of the Russian Federation. (e.g., Ademmer, 2017; Niebuhr and Schlitte, 2009). Given the different historical developments of these countries, the question arises to what degree innovation and institutions have influenced the economic growth of these countries.

Existing literature highlights the importance of innovation on economic development. The same can be said about the interaction between institutional arrangements and economic growth. However, the inclusion of institutional variables, like for example, degrees of civil liberties and political freedom, in the analysis of economic growth in CEE countries is limited so far. Additionally, there exists only bounded evidence on the differentiated impact of institutional variables on economic development inside the group of CEE countries. Thus, this paper addresses these gaps by answering two research questions: 1) Can the differences in economic development between Western European countries and CEE countries be explained by innovation performance and institutional factors? 2) What factors impact economic development of the CEE countries that are part of the European Union and the ones that are not part of the European Union?

To answer these questions, this paper first starts with an overview of the literature in Section 2. For the provision of the theoretical foundation, the literature review consists of two parts: The first part focuses on the relationship between innovation, institutions, and economic growth and the second part on the analysis of innovation systems of CEE countries. Section 3 presents the methodology of this paper. It starts with a definition of the geographical scope and relevant single NUTS0 regions. The procedure is described in Section 3.1. The data on the economic and institutional development of the CEE countries is described in detail in Section 3.2. The variables are selected by following the existing literature and investigating the major databases. Section 3.3 then describes the empirical strategy, which is followed by the analysis of the results in Section 4. Section 5 embeds the results into a discussion of what transformation looks like in the context of the EU and on the background of the new innovation policy smart specialization, and it provides the paper summary.

2. Innovation Systems and Regional Development

2.1. Innovation, Institutions, and Economic Growth

The relationship between economic growth and technological innovations has been intensively investigated by economic literature for decades. Analyzing innovation systems has been closely linked to the investigation of the relationship between innovation and economic growth and can be traced back, as Pece et al. (2015) point out, to the works of Schumpeter (1911, 1939) and Solow (1956). Schumpeter (1939) sees a connection between entrepreneurial innovation and economic change, even considering it as the main factor of economic evolution (Croitoru, 2017). Schumpeter’s (1939) general understanding of the causality of innovation and (capitalistic) economic development is shaped in a way where capitalism breeds innovation, hence creating new economic growth opportunities, that it needs for itself to survive. Solow (1956) sets a precedent by using neoclassical models to describe economic growth as a function of capital and labor input where technological innovation influences the growth rate. Romer (1986) and Lucas (1988) further develop the ideas of Schumpeter (1939) and Solow. (1956) They present further empirical evidence for innovation processes to be an important factor impacting economic growth.

Later empirical studies confirm this positive relationship. Thus, Nadiri (1993) finds a positive and strong correlation between R&D expenditures and the growth rate of output and total factor productivity. Most of the conducted studies analyzing the relationship between R&D expenditures and economic development assume a linear relationship between these variables, which is derived from the assumption that R&D effort leads to innovation, which in turn can be commercialized, and ultimately increases economic activity (Pessoa, 2007). Pessoa (2007), however, finds only a weak link between R&D expenditures and economic growth, arguing that secondary factors influence GDP growth in the context of innovation as well. The author suggests that the relationship between R&D expenditures and economic development must be analyzed with more nuance, proposing a more precise analysis using variables such as patent counts, education expenditure, and qualification of the workforce. Accordingly, the importance of competition and the quality of education provided in economies for their development and growth is highlighted. These ideas are generally supported by studies conducted by Aghion et al. (2002, 2010). Bogliacino & Pianta (2011) show that innovation can create economic growth with two different, yet not mutually exclusive, methods (Pianta, 2001) or "engines of growth" (Bogliacino & Pianta, 2011, p. 41): (i) innovation for technological competitiveness (product innovation) and (ii) innovation for cost competitiveness (process innovation). While the innovation of technological competitiveness is based on product innovation, internal innovative efforts, and the opening of new markets, the latter has its focus on increasing efficiency through minimizing labor, material, and organizational costs and waste (Bogliacino & Pianta, 2011). Hence, depending on an organisation's goals regarding labor and capital productivity, innovation efforts require a differentiated consideration of the 'engines of growth' (ibid.).

A further study conducted by Westmore (2013) uses a panel model, based on 19 OECD countries, to investigate the relationship between innovation policy and patenting activity as well as their influence on productivity growth. The author finds that business R&D fostering policies positively influence patenting activity. In greater detail, policies designed at providing R&D tax incentives and strong patent rights promote innovation activity. On the other hand, no direct correlation between innovation policy and productivity growth could be found, which is explained by the heterogeneity of policy impacts across various countries (ibid., 2013).

Discussing the relationship between economic development and innovation, Filippetti and Archibugi (2011) use the concept of National Innovation Systems (NIS) as a framework to explain the mentioned relationship at the country level. This framework was widely accepted in the innovation economics literature (Freeman 1987; Lundvall 2016; Nelson 1993). Generally, the approach sees innovation and technological development processes as the result of complex relationships of various actors in a system. Actors can be governmental institutions, private companies, universities, and other research organizations (OECD, 1999). Considering these actors, governments propose and implement policies that are designed to influence innovation processes. The result is the genesis, storage, and transfer of "knowledge, skills, and artifacts which define new technologies" (Metcalfe, 1995 in OECD, 1999: 24). Filippetti & Archibugi (2011) summarize that NIS characteristics differ between countries and are the result of country-specific innovation environments. NIS is often used by international organizations as a tool for analyses. Hence, the European Commission, i.e., the European Union (EU), and the Organization for Economic Cooperation and Development (OECD), as well as Western European countries adopted the concept of NIS in their respective studies and policymaking (Lundvall et. al, 2002; López-Rubio et al., 2022).

Apart from hard factors, such as number of introduced innovations, number of firms in the market, or number of employees in high-tech sectors, also norms and conventions existing in a specific country may impact its economic growth, directly or indirectly. These norms, or in other words, institutions, were introduced in economic analyses by North (1990). The author identifies institutions as ‘rules of the game’, which shape human interactions. He further divides these ‘rules’ into formal (property rights, policies, laws) and informal (values, norms, knowledge) (North, 1990).

Since North’s seminal work, the role of formal and informal institutional arrangements on economic development and growth has been widely investigated. Hence, the systematic literature review, conducted by Urbano et al. (2019), shows the predominance of the institutional approach in explaining economic growth and, especially, entrepreneurship during the last decade. Furthermore, Acemoglu et al. (2014) support the positive effect of institutions on long-term development by examining cross-country historical data. Esfahani and Ramirez (2003) further find the moderating effect of institutional factors (e. g., credibility and contract enforcement) on the relation between infrastructure services and GDP development. Gherghina et al. (2019) confirm the positive impact of different institutional parameters (e. g., control of corruption, government effectiveness, rule of law) on economic growth based on the sample of eleven CEE countries.

Additionally, the link between two types of institutions has been investigated. Thus, Holmes et al. (2013), analyzing a sample of fifty countries, find that informal institutions, such as cultural dimensions of collectivism and future orientation, impactinstitutions, which in turn influence economic growth. Furthermore, recent literature examines the specificities of the interaction between institutions and economic growth for specific country categories. Thus, already Esfahani and Ramirez (2003) underline the differences between investment-GDP ratios between institutionally stronger and weaker countries. Most recently, Dorożyński et al. (2020) point out the impact of the institutional differences between CEE countries (estimated based on the Global Competitiveness Index) on the investment attractiveness.

2.2. Innovation Research Conducted on CEE Countries

In comparison to other European economies, those of Central and Eastern Europe differ in their structural conditions and innovation-related characteristics. This can be explained by the transition process from a planned to a market economy, which these countries underwent. The peculiarity of this process shows in the necessity to change not only formal market conditions, but also informal institutional settings, which requires time and effort of the different actor groups (Gabrisch and Hölscher, 2006). Kravtsova and Radosevic (2012) point out that Eastern European countries are affected by a certain degree of inefficiency of national innovation systems in terms of generating R&D output. On the other hand, the CEE countries were able to slowly narrow this gap in knowledge production capacity in the years after 2000 (Kirankabes and Erkul 2019).

The transition process in different countries was organized either via so-called shock therapy, which meant rapid privatization and price liberalization, or gradualism (also known as the evolutionary-institutionalist approach), which was described by the step-by-step sequencing of the reforms (e. g., Havrylyshyn, 2007; Jens, 1993). The first strategy was chosen, for example by Baltic countries, like Poland, Czechia, and Slovakia, whereas gradualism was applied by, for example, Georgia, Romania, and Ukraine. Additionally, such countries as Bulgaria, Albania, and Russia initially started with rapid reforms, which were then slowed down; and such countries as Belarus introduced only a limited number of reforms (Havrylyshyn, 2007; Šimić Banović et al., 2018).

Reforms impacted the economic and innovation performance of CEE countries significantly, however, heterogeneities in this regard can be observed among countries (Soulsby et al., 2021). Though initially overwhelmed by the speed of the reforms, the countries which applied shock therapy appeared to have higher economic and social indicators in the long term (Šimić Banović et al., 2018). The relative success of some countries, however, was impacted by many factors apart from the speed of the transition, including militarization or overindustrialization of the economy (Popov, 2007). Also, different institutional quality impacted countries' development (Dorożyński et al., 2020). Furthermore, as Stojcic et al. (2019) find, some CEE countries have experienced significant economic growth rates through an increase in foreign investment and the integration of their economies into the global market. Another impacting factor may be the EU entry of Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia in 2004, Romania and Bulgaria in 2007, or Croatia in 2013. Four different stages of EU accession (pre-negotations, negotiations, approval, and EU-memberships) have also influenced the flow of foreign direct investment (FDI) to the countries (Benfratelo et al., 2022).

While multiple innovation-related studies on Central and Eastern European economies have been conducted (Scrieciu & Stringer, 2008; Radošević, 2015; Stojecic & Orlic, 2019, Stojčić, 2021), the publication of Pece et al. (2015) offers a concrete analysis between their innovative characteristics and economic performance. Overall, they find a positive correlation between innovation and economic growth in some CEE countries, namely Poland, Czech Republic, and Hungary.

It can be stated that most CEE countries have reached relatively high-income levels due to the increasing production of high-value products (Stojčić et al. 2019; Stojčić, 2021). Compared to more advanced economies, especially to their western counterparts, CEE countries show, however, different innovation characteristics. Generally, state subsidies make up in CEE countries a higher percentage of total R&D funding. However, their R&D expenditures are lower, as the firms in CEE countries generally focus on production capabilities (EBRD, 2014). Contextualizing the characteristics, economic growth in CEE countries is positively influenced by the presence of subsidiaries of foreign corporations and the FDI stock (Majcen et al. 2009). Hence, R&D expenditures in CEE countries are rather used for the acquisition of technology from abroad than the construction of innovation capabilities (Radošević, 2017). The focus on the acquisition of machinery and technology is obstructive to innovative capacity building (Immarino et al., 2012). Accordingly, CEE countries have weaker and less resilient innovation systems (Radošević, 2015, 2017; Stojecic & Orlic, 2019, Stojčić, 2021). Therefore, policy-makers and researchers generally advice CEE countries to improve domestic innovation capabilities and, thus, to follow the smart specialization strategies (Radošević, 2017).

2.3. Research Gap

As the literature review in the previous subchapters illustrates, extensive research on the role of innovation for economic development has been done. The same can be said about the interaction between institutional arrangements and economic growth. However, the inclusion of institutional variables, such as the civil liberties and political freedom, in the analysis of economic growth in CEE countries is limited so far. While Henisz (2000) as well as Catrinescu et al. (2009) found a relationship between between economic growth and institutions' quality and design, Barro and Sala-i-Martin (2004) found growth rate and democracy in partial relation. However, no concrete analysis in the context of CEE countries has been conducted. The research presented in this paper further develops the analysis and discusses innovative as well as institutional variables and their role in the economic development of CEE countries. Additionally, when CEE countries are considered, the focus is often put on the EU members (e. g., Gherghina, 2019). Therefore, Radosevic (2022) calls for the comprehensive understanding of the transformation of CEE countries, which is done in this paper. For a better understanding on the CEE specificities, the analysis includes not just CEE but also Western European countries. Through this approach, this research also aims at understanding whether the innovative and institutional variables have different effects on CEE countries than they do on Western European countries. Additionally, based on previous literature considerations (e. g., Dorożyński et al., 2020; Havrylyshyn, 2007), a comparison between EU and non-EU countries is conducted.

In the following anaysis first of all, the impact of the different institution and innovation indicators on the GDP of the CEE countries as well as the Western European countries is observed. In a further step, the differences between the impact of various indicators on the GDP of CEE countries and EU members compared to CEE countries and non-EU members are observed.

3. Methodology for Innovation System Assessment

3.1. Geographical Scope

The geographical scope of this research encompasses in total 37 European countries. Of these 37 countries, 16 countries are categorized as being part of CEE and the other 21 as non-CEE. The categorization is based on the definition provided by EUR-Lex with EuroVoc (5892). Out of the 16 CEE countries, eight are members of the European Union—these are Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, Slovakia, and Slovenia. The other eight are neighboring countries to the EU—namely, Albania, Belarus, Bosnia and Herzegovina, Northern Macedonia, Montenegro, Moldova, Russia, and Ukraine The non-CEE countries represent other European countries, which include both EU members and non-EU members. Nevertheless, as research heuristic, all non-EU countries are counted as being part of the European Union in the analysis. This is justified along three points: (1) the UK left the EU in early 2020, the last temporal data point in this analysis; (2) Norway and Iceland are part of the European Economic Area (EEA) and, thus, extensively integrated in the European Common Market; and (3) Switzerland holds multiple trade and political agreements that integrate it into the EU internal market—the Schengen Agreement, the Dublin System, as well as the EU's research and mobility programs (EEAS, 2021; Eurostat, 2020). Defining EU countries, EEA countries, and Switzerland as a homogenous group follows the research approach of Maradana et al. (2022) and Pradhan et al. (2016), who analyze the relationship between innovation variables and GDP growth in the entire EEA and not just for EU members. Therefore, this research deems it adequate to include the UK, Norway, Iceland, and Switzerland in one group of non-CEE countries.

Figure 1: Geographic Scope of this Research

The geographic scope is visualized in figure 1.

3.2. Data

The selected variables to answer the stated research questions build on previous research. Table 1 summarizes the data used, provides a link to the literature and further describes the data. The collected data ranges from the year 2000 until the year 2020.

Existing literature on the influence of research and institutional variables on economic development uses the GDP with varying specifications as a dependent variable (Henisz, 2000; Petariu et al., 2013; Pece et al., 2015; Wong et al., 2005). GDP is understood as the sum of all final goods and services created within an economy over the time span of one year (Bergheim, 2008). While GDP itself and its growth are useful to describe an economy's size and development, it has the weakness of being insufficient for the comparison of economic development. Thus, following the approach of Catrinescu et al. (2009) and Maradana et al. (2022), for this study we choose to put the GDP growth in relation to the population for the dependent variable—i.e., GDP per capita ($GDPpc$). The GDPpc data for the observed countries were extracted from the World Bank (2022). Comparing the development of the GDP per capita over time, allows to observe the relative development of economies. Table A.3 in the appendix shows convergence processes in both the country and region-specific equations. The identified convergence processes follow the observations of Barro and Sala-i-Martin (1997), but also of Grela et al. (2017). The latter observe a converging trend of CEE countries towards the EU-15 and see FDI as an explanatory variable for this convergence.

Given the goal of analyzing the influence of institutional and innovation variables, the independent variables consist of a mix of macroeconomic, innovation-related, and institutional variables. Building on the previous research of Pece et al. (2015), Petrariu et al. (2013), and Nistor (2015), the regressions include FDI inflows as a determinant for economic development. In order to make the FDI as a determinant more comparable, it is put in relation to the according GDP of the given year ($FDIpGDP$) (Čičak and Sori, 2015). Furthermore, to indicate the innovative characteristics of a given economy, variables concerning intellectual property are used—namely, the annual number of registered patents (PAT) and trademarks (TDM). Intellectual property rights are intended to give the inventor/applicant ownership rights to their creation, thereby stimulating innovation activities. Trademarks reflect non-technological innovation in all economic sectors, including services, which otherwise get little recognition when measuring intellectual property only by patents. Trademarks thus create a connection between innovation and the market and also reflect the importance of non-technological innovations (Eurostat, 2022). For the specification, these variables are calculated as a relation of the number of patents or trademarks to the number of employed, i.e., the human capital stock (Westmore, 2013). Due to the high correlation of the variables and the similar characteristic of describing the output of intellectual property, this paper uses a cumulative variable ($intlpEMPL$), by adding PAT and TDM and putting the sum in relation to the number of persons employed in the according year.

As institutional variables, four different indices as well as scores are chosen that describe the human development, political and civil liberties, and corruption in a given nation. Utilizing the Human Development Index (HDI) as an institutional variable follows the research by Zhang & Danish (2019) and Ulas & Keskin (2017), who determine it to be a significant variable in explaining economic growth. Concerning political and civil liberties, Zeaiter and Kassem (2017) show in their research that political freedoms have a significant and positive impact on economic growth. This is complemented by the research of Ahmed & Ahmad (2020), who also find a positive relationship between political freedoms and civil liberties and economic growth. Thus, this research follows the previous literature and utilizes the scores for political (PLF) and civil liberties (CVL) given by Freedom House (n.d.). The variables for the human development, political and civil liberties are complemented with the measure of corruption within the countries. Grochová & Otáhal (2012) and Svendsen (2003) find a significantly negative impact of corruption on economic growth in Eastern European Countries. Thus, based on the research of Svendsen (2003), this paper uses the Perceived Corruption Index (CPI) to describe and measure the influence of corruption on economic growth in the analyzed countries.

In the appendix, Figure A1 and Figure A2 show the simple correlation between the Log GDP per capita and Intellectual Property Applications per Employed as well as between the Log GDP per capita and Human Development Index Score. The results show an overall fit of the Log GDP per capita value and the HDI score of the previous year (R^2=0.8930). The correlation of the dependent variable and the number of intellectual property applications is less obvious with R^2=0.2739. Still, one can deduce a relationship between the GDP component and innovations as well as institutional settings.

Furthermore, this research also includes various control variables, namely the number of people living within the respective country ($tPOP$), the population density (*dPOP*), the total number of employed (*tEMPL*), as well as the employment rate (*rEMPL*) (Doh & Acs, 2010; Lechner & Wunsch, 2010). Additionally, a sector variable is included to describe the influence of the manufacturing sector (TOTL). The variable is expressed as the percentage of manufacturing sector (ISIC divisions 05-43) in GDP and follows the definition provided by the World Bank (2022). The influence of manufacturing on economic growth has been researched by Szirmai & Verspagen (2015). They find a significant yet decreasing influence on GDP growth. Additionally, Stojčić et al. (2019) and Stojčić (2021) observe an increase of high value-added production in CEE economies.

For a more nuanced and detailed perspective on the effects of innovation and institutional variables, regional dummy variables are created. These summarize the observed countries depending on their EU status and whether they are a CEE country or not: $\delta * CEE_{n\vee y}EU_{n\vee y}$. Thus, three dummy variables are created: CEE countries that are EU members CEE_yEU_y, CEE countries that are not EU members CEE_yEU_n, and EU members that are not CEE countries CEE_nEU_y. The geographic composition can be extracted from Figure 1. Table 1 summarizes the data.

The geographical scope of this research encompasses in total 37 European countries. Of these 37 countries, 16 countries are categorized as being part of CEE and the other 21 as non-CEE.

Table 1: Overview of variables and description

Variable Name	Abbrevation	Description	Source	Variable is used in
GDP total	GDPt	Gross domestic product (GDP) is the standard measure of the value added created through the production of goods and services in a country during a certain period. As such, it also measures the income earned from that production or the total amount spent on final goods and services (less imports). (World Bank, 2022)	The World Bank (2022)	Petrariu et al., 2013 ; Pece et al., 2015 ; Wong et al., 2005
Log GDP per capita	LogGDPpc	Logarithmic value of GDP per capita	The World Bank (2022)	Pece et al., 2015 Petrariu et al., 2013 Aghion et al. 2010
Inward FDI financial flows / Inward FDI financial flows per GDP	FDI / FDIpGDP	Foreign direct investment (FDI) is a category of cross-border investment in which an investor resident in one economy establishes a lasting interest in and a significant degree of influence over an enterprise resident in another economy.	The World Bank (2022)	Pece et al., 2015 Nistor, 2015
Population	tPOP	(Total) national population	The World Bank (2022)	Pece et al., 2015
Population density	dPOP	People per km^2 of land area	The World Bank (2022)	
Working population	wPOP	Labor force comprises people ages 15 and older who supply labor for the production of goods and services during a specified period. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time job-seekers. Not everyone who works is included, however. Unpaid workers, family workers, and students are often omitted, and some countries do not count members of the armed forces.	World Development Indicators (2022)	Pece et al., 2015
Employment Rate	rEMPL	Employment to population ratio, 15+, total (%) (modeled ILO estimate)	World Development Indicators (2022)	Coccia (2013)

Table 2: Overview of variables and description (cont.)

Human Development Index	HDI	A statistic composite index of life expectancy, education (mean years of schooling completed and expected years of schooling upon entering the education system), and per capita income indicators: - Life expectancy index - Expected years of schooling - Mean years of schooling - GNI per capita (PPP $)	United Nations Development Programme (2022)	Petrariu et al., 2013 Ulas & Keskin (2016) Zhang & Danish (2019)
Annual number of registered patents / … per employed	PAT / PATpEMPL	Total patent applications (direct and PCT national phase entries)	WIPO statistics database (2022)	Mardana et al., 2022 Pece et al., 2015 Westmore 2013
Annual number of registered trademarks / … per employed	TDM / TDMpEMPL	Total trademark applications (direct and via the Madrid system)	WIPO statistics database (2022)	Pece et al., 2015
Intellectual Property Applications / … per employed	intlpEMPL	Sum of patent and trademark applications		
Transparency international measure	CPI	Perceived levels of public sector corruption 0 (highly corrupt) 100 (very clean)	Transparency International (2022)	Catrinescu et al. (2009) Grochová & Otáhal (2012) Svendsen (2003)
Freedom house	PLF	Political rights rating: 1 (high) – 7 (low)	Freedom House Organisation (2022)	Ahmed & Ahmad (2020) Catrinescu et al. (2009) Henisz (2000) Zeaiter and Kassem (2017)
	CVL	Civil liberties rating: 1 (high) – 7 (low)	Freedom House Organisation (2022)	Barro and Sala-i-Martin (2004)
Manufacturing value added (% of GDP)	TOTL	ISIC divisions 05-43, Percentage of GDP	World Bank (2022)	Szirmai & Verspagen (2015)

Table 2: Correlation matrix of variables

	GDPt	GDPpc	FDI	FDIpDGP	PAT	TDM	intlpEMPL	HDI	CPI	CVL	PLF	TOTL	tEMPL	rEMPL	tPOP	dPOP
GDPt	1,000															
GDPpc	0.260* (0.000)	1,000														
FDI	0.372* (0.000)	0.158* (0.000)	1,000													
FDIpGDP	-0.097* (0.007)	0.016 (0.652)	0.219* (0.000)	1,000												
PAT	0.878* (0.000)	0.271* (0.000)	0.332* (0.000)	-0.072* (0.044)	1,000											
TDM	0.928* (0.000)	0.293* (0.000)	0.338* (0.000)	-0.084* (0.020)	0.894* (0.000)	1,000										
intlpEMPL	0.029 (0.431)	0.706* (0.000)	0.048 (0.184)	0.145* (0.000)	0.080* (0.027)	0.116* (0.001)	1,000									
HDI	0.373* (0.000)	0.785* (0.000)	0.201* (0.000)	0.008 (0.819)	0.367* (0.000)	0.426* (0.000)	0.429* (0.000)	1,000								
CPI	0.217* (0.000)	0.645* (0.000)	0.220* (0.000)	0.065 (0.071)	0.220* (0.000)	0.249* (0.000)	0.358* (0.000)	0.762* (0.000)	1,000							
CVL	-0.127* (0.000)	-0.514* (0.000)	-0.112* (0.002)	-0.097* (0.007)	-0.138* (0.000)	-0.233* (0.000)	-0.320* (0.000)	-0.668* (0.000)	-0.607* (0.000)	1,000						
PLF	-0.105* (0.003)	-0.448* (0.000)	-0.098* (0.006)	-0.078* (0.029)	-0.121* (0.001)	-0.217* (0.000)	-0.271* (0.000)	-0.592* (0.000)	-0.557* (0.000)	0.935* (0.000)	1,000					
TOTL	0.063 (0.081)	-0.045 (0.206)	-0.049 (0.175)	-0.147* (0.000)	0.139* (0.000)	0.066 (0.066)	-0.154* (0.000)	0.035 (0.326)	0.045 (0.213)	0.083* (0.021)	0.111* (0.002)	1,000				

Table 2: Correlation matrix of variables (cont.)

	GDPt	GDPpc	FDI	FDIpDGP	PAT	TDM	intlpEMPL	HDI	CPI	CVL	PLF	TOTL	tEMPL	rEMPL	tPOP	dPOP
tEMPL	0.720*	-0.044	0.245*	-0.107*	0.594*	0.559*	-0.114*	0.016	-0.110*	0.298*	0.321*	0.143*	1,000			
	(0.000)	(0.221)	(0.000)	(0.003)	(0.000)	(0.000)	(0.002)	(0.653)	(0.002)	(0.000)	(0.000)	(0.000)				
rEMPL	0.164*	0.440*	0.126*	0.030	0.188*	0.135*	0.257*	0.476*	0.409*	-0.240*	-0.212*	0.094*	0.132*	1,000		
	(0.000)	(0.000)	(0.000)	(0.401)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.009)	(0.000)			
tPOP	0.720*	-0.061	0.239*	-0.112*	0.587*	0.561*	-0.124*	0.001	-0.119*	0.293*	0.311*	0.138*	0.997*	0.101*	1,000	
	(0.000)	(0.092)	(0.000)	(0.002)	(0.000)	(0.000)	(0.001)	(0.984)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)		
dPOP	0.070	0.111*	0.161*	0.381*	0.110*	0.106*	0.323*	0.160*	0.165*	-0.225*	-0.187*	-0.125*	-0.051	0.182*	-0.057	1,000
	(0.050)	(0.002)	(0.000)	(0.000)	(0.002)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.155)	(0.000)	(0.110)	

Note: All regressions are OLS. Robust standard errors are in parentheses. See Table 1 for more detailed variable definitions and sources.

Table 3: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPt	777	4.38E+14	7.82E+14	9.84E+11	3.98E+15
GDPpc	777	26,550,935	24,143,812	440,672	123678.7
FDI	777	1.78E+13	5.51E+13	-3.45E+14	7.34E+14
FDIpGDP	777	.098	.332	-.575	4,491
PAT	775	12,923,847	29565.23	1	184615
PATpEMPL	775	.002	.002	0	.013
TDM	764	66,735,506	123741.73	53	833822
TDMpEMPL	764	.012	.022	0	.189
intlpEMPL	762	.014	.023	0	.202
HDI	777	.845	.068	.643	.957
CPI	777	58,899	21,637	15	100
CVL	777	1,795	1,249	1	7
PLF	777	1,752	1,411	1	7
TOTL	777	13,706	05. Jul	3,718	28.55
EtP	777	52,871	8,461	-10,825	76.85
tEMPL	777	8214316.7	13700825	145502.84	71695498
rEMPL	777	.908	.057	.689	.982
tPOP	777	18088614	28962682	281205	1.47E+11
dPOP	777	145,738	222,206	2,805	1,610,412
wPOP	777	8943446.3	14733494	155319	76029232

Notes: See Table 1 for more detailed variable definitions and sources.

3.3. Empirical Strategy

The research strategy includes two steps. First, we run a simple ordinary least square regression (OLS) with the logarithm of the gross domestic product per capita ($LogGDPpc$) as dependent variables and a number of explanatory variables to answer the first research question. Although available data includes a temporal dimension and thus limits the usage of the OLS regression, conducting an OLS regression follows the advice of Wooldridge (2010) for gaining a better understanding of the data and the relationship between the dependent and independent variables. Here, the empirical strategy is a stepwise regression, which includes first only innovation variables, second only institutional variables, and third a combination of innovation and institutional variables.

Since we use annual data from the year 2000 to the year 2020, the annual data reflects the dynamic change compared to the previous year. In the first step, the multiple ordinary least squares regression model that controls for time effects and includes region-wise specific dummies is conducted. For further specification, we include the institutional variables with a 1-year lag, following the work of Catrinescu et al. (2009). Furthermore, by including the 1-year lag for the institutional variable we overcome possible problems of endogeneity.

In a second regression approach, related to the second research question, we run a fixed effect panel regression. Here, we assume that unobserved characteristics, such as institutions, infrastructure, or geography, are constant or “fixed” in the model. Moreover, among the basic estimators, fixed effects (FE) are the most robust because they remove heterogeneity entirely. On the other hand, random effects (RE)remove only a fraction of this heterogeneity and a pooled OLS regression none of it. The method of the empirical strategy was chosen here in such a way that all three methods are presented with cluster-robust standard errors in order to obtain a statement about the results and their robustness. The goal of pooled regression is to represent a descriptive regression. The FE model, on the other hand, is intended to control systematic, non-measurable differences between the regions, as described above (Wooldridge 2010).

The panel regressions split the unobserved, individual heterogeneity into two error terms. One error term collects all unobserved variables that change within countries over time ($\epsilon_{i,t}$). The second error term collects all variables that do not change within countries (μ_i). Fixed effects models assume that individual unobserved heterogeneity (μ_i) is constant, unchanging, and “fixed” over time (e. g., McCaffrey et al. 2012, Wooldridge 2010). There are also certain structural path dependencies that only develop or adapt relatively slowly in time and space.

Hence, first, the relationship between log GDP and gross value added is calculated (1):

$$lnGDPpc_i = a + b_1 * x_{i1} + \cdots + b_p * x_{ip} + u_i \tag{1}$$

Second, we estimate the stepwise regression complemented with time and region dummies (2):

$$lnGDPpc_i = a + \delta_1 * year + \delta_2 * CEE + b_{i1} * x + \cdots + b_{ip} * x + u_i \tag{2}$$

Then, the region-specific regressions depending on CEE status and EU membership is assessed (3):

$$lnGDP_{pc} = a + \delta * CEE_{n\vee y} EU_{n\vee y} + b_1 * x_{it1} + b_{HDI} * x_{it-1} + b_{CPI} * x_{it-1} + b_{PLF} * x_{it-1} + \cdots b_x * x_{it} + u_i \tag{3}$$

4. Results

4.1. OLS-Regression

Table 4 presents the results of the stepwise OLS regression. The observations include the time period of 2000-2020 and the data from 37 European countries. Here, model specification i includes only innovation-related indicators; ii includes only institution-related indicators; iii includes both innovation- and institution-related indicators as well as the binary variable, which is equal to 1 for CEE countries that are non-EU members (*CEEyEUn)* and 0 otherwise; iv includes both innovation- and institution-related indicators as well as the binary variable, which is equal to 1 for CEE countries that are EU members (*CEEyEUy)* and 0 otherwise; v includes innovation- and institution-related indicators and additional control variables. The slightly different number of observations across the specifications is explained by the occurrence of missing data.

The results show the positive effect of the intellectual property per employee variable on the economic growth among all model specifications, which generally corresponds to the major literature (e. g., Bogliacino & Pianta, 2011; Westmore, 2013). Consistent with existing literature, the same can be said about the consistent positive effect of the Human Development Index, indicating that stronger institutions, translate into greater economic prosperity (Zhang & Danish, 2019; Ulas & Keskin, 2016). Additionally, higher levels of the perceived corruption index—meaning an economy is 'cleaner' from corruption—are related to higher economic performance, which is also in line with theory-based expectations (Svendsen, 2003). However, the significance of the effect vanishes when control variables are added to the model.

An ambiguous result is found related to the variable of political liberty, which is observed to have a negative effect on economic performance in the model specification ii and a positive effect in the model specification iii, when the country classification variable is added to the model. Another ambiguous result is also found for an FDI inflow variable, which is negative in specification i and positive in specification v. These results may hint at specificity of the effect for CEE and non-EU countries and needs to be further explored in subsequent analyses. Additionally, it should be noted that the categorization into *CEEyEUn* has a significantly negative impact on *LogGDPpc*, meaning that being a CEE country and not being an EU member negatively impacts a country's economic development. Although this may indicate the generally lower GDP per capital level of such countries, no effect on the *CEEyEUy* variable was found. However, this analysis provides only a general overview of variables' impact on economic growth, without differentiating between the impact that specific factors may have on the different country groups. Therefore, we additionally present the results of the OLS analysis for different country groups for the same time period (2000-2020) in Table 5. Here, model specification I includes the CEE countries, which are non-EU members, model specification II includes CEE countries, which are simultaneously EU members, and model specification III includes non-CEE countries, which are EU members.

The results show the differentiation of the impact of different factors on the economic growth within different country categories. Thus, the positive impact of FDI inflows is outlined only for the case of those CEE countries, which are non-EU members. This may support the arguments of the dependence of these countries on foreign investments (Majcen et al. 2009)

Table 4: OLS regression - stepwise of Log GDP per Capita with Innovation and Institutional Variables and additional controls

	i	ii	iii	iv	v
	LogGDPpc	LogGDPpc	LogGDPpc	LogGDPpc	LogGDPpc
FDIpGDP	-.118*		.003	.009	.045*
	(.065)		(.021)	(.021)	(.027)
intlpEMPL	25.019***		7.144***	7.05***	7.353***
	(2.595)		(.453)	(.449)	(.446)
lag_HDI1		13.302***	13.633***	14.32***	13.41***
		(.347)	(.395)	(.379)	(.456)
lag_PLF1		-.027**	.049***	.003	-.002
		(.013)	(.017)	(.013)	(.012)
lag_CPI1		.005***	.002***	.001	.001
		(.001)	(.001)	(.001)	(.001)
yearid			-.021***	-.023***	-.018***
			(.002)	(.002)	(.003)
CEEyEUn			-.225***		
			(.056)		
CEEyEUy				-.03	
				(.028)	
rEMPL					.065
					(.283)
TOTL					.006**
					(.002)
dPOP					0***
					(0)
tPOP					0
					(0)
CEE					-.166***
					(.034)
_cons	9.348***	-1.755***	-1.812***	-2.27***	-1.587***
	(.047)	(.261)	(.29)	(.291)	(.331)
Observations	762	740	725	725	725
Adj. R-squared	.275	.899	.93	.928	.931

*** $p<.01$, ** $p<.05$, * $p<.1$

Notes: All regressions are OLS. Robust standard errors are in parentheses. See Table 1 for more detailed variable definitions and sources.

Divergent results were also found for the effect of the intellectual property indicator on economic performance. Thus, the *intlpEMPL* variable appeared to be insignificant for the CEE countries that are non-EU members, significant and negative for CEE EU members, and positive and significant for non-CEE countries that are EU members. This result contradicts major literature, which finds a positive correlation between high innovation indicators and economic growth for CEE countries (Pece et al., 2015). However, such a result may hint at the fact, that CEE countries, especially those, which are the members of the EU, are still rather acquiring technology from abroad or are involved in the service and construction processes than developing their own innovations from scratch, as suggested by Radošević (2017). This idea may be supported by the negative influence of the manufacturing sector (*TOTL*) on economic development for the case of CEE and non-EU countries. Additionally, it can be suggested, that the patent/trademark statistics generally may be biased towards Western countries, because of the high presence of headquarters there.

Furthermore, in line with the literature (Zhang and Danish, 2019; Ulas and Keskin, 2016), a positive effect of HDI variables was found for all model specifications also in this analysis. Additionally, a significantly positive effect of political liberties was observed only for the case of CEE and non-EU countries, which highlights the especial importance of political freedom for economic development in this country category. This is consistent with the findings of Ahmed and Ahmad (2020). Contrary to the expectations, the economies that are 'cleaner' from corruption show lower GDP per capita levels. Some previous research (e. g., Christos et al., 2018) failed to identify a significant impact of CPI on GDP for CEE countries. One of the explanations of this result may lie in the limitations of this indicator measurement, which relate to the effects and synergies between individual data sources impacting CPI values for different countries (Budsaratragoon and Jitmaneeroj, 2020).

Table 5: OLS regression of Log GDP per Capita with Innovation and Institutional Variables and Additional Controls by Country Group

	I CEE: YES EU: No LogGDPpc	II CEE: YES EU: YES LogGDPpc	III CEE: No EU: YES LogGDPpc
FDIpGDP	2.305***	.124	.035
	(.653)	(.131)	(.024)
intlpEMPL	69.48	-52.968***	7.693***
	(50.707)	(7.58)	(.418)
lag_HDI1	6.405***	11.313***	13.189***
	(1.423)	(1.784)	(.586)
lag_CPI1	-.007**	-.006***	.001
	(.003)	(.002)	(.001)
lag_PLF1	.094***	.033	-.07
	(.035)	(.031)	(.057)
TOTL	.011**	-.041***	.006*
	(.005)	(.013)	(.003)
rEMPL	-2.949***	.016	1.344***
	(.48)	(.549)	(.406)
dPOP	.001	.01***	0***
	(.002)	(.004)	(0)
tPOP	0***	0***	0
	(0)	(0)	(0)
yearid	.053***	.02***	-.024***
	(.011)	(.007)	(.004)
_cons	4.743***	.193	-2.458***
	(1.062)	(1.206)	(.481)
Observations	160	160	425
R-squared	.785	.89	.876

*** *p<.01, ** p<.05, * p<.1*

Notes: All regressions are OLS. Robust standard errors are in parentheses. See Table 1 for more detailed variable definitions and sources.

4.2. Fixed Effect Panel Regression

In this case, the independent variable Log of GDP per capita was modeled as a function of a number of explanatory variables. The dataset contains an id variable, which identifies the groups of regions x[i,t]. The groups are Western European countries, CEE countries with EU membership, and CEE countries without EU membership. Before fitting the model, we ran a fixed effects and corresponding random effects model. We used a Hausman specification test, which compare both the fixed effects and random effects model for its consistency. The results show a Chi-square test value of 40.878, thus, suggesting the usage of a fixed effects model.

Results generally correspond to those observed in the OLS regression. Thus, when all countries are considered in a pooled manner, positive effects of *intlpEMPL* and *lag_HDI1* indicators are observed. Contrary to the results in Table 5, here, economies that are ‘cleaner’ from corruption, show a higher economic performance, as the *lag_CPI1* coefficient is positive and significant. Furthermore, the *lag_PLF1* coefficient appears to be insignificant. Thus, when all countries are considered, political freedom does no longer act as a significant determinant of economic performance.

Furthermore, according to the results in the panel model, FDI per GDP is not significant on the change of GDP per capita. This result adds to the debate, as Nistor (2014) finds a positive relationship between FDI inflows and GDP growth in CEE economies. Furthermore, the authors Lefilleur and Maurel (2010) indicate that the results in terms of FDI investment may differ between Eastern and Central European countries. Improved market access to Central European countries can significantly increase FDI spending. According to this, the geographical proximity to the market with regard to upstream industries and service links with the EU15 countries is an important determinant of the level of FDI itself. Additionally, as in previous models most of the control variables (*TOTL*, *dPOP,* and *tPOP*) appeared to be significant as well.

While it stands outside of the scope of this paper, the results can be further put into context of the economic convergence between the chosen regions. As Appendix 3 illustrates, one can observe convergence processes in both the basic and region-specific equations. The identified convergence processes would support the observations of Grela et al. (2017), who observe a converging trend of CEE countries towards the EU15. This raises again the question on the insignificance of FDI per GDP in this model, as Grela et al. (2017) see FDI as one explaining variable for said convergence.

Table 6: Panel regression of Log GDP per Capita with Innovation and Institutional Variables and additional controls by country group

LogGDPpc	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
FDIpGDP	.042	.038	1.12	.261	-.032	.116	
intlpEMPL	7.182	.548	13.10	0	6.106	8.259	***
rEMPL	-.151	.247	-0.61	.541	-.636	.334	
lag_HDI1	11.442	.323	35.47	0	10.808	12.075	***
lag_CPI1	.004	.001	4.70	0	.002	.006	***
lag_PLF1	.027	.017	1.63	.105	-.006	.061	
TOTL	.007	.003	2.84	.005	.002	.012	***
dPOP	0	0	-2.80	.005	0	0	***
tPOP	0	0	2.19	.029	0	0	**
Constant	-.283	.291	-0.97	.331	-.855	.288	

Mean dependent var	9.732	SD dependent var	1.084
R-squared	0.804	Number of obs	725
F-test	324.262	Prob > F	0.000
Akaike crit. (AIC)	305.173	Bayesian crit. (BIC)	351.034

*** *p<.01,* ** *p<.05,* * *p<.1*

Notes: Panel regression in a fixed effects model; see Table 1 for more detailed variable definitions and sources.

5. Conclusions

This paper investigates the role of innovation and institutions on the development of CEE countries for the period of 2000 to 2020 revealing the differences in the role of these factors in countries' transformation. This paper addresses the limited evidence of the impact of institutional variables on countries' development as well as the bounded geographical scope of the existing literature. The analysis is performed for 37 European countries, including both EU and non-EU members as well as CEE and Western European countries.

The results for all 37 countries indicate that high levels of institutional variables, such as the Human Development Index, as well as high levels of innovation indicators are generally important for economic development. However, the results also show the differences between country categories, which are especially visible between EU and non-EU countries. For CEE non-EU countries, the institutional indicator *political freedom* and the innovation indicator *FDI inflow* appear to be especially important for their development. This corresponds to the theory-based considerations (e. g., Barro 2004, Radošević, 2017; Pece et al., 2015) and indicates that CEE countries are profiting from foreign investments and stable political institutions. The insignificance of innovation-output-related indicators for CEE non-EU members may indicate that these countries are still not innovation producers but rather users. Kravtsova & Radošević (2012) come to a similar conclusion, pointing out that Eastern European countries suffer a certain degree of inefficiency when it comes to the implementation or the application of science for innovation output. Grela et al. (2017), on the other hand, see foreign direct investment as an explanatory variable for catching-up—i.e., countries with lower GDP grow faster. The results can be further put into context of the economic convergence. As Appendix 3 illustrates, one can observe a convergence process in both the basic and region-specific equations.

However, the limitations of the indicators need to be considered. Future research could focus more on the inventor counts, which may provide a broader picture of innovation potential of CEE countries. The same can be said about the ambiguous results of the CPI indicator. The ambiguous results of the CPI indicator can be explained through the nature of the variable as an estimation based on the perception of the issuing institutions. While it can offer a quantitative value, its validity and reliability are questionable.

These research limitations give rise to further research needs. First, the Eastern European EU member states could be broken down and considered regionally. If statistically possible, the eastern neighboring countries of the EU should be included in the analysis of a panel model of the NUTS2 regional level. For example, Barbero and Rodrígues-Crespo (2022) analyze the interrelation between technological, institutional, and regional variables of geographical peripheries measured by NUTS2 regions. The authors found that the interaction of technology, institutions, and geographical factors may be important for the implementation of place-based policies. This notion can be used by further research, by juxtaposing EU and non-EU members on the NUTS2 level.

Second, the European Commission places great emphasis on the social, economic, and institutional convergence of regions. This development is supported across Europe by the so-called Research and Innovation Strategies for Smart Specialization (RIS3). Smart specialization is intended to trigger positive economic development through regional competitive advantages with a place-based dimension (Gómez Prieto et al., 2019). The RIS3 approach enables the identification of competitive advantages by focusing efforts and resources on regional economic specializations (priorities) and the discovery of knowledge capabilities in different areas with different priorities. Since the application of the principles of RIS3 are mandatory for all European countries in order to receive funds from EU structural development funding (Gómez Prieto et al., 2019; McCann and Ortega-Argilés, 2013), this is also an instrument of the European neighborhood policy for the convergence of regions. Innovations and the institutions behind them are, therefore, the central building block for the convergence of CEE countries to Western European countries. Thus, Foreman-Peck and Zhou (2022) show, for instance, that EU innovation policy has a significant impact on the development of EU countries. However, this depends on the age of the EU-membership. For old EU member states, such as Germany and France, national innovation policies are more relevant than EU policies; the opposite is true for the new EU members, such as Poland or Romania. The effects of EU innovation policy are significant here, while nationally supported innovation projects are being crowded out. This is in line with significant external EU-financed innovation initiatives, which are often associated with co-financing shares from companies and are likely to leverage the effects again. This aspect should also be considered in future studies.

Third, for the EU policy's smart specialization to form a role model for neighboring countries, the regional specialization patterns of the NUTS2 regions of Europe should be analyzed. Some authors suggest that RIS3 applies specifically to developed regions (e. g., McCann & Ortega-Argilés, 2015; Camagni & Capello 2014), though, less developed regions, like Eastern European economies, can learn from such an EU role model and converge economically. Thus, a more detailed regional analysis of the findings of the present study might support the future economic development in Europe.

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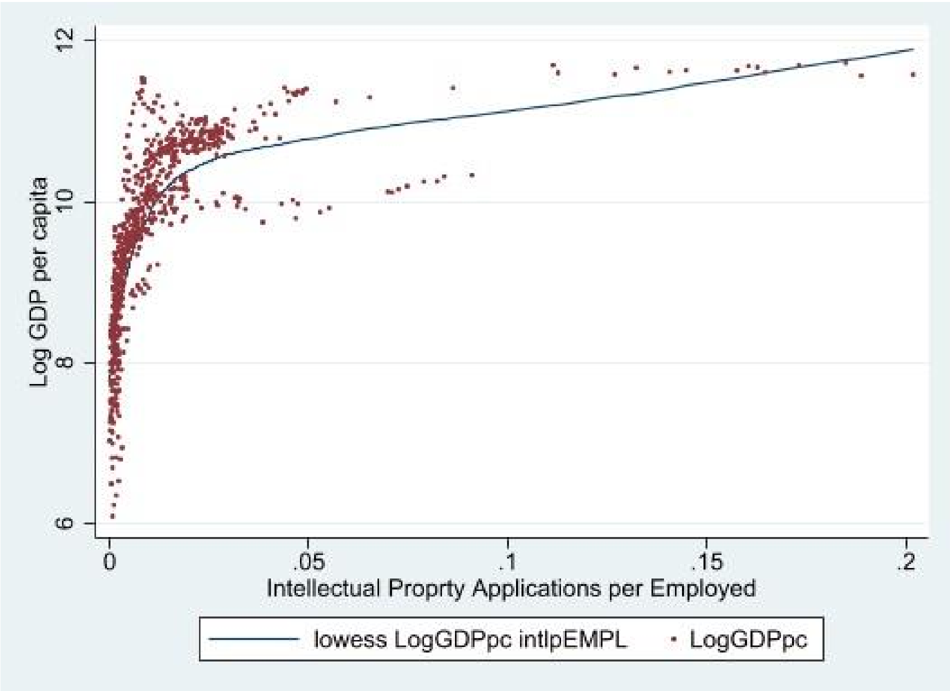
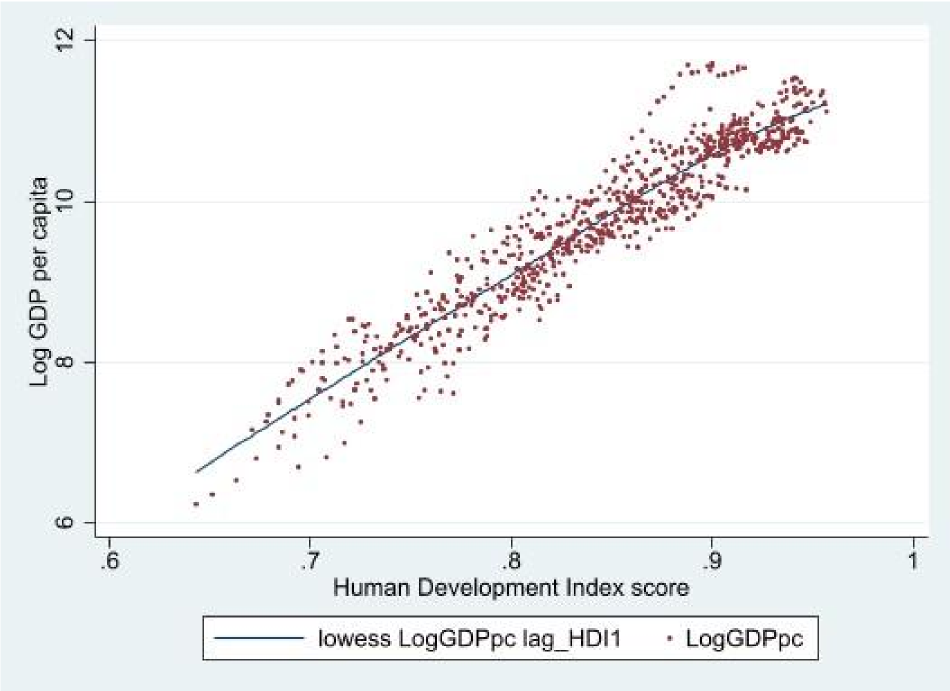
Appendix

A1: Simple correlation of Log GDP per capita and Intellectual Property Applications per Employed



Note: Number of observations is 762. The regression is between the log value of GDP per capita (y) and the quotient of number of intellectual property claims and the number of employed (x), the overall fit R2 is 0.2739.

A2: Simple correlation of Log GDP per capita and Human Development Index Score



Note: Number of observations is 740. The regression is between the log value of GDP per capita (y) and the lagged value of HDI (x), the overall fit R2 is 0.8930.

A3: Convergence Matrix in three time periods (2000-2020; 2000-2010; 2011-2020) with the logarithmic GDP per capita growth as the independent and GDP per capita as the dependent variable

	(1) Basic Equations		(2) Region Specific Equations	
Period	Beta	R^2	Beta	R^2
2000-2020	-.0000185 (0.000)	0.59	-.0000186 (0.000)	0.5896
2000-2010	-.000018* (0.074)	0.599	-.0000183 (0.083)	0.5994
2011-2020	-.000023 (0.001)	0.666	-.0000228 (0.001=	0.6667

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