

Röthel, Tim; Leschke, Martin

Article — Published Version

Unveiling the mutual dynamics: Institutions, education and economic growth over 138 years in OECD countries

Kyklos

Suggested Citation: Röthel, Tim; Leschke, Martin (2024) : Unveiling the mutual dynamics: Institutions, education and economic growth over 138 years in OECD countries, Kyklos, ISSN 1467-6435, Vol. 78, Iss. 1, pp. 243-270,
<https://doi.org/10.1111/kykl.12416>

This Version is available at:

<https://hdl.handle.net/10419/313689>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<http://creativecommons.org/licenses/by/4.0/>

Unveiling the mutual dynamics: Institutions, education and economic growth over 138 years in OECD countries

Tim Röthel¹  | Martin Leschke²

¹German Institute of Development and Sustainability (IDOS), Bonn, Germany

²Department of Law, Business, and Economics, University of Bayreuth, Bayreuth, Germany

Correspondence

Tim Röthel, German Institute of Development and Sustainability (IDOS), Tulpenfeld 6, 53113 Bonn, Germany,
Email: tim.roethel@idos-research.de

Abstract

Many articles examine the effect of institutions and education on economic growth in growth models or empirical settings. However, the opposite effect of economic development on institutions and education is less researched. Systematic evidence is scarce when looking at the interplay of education and institutions. Most of the literature focuses on post-war evidence starting in the 1960s only. However, institutions and education, both, only change slowly over time and, thus, should be analysed over a longer period. In this article, we try to close a gap by examining the relationship between all three variables over 138 years. By estimating a vector error correction model for a sample of 20 Organisation for Economic Co-operation and Development (OECD) countries, we are additionally able to differentiate between short- and long-run results. We find positive effects of institutions and education on growth and vice versa. In contrast, institutions and education do not significantly affect each other. Our results are robust to several robustness tests and extensions.

KEYWORDS

growth, human capital, institutions, long-run, PMG estimator

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2024 The Author(s). Kyklos published by John Wiley & Sons Ltd.

1 | INTRODUCTION

According to institutional economists, such as Douglass (e.g. North, 1990), James (e.g. Buchanan, 1975), Daron Acemoglu (e.g. 2001) and others, institutions play a crucial role in economic development, shaping the incentives, behaviours and interactions of individuals and organisations within a society. Institutions impact economic development in three main ways: First, property rights are fundamental for economic development. When individuals and businesses have confidence that their property will be protected and that contracts will be enforced, they are more likely to invest, innovate and engage in productive economic activities. Second, effective market institutions, such as competition laws, regulatory frameworks and consumer protections, create a level playing field for businesses. They prevent monopolies, encourage fair competition and ensure markets operate efficiently, leading to innovation and economic growth. Third, stable political institutions guarantee checks and balances and, therefore, prevent exploitation by the state, create an environment of certainty, keep corruption down and encourage long-term investment. While neoclassical economists often implicitly included institutions in their models, it took some time until they used such variables regularly and explicitly (North, 1990). Dawson (1998), for example, extends the neoclassical model by Mankiw et al. (1992) by incorporating an institutional variable.

Besides institutions, education (or human capital) is another critical determinant of economic development. One obvious explanation for this relationship is the higher productivity of workers resulting from more education. The higher level of productivity leads to more output and thus economic development or growth (e.g. Lucas, 1988). The empirical literature (e.g. Acemoglu et al., 2018; Mankiw et al., 1992, section 2) supports the hypothesis that institutions as well as education are both critical factors influencing the total factor productivity. Thus, in this article, we will examine the relationships between these three variables in more detail.

However, development is not a one-way street. Higher economic development, and thus higher wealth, might lead to higher education spending and a higher demand for education (e.g. Glewwe & Jacoby, 2004). Additionally, with higher wealth, people might be better able to participate in the political process and push for better institutions (e.g. Tian et al., 2020). Eventually, what can we say about the relationship between institutions and education? People might only fully reflect on the importance of institutions and make the right voting decisions if they are sufficiently educated (e.g. Fortunato & Panizza, 2015). Moreover, suppose there is no room for development due to a lack of property rights or other institutional restrictions. In that case, there is no need to invest in one's own education. This could be seen in many Soviet countries or other autocracies where careers are not the result of personal effort but are tied to party memberships or loyalty to the regime. These hypotheses will be discussed in more detail in Section 2.

Against this background, we would like to close two research gaps. First, as laid out above, we do not only analyse to which extent institutions and human capital foster GDP growth. We will also analyse the impact of human capital and GDP growth on institution-building and whether GDP growth and institutions will raise human capital. Secondly, we will analyse these interconnections over a long period (from 1870 to 2007) for 20 OECD countries using panel data. We will use an error correction model to capture long-run similarities between these countries and short-run differences across the countries. In the literature, the relationship between these three variables has yet to be systematically examined, especially over such a long period.

The paper's main findings are that institutions and human capital significantly foster growth. These results are robust to various extensions. Further, GDP growth positively affects human capital and institution building. However, the effects of education and institutions on one another are not robust.

The course of this paper is as follows: Section 2 provides an overview of the literature with respect to our hypotheses. Section 3 introduces the data and the empirical framework, whereas Section 4 presents the main findings. Extensions are discussed in Section 5. The paper finishes with a short conclusion.

2 | LITERATURE REVIEW

Over time, increases in the quantity and quality of physical capital, labour and technical and organisational progress should shift potential GDP p.c. (Islam, 1995; Mankiw et al., 1992). This is the wisdom of the 'old growth theory' (Solow, 1956). Investment in a competitive setting fosters GDP growth through improved productivity, technological progress, openness and secure property rights. Moreover, the geographical location and culture may influence institution-building and investment and, therefore, should impact GDP p.c. (e.g. Acemoglu et al., 2001; Easterly & Levine, 2003; Rodrik et al., 2004).

Since the 1990s, economists such as Rodrik (2000) and many others argued that institutions are important determinants of growth and that property rights represent a core category of economic institutions. The theoretical background of this hypothesis is much older starting with publications of early enlightenment philosophers like Hobbes (1651) and Locke (1690). The famous philosopher Hobbes (1651) argues that without law and order imposed by the state, life will be a war of 'each against all' (*Bellum omnium contra omnes*), '...and the life of man solitary, poor, nasty, brutish, and short'. Locke (1690) later emphasises that people should have fundamental rights, such as the rights to life, liberty and property. Further, Montesquieu (1748) states that arbitrary governmental action against the will and the welfare of the people can only be avoided by implementing certain constraints on the government, for example, the separation or division of the state's powers (into legislative, executive and judiciary power). The economic philosophers Hayek (1960) and Buchanan (1975) have pushed this idea further.

More recently, Acemoglu et al. (2004) attributed great importance to the state's role in formalising and protecting property rights. The focus on institutions, such as property rights and political constraints, does not mean we should neglect other variables' impact on GDP p.c. It entails only the hypothesis that without property rights and political constraints, sustainable GDP p.c. growth cannot seriously be explained in the long-run. Unfortunately, institutional variables, such as rule of law, property rights, or constitutional law, cannot be directly measured (at least historically). This might be a problem, especially if one is interested in determining the quality of institutions in detail. Against this background, one solution is to use proxies.

Glaeser et al. (2004) use several different institutional measures to estimate the effect on economic growth. Some variables, for example, executive constraints or the expropriation risk, are significant and positive; others, for example, judicial independence, are not. Another more recent study by Góes (2016) indicates a positive relationship between economic freedom and GDP growth. Finally, in their meta-regression analyses, Efendic et al. (2011) and Colagrossi et al. (2020) show that overall the evidence indicates a positive effect of institutions or democracy on economic performance. This leads us to our first hypothesis.

Hypothesis 1. Institutions have a positive effect on economic growth.

In the Keynesian growth model as well as in the neo-classical models of the Solow type, physical capital and exogenous technological progress played a dominant role. Since the mid of the 1980s, endogenous growth theories (e.g. Lucas, 1988; Romer, 1986, 1990) identified human capital and education as important factors contributing to long-run economic growth. A vast amount of empirical research supports the hypothesis that better education (human capital) will lead to higher growth rates (e.g. Acemoglu & Angrist, 2000; Barro, 2000; Krueger & Lindahl, 2001; Mankiw et al., 1992). Ehrlich and Murphy (2007) describe human capital as an 'intangible asset, best thought of as a stock of embodied and disembodied knowledge, comprising education, information, health, entrepreneurship and productive and innovative skills'. Increases in human capital arise through investment in schooling, job training and health, as well as through research and development projects and informal knowledge transfers. Marconi (2018) finds a positive effect of the average years of education on GDP growth over a long time between 1980 and 2005 for 118 countries. Indeed, the idea that education and human capital are important factors for the development of an individual and a country can already be found in the works of 'old' economists such as Smith (1776), Pigou (1920) and Machlup (1972). Even though the evidence of a positive effect of education seems clear at first, other studies do not find any significant effects of higher school enrolment and educational attainment

(e.g. Islam, 1995; Knowles & Owen, 1995). This effect might even turn negative above a certain threshold of education. McGowan and Andrews (2017) argue that higher skill and qualification mismatch is associated with lower labour productivity and, thus, potentially with lower growth rates. Finally, Benos and Zotou (2014) summarise these results in their meta-regression analysis, pointing at the large problem of publication bias inherent in this body of literature. Nevertheless, we follow the endogenous growth theories and propose the following hypothesis.

Hypothesis 2. Human capital has a positive effect on economic growth.

Even if most researchers analyse the impact of institutions on growth, a reversed influence is conceivable, too. Diamond (1999) argues that agricultural progress and early economic growth enabled better institutions. Moreover, Lipset (1959) and Moore (1967) support the idea that higher income is a basis for creating better institutions. Also, some older analyses of democratic transition promote the hypothesis that higher economic development makes it easier to introduce democratic institutions (Kuznets, 1965, 1966). Following the argument by Acemoglu and Robinson (2000), a higher level of economic development might lead to the population demanding more redistribution from the political elites. In order to avoid unrest or revolution, the elites extend democratic institutions ensuring future participation of the public in the redistribution process. Nevertheless, a critical junctures hypothesis formulated by North (1990) and Acemoglu et al. (2004) emphasises that the main direction of causality is from democracy or institutions to income.

In their theoretical work, Zak and Feng (2003) demonstrate that economic growth is an important factor in the speed of transition to democracy. The results of these theoretical works are supported empirically by Heid et al. (2012), who find a positive relationship between income and democracy.

In the long-run, Gundlach and Paldam (2009) and Tian et al. (2020) provide evidence for a strong and positive effect of income on democracy and institutions, respectively. They argue that income might be one of the most critical determinants of democratic transition. Acemoglu et al. (2008) find a positive correlation but no causal effect of income on democracy over a period of 500 years. All in all, we hypothesise the following relationship.

Hypothesis 3. Economic growth has a positive effect on institutions.

According to Lipset (1959), wealth may lead to better education systems and social capital, inducing better democratic institutions (e.g. property rights). Djankov et al. (2003) add that more educated people are more likely to solve conflicts in a regulated manner and less likely to use violence. Glaeser et al. (2004) find that the level of schooling significantly affects the change in institutions in the following years. However, Acemoglu et al. (2005) show that time effects might drive this effect. When including these time effects in the regression of Glaeser et al. (2004), they cannot confirm the significant effect of schooling on democracy.

In contrast, Apergis and Payne (2017) find a positive relationship between education and democracy. The effect of education on democracy appears to be stronger in countries with lower income levels. The studies by Bobba and Coviello (2007) and Castelló-Climent (2008) support these results over a longer period between 1965 and 2000 and 1970 and 2000, respectively, for a large sample of countries. On the other hand, Fortunato and Panizza (2015) find a positive correlation between education and the quality of government in countries with higher levels of democracy.

Glaeser et al. (2007) develop a theoretical model to analyse the channel between education and democracy. They argue that education leads to higher civic engagement, and well-educated people benefit relatively more from democracy. Thus, in an autocratic regime, once people demand more education due to a higher return on education, the autocrat needs to provide more education in order to prevent a revolution. Parente et al. (2022) argue that this leads to a modernisation process which eventually ends in a democracy. This theory is supported by an empirical study by Apergis (2018), providing new evidence from 161 countries that education supports democracy. Similarly, Milligan et al. (2004) find that education increases attention to and interest in politics and thus leads to more informed and 'better' voting behaviour. Thus, we propose the following hypothesis.

Hypothesis 4. Human capital has a positive effect on institutions

Bjørnskov (2009) examines the effect of initial GDP p.c. and social capital on the growth rate of the average schooling length. Social capital is positively related to schooling length. However, initial GDP p.c. negatively affects the average schooling length. The author interprets this result as the high initial investment of wealthier countries to improve the education system. Oketch (2006) argues that richer countries invest more in education in order to achieve higher growth rates. He finds that per capita growth positively affects investment in education and, thus, increases human capital formation. Additionally, on a micro level, several studies investigate the effect of family income on child performance in school. Duncan et al. (2014), for example, argue that low-income families lack the resources to invest in education. A boost in parents' income leads to better school performance. This is in line with Glewwe and Jacoby (2004). They find that an increase in household wealth leads to a significant increase in school enrolment rates. They conclude that human capital does not only affect growth, but a reinforcing process between these two variables exists. Overall, we assume that higher GDP p.c. leads to a positive effect on human capital.

Hypothesis 5. Economic growth has a positive effect on human capital.

Ehrlich and Lui (1999) provide a theoretical framework for the effect of institutions on human capital. They argue that weak institutions will get individuals to invest in rent-seeking activities instead of human capital. Thus, in the absence of strong institutions, the level of human capital should be relatively lower. Natkhov and Polishchuk (2019) demonstrate how the allocation of human capital between productive and unproductive sectors is influenced by the quality of institutions. Glaeser et al. (2004) also estimate the effect of the initial level of institutions and of GDP p.c. on the growth of education. While GDP p.c. has a robust and significant positive effect, the different measures of institutions exhibit no such effect. In contrast, Rodrik et al. (2004) show that rule of law positively influences the human capital per worker. Brown and Hunter (2004) and Stasavage (2005) both examine the effect of democracy on education spending, especially for primary schools. They find a positive relation for Latin American and African countries, respectively. Samuels and Vargas (2023) confirm this result for a larger sample, in the absence of agrarian elites. Other studies examine the link between institutions and various educational outcomes. Tiongson (2000), Mo (2001) and Abdulla (2021) find negative effects of corruption on educational outcome variables.

In contrast, Pellegrini and Gerlagh (2004) find no significant relationship between corruption and schooling. The result has been confirmed by Pellegrini (2011) using a newer dataset. Finally, this leads to our last hypothesis.

Hypothesis 6. Institutions have a positive effect on human capital.

In this article, the long-run evidence is of particular interest. Thus, we will turn to long-run studies, for example, using growth or GDP p.c. as the dependent variable. Almost all long-run studies examine the period between 1960 and the beginning of the millennium. Gerring et al. (2005) and Acemoglu et al. (2018), for example, look at the effect of democracy on growth in a large sample of countries between 1950 and 2000 and 1960 and 2010, finding positive and significant effects. Gründler and Krieger (2016) confirm these results. Similarly, Hanushek and Woessmann (2007, 2012) examine the effect of schooling on economic growth and find positive and significant effects. The studies above mainly use fixed effects or system GMM estimators to identify the effects. Bassanini and Scarpetta (2002) estimate the human capital augmented growth model using the pooled mean group (PMG) estimator. There in the long-run, human capital significantly increases the growth rate. Lee and Kim (2009), Rivera-Batiz (2002) and Dias and Tebaldi (2012) show that both, education and policies, matter for economic growth. An older study by O'Rourke and Williamson (1997) provides some historical evidence with respect to globalisation, schooling and growth in the European periphery between 1870 and 1913. They identify schooling as a driver of convergence for some countries within their sample. Finally, Röthel and Leschke (2023) examine the effect of institutions and education in a neoclassical growth model between 1870 and 2007. They find robust positive and significant effects of both variables.

In contrast to most of these studies, we analyse the mutual influence of the three variables, GDP p.c., human capital and institutions, essential for social development. This allows us to test if these variables follow a virtuous circle since the dynamics between the variables are sufficiently accounted for the first time. Since we estimate the relationship over a long time, we are able to differentiate between short- and long-run effects of the variables on

one another. As in Bassanini and Scarpetta (2002), we use the PMG estimator, too, since it is the most appropriate estimator for a setting with many periods. We will discuss the estimator in more detail in the following section.

3 | EMPIRICAL FRAMEWORK

3.1 | Data

In this study, the relationship between economic growth, institutions and education, in the long-run, is of particular interest. The dataset comprises 20 countries between 1870 and 2007. Data availability limits our time horizon. Since our data stem from different data sources providing such data over a long time, we face a trade-off between the length and width of the data. By analysing 20 countries over the above-mentioned period, we try to solve this issue. As in many previous studies (e.g. Acemoglu et al., 2008), we measure economic growth using the GDP p.c. data from the Maddison Project Database (Bolt & Van Zanden, 2020). Institutions may be formal, such as laws, or informal, such as norms or values (North, 1990). In this article, we focus on formal institutions, such as the legal framework in a country. Even though some limitations may arise, we decided to proxy the legal framework by using one institutional variable. This is the usual approach in the literature. Concerning this institutional variable, we already discussed the argument by Buchanan (1975) in favour of property rights or binding rules for politicians above. This is in line with the results of Acemoglu and Johnson (2005) that property rights that protect the citizens' rights against the government are of first-order importance for economic outcomes. Thus, as a proxy for institutions, we use the liberal democracy index from the Varieties of Democracy Institute. This index takes a negative view of political power and emphasises individual rights against the tyranny of the state (Coppedge et al., 2022). Finally, we turn to the education variable. For our purpose, educational attainment regarding secondary education seems to be suitable as a proxy for overall education. Primary education shows less differences across countries, and tertiary education is an inappropriate measure of education in the 19th century. The education variable is taken from the Barro–Lee dataset and measures the average years of secondary schooling within the population between 15–64 years (Barro & Lee, 2015). Thus, it measures the stock of education within a country. Many previous studies (e.g. Acemoglu et al., 2005) used this variable, too. The education variable is only available every 5 years. Since the other two variables contain yearly data, we linearly approximate the education variable to obtain yearly data, too.

We assume that institutions and education are not only determinants of total factor productivity but (even more importantly) a precondition for private investment. Thus, in the following specifications, we will only focus on the three abovementioned variables and not include investment. However, this has been done by Röthel and Leschke (2023) who followed Dawson (1998) and investigated the factor productivity–effect of institutions and education on growth in a full growth model, including the investment variable, over the same period.

Table 1 presents the descriptive statistics. Since secondary education describes the average years of secondary schooling, it takes a value between 0 and 7.45 in the sample. Liberal democracy varies between 0.01 and 0.90, where higher levels of democracy are associated with higher index values. In the regression, we specify all variables in logarithmic form. This is in line with previous studies (e.g. Röthel, 2023; Wooldridge, 2020) and allows us to interpret

TABLE 1 Descriptive statistics.

	Obs.	Mean	Std. dev.	Min	Max
GDP per capita	2747	12,162.71	10,779.54	1352.00	74,879.81
Liberal democracy	2744	0.53	0.25	0.01	0.90
Secondary education	2760	1.53	1.63	0.00	7.45

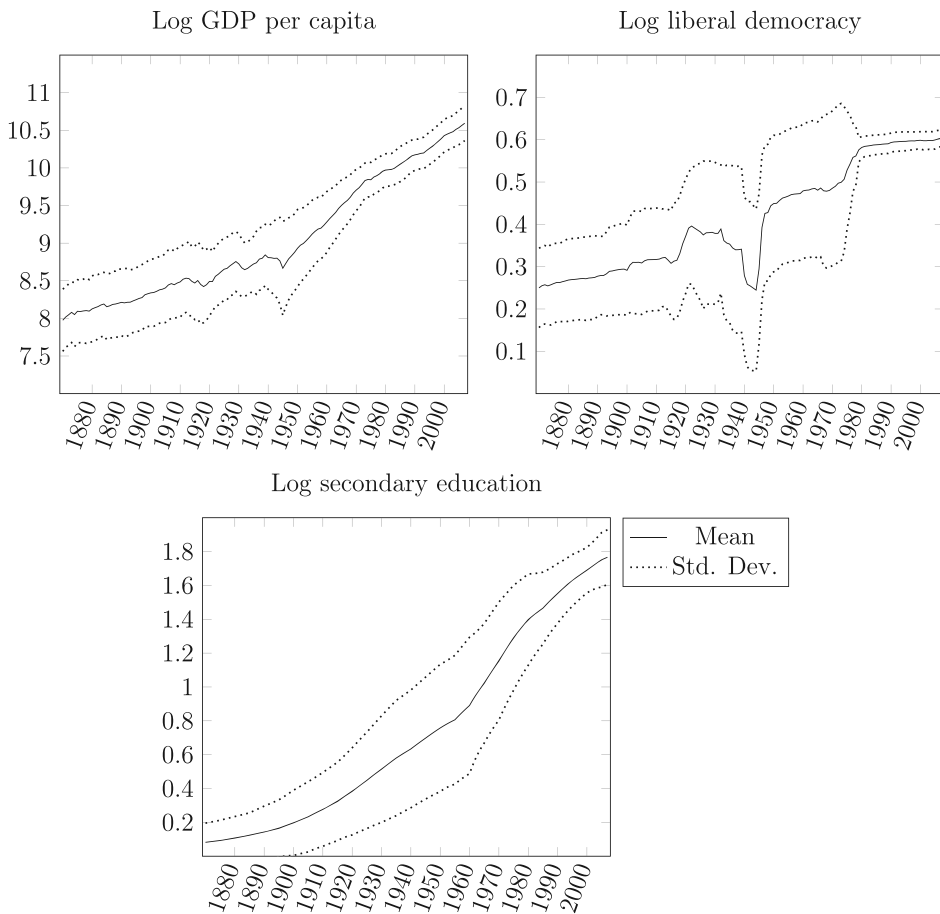


FIGURE 1 Mean and standard deviation of the variables (1870–2007).

the results as elasticities. Since taking the natural logarithm would create negative values for the democracy and education variables, we first apply the following linear transformation on these variables: $y = 1 + x$.

Figure 1 shows the average development of these three variables across the countries in the sample over time. Starting in 1870 at a rather low level, all three variables exhibit continuous and parallel growth until reaching their peak in 2007. The only exception are the values for liberal democracy in the years around the Second World War exhibiting a decline before recovering again in the 1950s.

One disadvantage of the length of our dataset is the countries themselves. Especially, at the beginning of our time frame, borders of some countries changed regularly. We address this potential problem by excluding certain countries from our sample as part of our robustness tests.

3.2 | Model

Turning to the regression equation and estimation strategy, we assume that lagged values of the variables affect their current values and the values of the other variables. Thus, we look at a dynamic linear relationship. There are several ways that are typically used to estimate dynamic panel specifications. Usually, when the panel is short with many cross-sectional units, estimators like the two-stage least squares or system GMM estimator are used.

However, these estimators are not necessarily designed for other settings, for example, with both large N and T (Roodman, 2009). Pesaran and Smith (1995) describe different possibilities for dealing with such data: One way would be to apply an estimator imposing a common slope, like the dynamic fixed effects (DFEs) estimator. Other possibilities would be either averaging the data over the cross-sectional units and estimating all together as a time series or averaging the data over time and estimating one single cross-section. However, Pesaran and Smith (1995) show that these estimators mostly provide inconsistent results in a dynamic environment. Additionally, the DFE estimator suffers from the so-called Nickell bias (Nickell, 1981). With large T , one could run single regressions for each unit and average the coefficients across groups, yielding the overall effect. This strategy is referred to as mean group estimator (MG) which is consistent at least for large N and T . Further, when applying a pooled estimator (fixed or random effects), all parameters across units are constrained to be the same, except for the intercepts. In contrast, with the MG estimator, all parameters are estimated separately across units. Thus, potential similarities are neglected (Pesaran et al., 1999). In order to account for dynamic heterogeneous models, Pesaran et al. (1999) introduce the PMG estimator. This intermediate estimator accounts for both short-run heterogeneity across units and long-run similarities. Thus, it combines pooling and averaging.

The data described above have a moderately large N and large T . Thus, either the MG or the PMG estimator can be applied. Since all countries are OECD countries, it is plausible to assume that in the long-run, all are affected by similar technological and other effects. However, in the short-run, these countries presumably differ in terms of these factors and deviate from the common long-run equilibrium. Therefore, we will assume that in the short-run, heterogeneity across countries exists, while in the long-run, similarities can be observed. Following the previous explanations in this section, we will apply the PMG estimator and compare the results to the MG and the DFE estimator. Following Pesaran et al. (1999) and Blackburne and Frank (2007), a convenient starting point is the following simple autoregressive distributed lag (ARDL) (p, q, q) framework:

$$y_{it} = \sum_{j=1}^p \lambda_{ij} y_{i,t-j} + \sum_{j=0}^q \delta_{1ij} d_{i,t-j} + \sum_{j=0}^q \delta_{2ij} s_{i,t-j} + \mu_i + \epsilon_{it}, \quad (1)$$

where y_{it} denotes GDP p.c., d_{it} liberal democracy and s_{it} secondary education in country i at time t . μ_i represents the country fixed effects and ϵ_{it} the error term. Reparameterizing, we get the following error correction equation:

$$\begin{aligned} \Delta y_{it} = & \phi_i (y_{i,t-1} - \theta_{1i} d_{it} - \theta_{2i} s_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta y_{i,t-j} \\ & + \sum_{j=0}^{q-1} \delta_{1ij}^* \Delta d_{i,t-j} + \sum_{j=0}^{q-1} \delta_{2ij}^* \Delta s_{i,t-j} + \mu_i + \epsilon_{it}, \end{aligned} \quad (2)$$

where $\phi_i = - \left(1 - \sum_{j=1}^p \lambda_{ij} \right)$, $\theta_{1i} = \frac{\sum_{j=0}^q \delta_{1ij}}{1 - \sum_{k=1}^p \lambda_{ik}}$, $\theta_{2i} = \frac{\sum_{j=0}^q \delta_{2ij}}{1 - \sum_{k=1}^p \lambda_{ik}}$.

$$\lambda_{ij}^* = - \sum_{m=j+1}^p \lambda_{im}, j = 1, 2, \dots, p-1,$$

and

$$\delta_{1ij}^* = - \sum_{m=j+1}^q \delta_{im}, \delta_{2ij}^* = - \sum_{m=j+1}^q \delta_{im}, j = 1, 2, \dots, q-1. \quad (3)$$

ϕ denotes the error correction parameter and can be interpreted as the speed of adjustment to equilibrium. We assume that our variables are nonstationary (integrated of order one $I(1)$) and cointegrated. Thus, the first part of

Equation (2) in brackets represents the long-run relationship between our three variables of interest. Since we assume a cointegrating relationship, they are stationary. The latter part of Equation (2) is the short-run dynamics that are first-differenced to make them stationary. Equations (1) and (2) are exemplary for the effects of institutions and education. However, we also estimate the following two ARDL (p,q,q) equations and reparameterize them accordingly, in order to estimate the effect of GDP and education on institutions and of GDP and institutions on education:

$$d_{it} = \sum_{j=1}^p \lambda_{ij} d_{i,t-j} + \sum_{j=0}^q \delta_{1ij} Y_{i,t-j} + \sum_{j=0}^q \delta_{2ij} S_{i,t-j} + \mu_i + \epsilon_{it}, \quad (4)$$

$$s_{it} = \sum_{j=1}^p \lambda_{ij} s_{i,t-j} + \sum_{j=0}^q \delta_{1ij} d_{i,t-j} + \sum_{j=0}^q \delta_{2ij} Y_{i,t-j} + \mu_i + \epsilon_{it}. \quad (5)$$

In order to test the assumptions laid out above, we conduct stationarity tests of the variables. Baltagi (2010) provides an overview of several common unit root tests. In this paper, the Im, Pesaran and Shin (IPS) test (Im et al., 2003) and the Fisher test (Choi, 2001) are applied since both seem to be most suitable in a large N and T setting. Table 2 shows the results of the unit root tests. The null hypothesis that all panels contain a unit root is tested against the alternative that some panels are stationary for the IPS test and against the alternative that at least one panel is stationary for the Fisher test. When the variables are specified in levels, the null hypothesis cannot be rejected for all variables. However, in the first difference specification, the null hypothesis can be rejected for all variables at the 1% level. Additionally, we need to test the assumption that the three variables are cointegrated. We have conducted the panel cointegration tests by Pedroni (2004) and Westerlund (2005). Table 3 shows the results. Both tests reject the null hypothesis of no cointegration among the variables.

As described by Yoo and Ku (2009), an error correction model can be used to establish “Granger causality” based on Granger (1969) among its variables. In our case, in line with our hypotheses, we assume bidirectional causality between the pairs of variables. If the error correction term and the variable of interest are significant, we have found long-run Granger causality. Thus, in the following sections, we will describe our significant results in a causal language.

Finally, we test the lag order by using Akaike's information criterion (AIC) (Akaike, 1974). The results in Table 4 show that the ARDL model (2,2,2) are the preferred one for GDP p.c. and liberal democracy as dependent variables. For the specification with secondary education as the dependent variable, the ARDL (2,1,2) is preferred. Thus, Equations (2), (4) and (5) will be adjusted accordingly.

TABLE 2 Tests for unit root.

Variable	IPS test		Fisher test	
	Level	First difference	Level	First difference
Log GDP per capita	12.6696	−24.2116***	10.0948	−23.6456***
Log liberal democracy	1.9136	−22.7993***	2.0539	−22.4411***
Log secondary education	6.9561	−5.9711***	6.6765	−6.2476***

Note: For the IPS test, 2 lags are used in the ADF regressions and the W-t-bar statistic is displayed. For the Fisher test, 2 lags are used in the ADF regressions and the inverse normal Z-statistic is displayed.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

TABLE 3 Tests for cointegration.

Test	Statistic
Westerlund test	
Variance ratio	−1.9698**
Pedroni test	
Modified Phillips–Perron	1.4950*
Phillips–Perron	1.5522*
Augmented Dickey–Fuller	3.5074***

Note: For the Westerlund test, the all panels option is being used. For the Pedroni test, 2 lags are used in the ADF regressions.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

TABLE 4 Lag order selection.

Model	(1) AIC	(2) AIC	(3) AIC
ARDL(1,1,1)	−9230.12	−13899.01	-
ARDL(2,1,1)	−9234.00	−14125.03	−20220.79
ARDL(1,2,1)	−9210.13	−13884.07	-
ARDL(1,1,2)	−9182.09	−13818.35	-
ARDL(1,2,2)	−9233.80	−13907.24	-
ARDL(2,2,1)	−9312.41	−14215.13	−20204.45
ARDL(2,1,2)	−9257.69	−14146.32	−20223.85*
ARDL(2,2,2)	−9334.78*	−14235.08*	−20205.85

Note: The table shows the AIC for different lag orders for the different models. Column (1) presents the models with GDP p.c. as the dependent variable, column (2) presents the models with liberal democracy as the dependent variable and column (3) presents the models with secondary education as the dependent variable. The star indicates which of the models is preferred according to the AIC.

4 | RESULTS

We will start by examining the effect of institutions and education on GDP p.c. The null hypotheses that both variables have no significant effect on GDP p.c. will be tested against the alternatives presented above in Hypotheses 1 and 2. Table 5 presents the baseline results of the three estimators: PMG, MG and DFE. Starting with the convergence coefficients, we find negative and significant estimates, indicating convergence to the long-run equilibrium. We can observe similar results for the three estimators when looking at the long-run coefficients. Both liberal democracy and secondary education positively affect GDP p.c. When looking at the short-run coefficients, all estimates are insignificant, at least in the PMG and MG estimations. The effects are long-term, likely because of the nature of the two explanatory variables. It usually takes some time until a change in democracy and education translates into economic growth. Suppose a government introduces a new regulation concerning property rights within a country (partly measured by the liberal democracy variable). In that case, strengthening property rights, for example, might affect business decisions in the same year. However, it might take longer until these business decisions, such as private investment, are reflected in a country's GDP. Similarly, an increase in the human capital stock of a country (reflected in the secondary education variable) will likely not increase GDP in the same year. It will take some time

TABLE 5 Baseline results GDP p.c.

		(1) PMG	(2) MG	Hausman Test	(3) DFE
Convergence coefficient	LogGDPp.c._{t-1}	−0.0292*** (0.0062)	−0.0436*** (0.0081)		−0.0194*** (0.00392)
Long-run coefficients	$\text{LogLiberalDemocracy}_t$	3.7662*** (0.4288)	4.0086** (1.5945)		3.395*** (0.685)
	$\text{LogSecondaryEducation}_t$	0.6709*** (0.0852)	0.8416*** (0.3061)		1.045*** (0.139)
			0.57		
Short-run coefficients	$\Delta\text{LogGDPp.c.}_{t-1}$	0.1090*** (0.0366)	0.1012** (0.0396)		0.148*** (0.0191)
	$\Delta\text{LogLiberalDemocracy}_t$	−0.0649 (0.1286)	−0.0686 (0.1269)		0.242*** (0.0368)
	$\Delta\text{LogLiberalDemocracy}_{t-1}$	−0.0074 (0.1215)	−0.0140 (0.1194)		0.0227 (0.0377)
	$\Delta\text{LogSecondaryEducation}_t$	0.0219 (0.1423)	0.0350 (0.1358)		0.0522 (0.143)
	$\Delta\text{LogSecondaryEducation}_{t-1}$	0.0841 (0.1733)	−0.0471 (0.1691)		−0.00206 (0.144)
	Constant	0.2194*** (0.0435)	0.3312*** (0.0615)		0.148*** (0.0303)
	Number of observations	2681	2681		2681
	Number of countries	20	20		20
	Number of periods	136	136		136

Note: The Hausman test is indicating that the PMG estimator is preferred over the MG estimator.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

until companies hire these employees with higher education. Furthermore, it will take even longer until these highly skilled employees affect the companies' output and, thus, a country's GDP.

Section 3 shows that the PMG estimator is consistent and efficient if the long-run restrictions are true. The MG estimator would be consistent as well. However, if the true model would be heterogeneous in the long-run, only the MG estimator would be consistent (Blackburne & Frank, 2007). Additionally, we know that the dynamic panel bias weakens the DFE estimator. Thus, we need to choose between the PMG and the MG estimator. In such a case, in order to find the preferred estimator, we can conduct a Hausman test (Hausman, 1978). Table 5 shows the test statistic in the column 'Hausman test'. It indicates that the PMG model is preferred over the MG model. The results confirm the hypothesis that institutions and education positively affect GDP p.c. The respective alternative Hypotheses 1 and 2 can both be rejected on the 1%-level.

As depicted in Figure 1, our variables seem to be affected by historic events. A standard way to control for specific events would be to add yearly time-fixed effects. However, when using the MG estimator, this would

exhaust our degrees of freedom. Bassanini and Scarpetta (2002) suggest using a limited number of period fixed effects to overcome this problem. Thus, we have included time dummies controlling for such specific historical events. Table 6 shows the results for different time dummies in columns 1 and 2. In column 1, we include dummies

TABLE 6 Baseline results GDP p.c. with time dummies.

		(1) PMG	(2) PMG
Convergence coefficient	LogGDPp.c._{t-1}	−0.0201*** (0.0039)	−0.0128*** (0.0027)
Long-run coefficients	$\text{LogLiberalDemocracy}_t$	2.5326*** (0.5031)	2.5779*** (0.7854)
	$\text{LogSecondaryEducation}_t$	1.0310*** (0.1110)	1.1321*** (0.1735)
	World War I (1914–1918)	−2.2270*** (0.4876)	−3.5073*** (1.1258)
	World War II (1939–1945)	−1.3921*** (0.3463)	−2.6626*** (0.9088)
	Great Depression (1929–1930)		−0.9228 (0.5657)
	Marshall Plan (1946–1952)		1.6417*** (0.6336)
	Oil Crisis (1973–1974)		0.2368 (0.4888)
	Fall of the Iron Curtain (1989–1990)		−0.4486 (0.4978)
Short-run coefficients	$\Delta\text{LogGDPp.c.}_{t-1}$	0.0870** (0.0378)	0.0691* (0.0381)
	$\Delta\text{LogLiberalDemocracy}_t$	−0.0484 (0.1219)	−0.0601 (0.1180)
	$\Delta\text{LogLiberalDemocracy}_{t-1}$	0.0221 (0.1138)	0.0211 (0.1123)
	$\Delta\text{LogSecondaryEducation}_t$	0.1229 (0.1580)	0.0918 (0.1590)
	$\Delta\text{LogSecondaryEducation}_{t-1}$	0.0457 (0.1783)	0.0723 (0.1791)
	Constant	0.1630*** (0.0287)	0.1097*** (0.0201)
	Number of observations	2681	2681
	Number of countries	20	20
	Number of periods	136	136

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

for the two World Wars only. To control for the Great Depression, the Marshall Plan and World War II aftermath, the Oil Crisis and the Fall of the Iron Curtain, we add even more dummies in column 2. The results are similar to those of the baseline estimation. The coefficient of liberal democracy remains significant and positive with a slightly smaller magnitude. In contrast, the coefficient of secondary education positively and significantly affects economic growth, gaining magnitude. As expected, both World War dummies strongly and negatively affect GDP p.c. growth. In contrast, the Marshall Plan dummy, capturing the World War II aftermath, is significant and positive, reflecting the economic revival after the war. The remaining dummies are insignificant.

Further, we examine the relationship between GDP p.c., secondary education and liberal democracy as the dependent variable. Here, we will test the null hypotheses that both variables have a significant effect on liberal democracy against the alternatives formulated in Hypotheses 3 and 4. The results are presented in Table 7. Again, the convergence effects are significant and negative, indicating convergence to the long-run equilibrium in all cases. Since the Hausman test suggests that the PMG estimator is preferred, we will focus on the first column in the following. In the long-run, GDP p.c. and secondary education positively and significantly affect liberal democracy. However,

TABLE 7 Baseline results liberal democracy.

		(1) PMG	(2) MG	Hausman test	(3) DFE
Convergence coefficient	$\text{LogLiberalDemocracy}_{t-1}$	-0.0630***	-0.0816***		-0.0597***
		(0.0141)	(0.0140)		(0.00600)
Long-run coefficients	LogGDPp.c._t	0.0490*	-0.1231		0.106***
		(0.0263)	(0.1773)		(0.0309)
	$\text{LogSecondaryEducation}_t$	0.0886***	0.3948		0.0442
		(0.0330)	(0.2824)		(0.0431)
			1.49		
Short-run coefficients	$\Delta\text{LogLiberalDemocracy}_{t-1}$	0.2461***	0.2373***		0.275***
		(0.0339)	(0.0297)		(0.0188)
	$\Delta\text{LogGDPp.c.}_t$	0.0654**	0.0617*		0.0762***
		(0.0324)	(0.0322)		(0.00996)
	$\Delta\text{LogGDPp.c.}_{t-1}$	-0.0097	-0.0108		-0.0111
		(0.0295)	(0.0309)		(0.0100)
	$\Delta\text{LogSecondaryEducation}_t$	0.0039	0.0117		-0.00566
		(0.0794)	(0.0692)		(0.0740)
	$\Delta\text{LogSecondaryEducation}_{t-1}$	0.1107	0.0961		0.0967
		(0.0940)	(0.0832)		(0.0747)
	Constant	-0.0056***	-0.0195		-0.0354**
		(0.0017)	(0.0300)		(0.0158)
	Number of observations	2681	2681		2681
	Number of countries	20	20		20
	Number of periods	136	136		136

Notes: The Hausman test is indicating that the PMG estimator is preferred over the MG estimator. *, ** and *** denote significance at the 10%-, 5%- and 1%-level, respectively.

GDP p.c. is significant at the 10%-level only. In the short-run, all variables except the lagged dependent variable and the change in GDP p.c. are insignificant. A change in GDP p.c. positively influences a change in liberal democracy. As explained in Section 2, one way to interpret the result would be that when people are better educated, they might

TABLE 8 Baseline results liberal democracy with time dummies.

		(1) PMG	(2) PMG
Convergence coefficient	$\text{LogLiberalDemocracy}_t$	−0.0858*** (0.0255)	−0.0856*** (0.0246)
Long-run coefficients	LogGDPp.c._t	0.0785*** (0.0192)	0.0840*** (0.0192)
	$\text{LogSecondaryEducation}_t$	0.0458* (0.0235)	0.0416* (0.0239)
	World War I (1914-18)	−0.0086 (0.0207)	−0.0002 (0.0218)
	World War II (1939-45)	−0.2508*** (0.0193)	−0.2687*** (0.0210)
	Great Depression (1929-30)		0.0085 (0.0315)
	Marshall Plan (1946-52)		0.1133*** (0.0208)
	Oil Crisis (1973-74)		0.0069 (0.0312)
	Fall of the Iron Curtain (1989-1990)		−0.0027 (0.0314)
Short-run coefficients	$\Delta\text{LogLiberalDemocracy}_{t-1}$	0.2335*** (0.0346)	0.2212*** (0.0361)
	$\Delta\text{LogGDPp.c.}_t$	0.0465* (0.0276)	0.0391 (0.0256)
	$\Delta\text{LogGDPp.c.}_{t-1}$	−0.0202 (0.0289)	−0.0268 (0.0276)
	$\Delta\text{LogSecondaryEducation}_t$	0.0135 (0.0807)	0.0370 (0.0796)
	$\Delta\text{LogSecondaryEducation}_{t-1}$	0.1372 (0.0963)	0.1214 (0.0966)
	Constant	−0.0262*** (0.0076)	−0.0303*** (0.0084)
	Number of observations	2681	2681
	Number of countries	20	20
	Number of periods	136	136

Note: All specifications were estimated using the PMG estimator.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

acknowledge the value of a higher level of institutions and thus demand this kind of change in institutions. In addition, the higher the level of GDP p.c., and thus the level of wealth of the people, the more time can be used to demand a higher level of institutions. Both arguments follow Lipset (1959). Returning to Hypotheses 3 and 4, we can reject both null hypotheses.

Similar to the above, we test the results when adding the same time dummies. Table 8 presents the results. The effect of education on democracy is positive and significant in all specifications. However, the significance level decreases compared to the baseline results. In contrast, the significance level of GDP p.c. increases. The World War II dummy remains significant and negative, and the Marshall Plan dummy remains significant and positive.

Finally, we examine the relationship between GDP p.c., liberal democracy and secondary education as the dependent variable. Again, we test the null hypotheses that both variables have no effect on secondary education against the alternatives 5 and 6 formulated above. Table 9 presents the results. The convergence coefficient is significant and negative in all specifications, indicating convergence. Additionally, as in the previous cases, the Hausman test favours the PMG estimator. The long-run coefficient of GDP p.c. significantly and positively affects secondary education, while the effect of liberal democracy is insignificant. All short-run coefficients, except for the lagged

TABLE 9 Baseline results secondary education.

		(1) PMG	(2) MG	Hausman test	(3) DFE
Convergence coefficient	$\text{LogSecondaryEducation}_{t-1}$	−0.0071*** (0.0017)	−0.0116*** (0.0024)		−0.0045*** (0.0007)
Long-run coefficients	$\text{LogLiberalDemocracy}_t$	0.0075 (0.1313)	−2.7731 (4.0061)		0.4360 (0.3540)
	LogGDPp.c._t	0.7616*** (0.0294)	0.7770 (0.6218)		0.6810*** (0.0640)
			0.80		
Short-run coefficients	$\Delta\text{LogSecondaryEducation}_{t-1}$	0.8736*** (0.0103)	0.8474*** (0.0106)		0.8820*** (0.0094)
	$\Delta\text{LogLiberalDemocracy}_t$	0.0087 (0.0063)	0.0048 (0.0072)		−0.0023 (0.0049)
	$\Delta\text{LogGDPp.c.}_t$	−0.0031 (0.0025)	−0.0054** (0.0026)		−0.0014 (0.00260)
	$\Delta\text{LogGDPp.c.}_{t-1}$	−0.0033 (0.0030)	−0.0046 (0.0028)		−0.0000 (0.0024)
	Constant	−0.0420*** (0.0102)	−0.0586*** (0.0122)		−0.0235*** (0.0041)
	Number of observations	2686	2686		2686
	Number of countries	20	20		20
	Number of periods	136	136		136

Note: The Hausman test is indicating that the PMG estimator is preferred over the MG estimator.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

dependent variable, are insignificant. The short-run results may not be surprising since it takes relatively long until a shock towards the education system translates into a change in school attainment. In the long-run, GDP p.c. is a country's potential wealth to invest in the education sector. Thus, with a higher level of GDP, a country can invest more in education, which may lead to higher attainment rates in the future. The causal link between institutions and education is not straightforward and remains insignificant. Returning to Hypotheses 5 and 6, we can reject the null

TABLE 10 Baseline results secondary education with time dummies.

		(1) PMG	(2) PMG
Convergence coefficient	$\text{LogSecondaryEducation}_t$	−0.0076*** (0.0019)	−0.0079*** (0.0019)
Long-run coefficients	LogGDPp.c._t	0.7450*** (0.0256)	0.7499*** (0.0240)
	$\text{LogLiberalDemocracy}_t$	0.1595 (0.1245)	0.0748 (0.1076)
	World War I (1914–1918)	0.0220 (0.0580)	0.0110 (0.0506)
	World War II (1939–1945)	0.2483*** (0.0622)	0.2094*** (0.0541)
	Great Depression (1929–1930)		−0.0896 (0.0770)
	Marshall Plan (1946–1952)		0.1095** (0.0487)
	Oil Crisis (1973–1974)		0.0124 (0.0781)
	Fall of the Berlin Wall (1989–1990)		0.0910 (0.0563)
Short-run coefficients	$\Delta\text{LogSecondaryEducation}_{t-1}$	0.8706*** (0.0109)	0.8694*** (0.0112)
	$\Delta\text{LogLiberalDemocracy}_t$	0.0094 (0.0062)	0.0089 (0.0063)
	$\Delta\text{LogGDPp.c.}_t$	−0.0022 (0.0025)	−0.0031 (0.0025)
	$\Delta\text{LogGDPp.c.}_{t-1}$	−0.0023 (0.0028)	−0.0030 (0.0029)
	Constant	−0.0450*** (0.0118)	−0.0466*** (0.0118)
	Number of observations	2686	2686
	Number of countries	20	20
	Number of periods	136	136

Note: All specifications were estimated using the PMG estimator.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

hypothesis of the former while we cannot reject the null hypothesis of the latter. Table 10 presents the results, including time dummies. The results remain almost exactly the same and confirm those of the baseline estimation. GDP p.c. remains significant and positive, while liberal democracy is insignificant. Nevertheless, we treat our results as preliminary and will further test them in the following extensions section.

5 | EXTENSIONS

Several factors might influence our results that we have yet to control for. First, we will focus on the estimation with GDP p.c. as the dependent variable. The coefficients, for example, might be driven by single countries only. Thus, we have again estimated the PMG model of Equation (2), testing for the sensitivity of a reduction of countries. Figure 2 displays the point estimate and the 95%-confidence interval for liberal democracy when each of the countries is removed from the sample. The point estimate to the left shows the main 'baseline estimation' from Table 5. The second point estimate displays the results when Austria (AUS) is removed from the sample. This procedure is repeated until every country has been removed from the equation once. Similarly, Figure 3 shows the sensitivity of the education variable when single countries are removed. Again, on the left, 'MAIN' denotes the baseline estimation followed by the other countries. All point estimates remain positive and significant, confirming the results above. However, the magnitude of the coefficients slightly differs when removing single countries.

Figures 4 and 5 show the baseline results for both variables from Equation (4) when countries are excluded from the sample. The long-run coefficient of GDP p.c. remains significant and positive, confirming the previous results. In contrast, the coefficient of secondary education is insignificant for most of the specifications. Table 7 provides a significant coefficient on the 10%-level. However, even on the 10%-level, our results are not robust to the exclusion of single countries.

Figures 6 and 7 show the results for the exclusion of countries with respect to Equation (5), where secondary education is the dependent variable. Similar to the previous results, the long-run coefficient of GDP p.c. is significant,

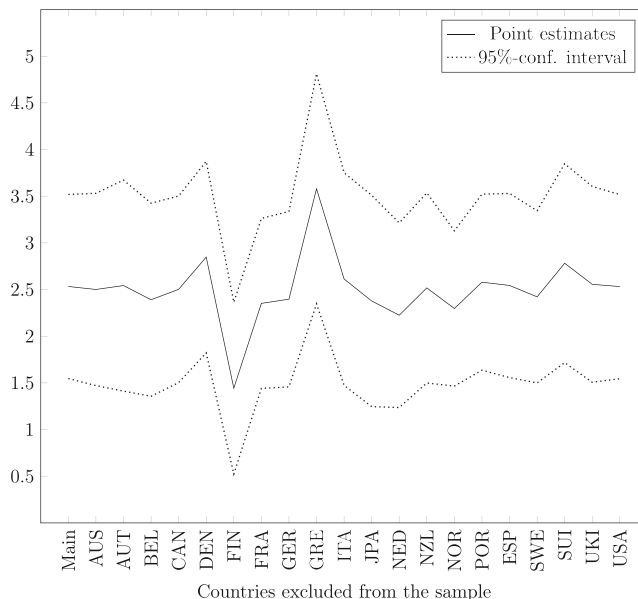


FIGURE 2 Baseline GDP estimation: Sensitivity of liberal democracy coefficient.

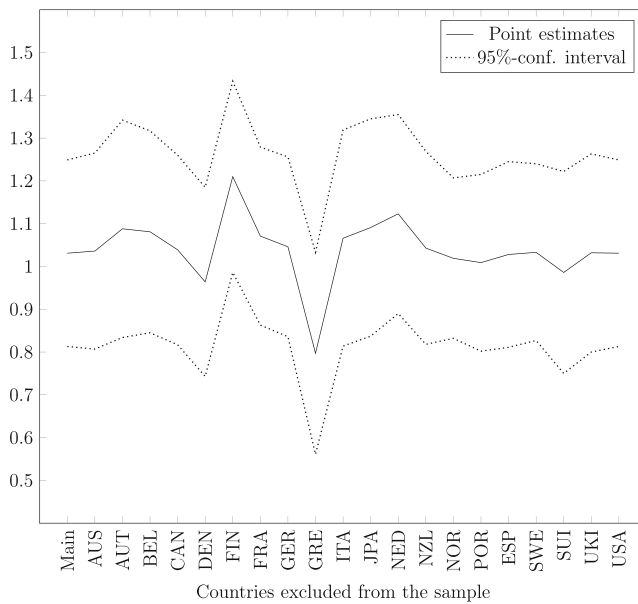


FIGURE 3 Baseline GDP estimation: Sensitivity of secondary education coefficient.

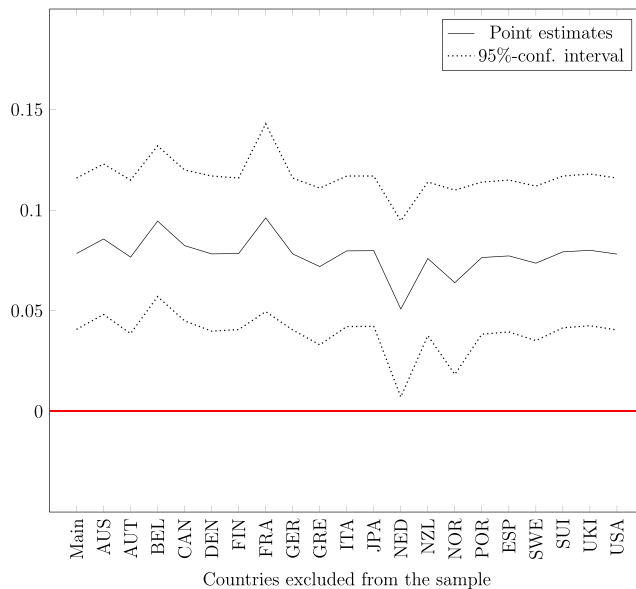


FIGURE 4 Baseline liberal democracy estimation: Sensitivity of GDP p.c. coefficient. [Colour figure can be viewed at wileyonlinelibrary.com]

while the liberal democracy coefficient is insignificant. Overall, most results are robust to removing single countries from the sample. Only secondary education does not seem to affect liberal democracy in the long-run.

Further, one could argue that the lag structure affects the PMG results. Even though the lag structure has been chosen based on the AIC, we will also look at the results of the ARDL(1,1,1), ARDL(2,1,1), ARDL(1,2,1), ARDL(1,1,2),

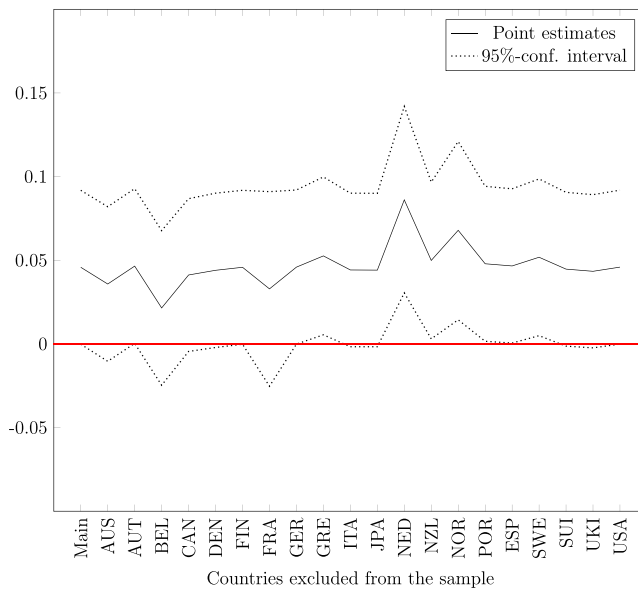


FIGURE 5 Baseline liberal democracy estimation: Sensitivity of secondary education coefficient. [Colour figure can be viewed at wileyonlinelibrary.com]

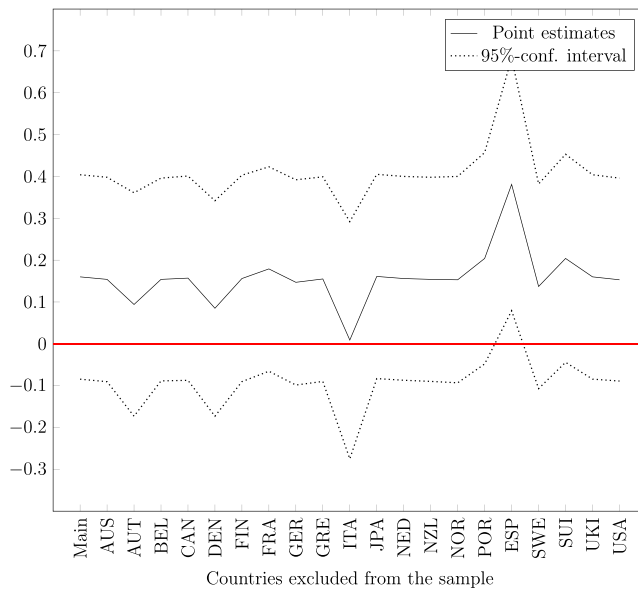


FIGURE 6 Baseline secondary education estimation: Sensitivity of liberal democracy coefficient. [Colour figure can be viewed at wileyonlinelibrary.com]

ARDL(1,2,2), ARDL(2,2,1) and ARDL(2,1,2). For GDP p.c. as the dependent variable, they are presented in Table 11. Generally, the coefficients all remain stable throughout the different specifications and confirm the previously found results. Both, liberal democracy and secondary education, remain positive, significant and of roughly the same

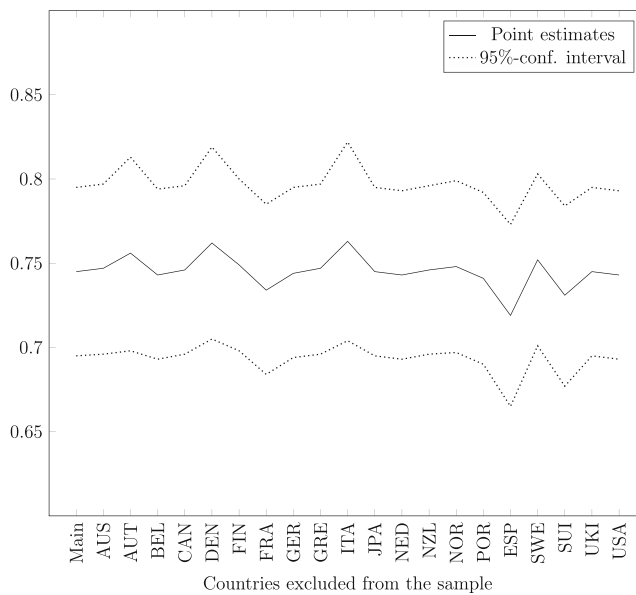


FIGURE 7 Baseline secondary education estimation: Sensitivity of GDP p.c. coefficient.

magnitude as in previous specifications. Table 12 shows the same for liberal democracy as the dependent variable. Again, the results for the convergence coefficient and GDP p.c. remain the same and stable. However, the long-run secondary education coefficient is either insignificant or positive and significant. This confirms the results from the previous exclusion of countries. Lastly, we also test the sensitivity to the lag structure when secondary education is the dependent variable. There, the structure of Table 13 differs from those presented before. Since the model with only one lag of the dependent variable is not solvable, we have tested the sensitivity to a different lag structure only for the ARDL(2,1,1), ARDL(2,2,1) and ARDL(2,2,2). Remember that the AIC indicated that the ARDL(2,1,2) is the best choice in the baseline estimation. Again, the results remain similar to those of the previous estimations. GDP p.c. positively and significantly affects secondary education, while liberal democracy is insignificant.

Eventually, one could argue that, instead of using yearly data, it would be more appropriate to use 5-year averages. This might be advantageous since institutions and education usually only change slowly over time. When using averages, we also avoid putting too much emphasis on small changes. Finally, as explained above, the education data are only available every 5 years. Table 14 presents the PMG baseline results, including time dummies for all three dependent variables. In column one, we find similar positive and significant coefficients of the long-run estimates of liberal democracy and secondary education. In columns 2 and 3, we also see a significant and positive effect of GDP p.c. on institutions and education, respectively. Additionally, liberal democracy does not seem to affect education in the long-run. Again, these results confirm the previous findings. Similar to the above, the long-run education coefficient falls out of line, when liberal democracy is the dependent variable. In column 2, we find a significant and negative effect on institutions. This result confirms the nonrobustness of the effect of this variable on institutions.

We will now return to the hypotheses proposed in Section 2. The null Hypotheses 1 and 2, that institutions and human capital have no effect on economic growth, can both be rejected. The null Hypotheses 3 and 5, that economic growth has no effect on institutions and human capital, respectively, can also be rejected. Moreover, our results indicate that we cannot reject the null Hypothesis 4 that human capital does not affect institutions. The same holds for null Hypothesis 6 that institutions have no effect on human capital.

TABLE 11 Sensitivity to lag structure GDP p.c.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ARDL(1,1,1)	ARDL(2,1,1)	ARDL(1,2,1)	ARDL(1,1,2)	ARDL(1,2,2)	ARDL(2,2,1)	ARDL(2,1,2)
Convergence coefficient	-0.0232*** (0.0041)	-0.0243*** (0.0044)	-0.0218*** (0.0038)	-0.0241*** (0.0043)	-0.0224*** (0.0039)	-0.0194*** (0.0037)	-0.0249*** (0.0045)
Long-run coefficients	3.3757*** (0.4927)	2.9176*** (0.4422)	3.2492*** (0.5268)	3.2674*** (0.4687)	3.1963*** (0.5083)	2.5970*** (0.5246)	2.8652*** (0.4294)
<i>LogSecondaryEducation_t</i>	0.8067*** (0.1003)	0.8663*** (0.0928)	0.8451*** (0.1065)	0.8237*** (0.0972)	0.8613*** (0.1040)	1.0166*** (0.1144)	0.8837*** (0.0909)
Constant	0.1836*** (0.0295)	0.1934*** (0.0325)	0.1736*** (0.0277)	0.1907*** (0.0310)	0.1785*** (0.0286)	0.1579*** (0.0274)	0.1980*** (0.0335)
Time dummies	YES	YES	YES	YES	YES	YES	YES
Number of observations	2705	2686	2682	2687	2682	2681	2686
Number of countries	20	20	20	20	20	20	20
Number of periods	137	136	136	136	136	136	136

Notes: All specifications were estimated using the PMG estimator. *, ** and *** denote significance at the 10%, 5% and 1%-level, respectively.

TABLE 12 Sensitivity to lag structure liberal democracy.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ARDL(1,1,1)	ARDL(2,1,1)	ARDL(1,2,1)	ARDL(1,1,2)	ARDL(1,2,2)	ARDL(2,2,1)	ARDL(2,1,2)
Convergence coefficient	-0.0745^{***} (0.0251)	-0.0845^{***} (0.0258)	-0.0758^{***} (0.0253)	-0.0753^{***} (0.0252)	-0.0765^{***} (0.0254)	-0.0853^{***} (0.0255)	-0.0848^{***} (0.0258)
Long-run coefficients							
$LogGDPp.c._t$	0.0767^{***} (0.0204)	0.0865^{***} (0.0185)	0.0604^{***} (0.0207)	0.0780^{***} (0.0205)	0.0652^{***} (0.0206)	0.0764^{***} (0.0192)	0.0873^{***} (0.0186)
$LogSecondaryEducation_t$	0.0383 (0.0249)	0.0334 (0.0226)	0.0589^{**} (0.0251)	0.0374 (0.0252)	0.0538^{**} (0.0251)	0.0471^{**} (0.0233)	0.0339 (0.0229)
Constant	-0.0202^{***} (0.0069)	-0.0312^{***} (0.0092)	-0.0105^{***} (0.0040)	-0.0215^{***} (0.0072)	-0.0138^{***} (0.0049)	-0.0244^{***} (0.0072)	-0.0321^{***} (0.0094)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	2705	2682	2686	2687	2686	2681	2682
Number of countries	20	20	20	20	20	20	20
Number of periods	137	136	136	136	136	136	136

Note: All specifications were estimated using the PMG estimator.
*Denotes significance at the 10% level.
**Denotes significance at the 5% level.
***Denotes significance at the 1% level.

TABLE 13 Sensitivity to lag structure secondary education.

		(1) ARDL(2,1,1)	(2) ARDL(2,2,1)	(3) ARDL(2,2,2)
Convergence coefficient	$\text{LogSecondaryEducation}_{t-1}$	−0.0075*** (0.0019)	−0.0076*** (0.0019)	−0.0078*** (0.0019)
Long-run coefficients	$\text{LogLiberalDemocracy}_t$	0.1652 (0.1296)	0.1219 (0.1298)	0.1014 (0.1214)
	LogGDPp.c._t	0.7406*** (0.0264)	0.7449*** (0.0266)	0.7505*** (0.0254)
	Constant	−0.0439*** (0.0112)	−0.0447*** (0.0115)	−0.0458*** (0.0118)
	Time dummies	Yes	Yes	Yes
	Number of observations	2687	2682	2681
	Number of countries	20	20	20
	Number of periods	136	136	136

Note: All specifications were estimated using the PMG estimator.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

6 | CONCLUSION

A large share of the literature and empirical analyses support the idea that both institutions and human capital (education) have a significant impact on GDP p.c. (growth). Our empirical analysis is in line with these findings. Based on the long time horizon, from 1870 until 2007, we are able to show the high impact of institutions and education on GDP p.c. But we do not stop at this point. Some strands of literature also provide four additional hypotheses: (1) GDP p.c. should positively influence institutions. (2) Also, human capital might affect institution building in a positive manner. (3) GDP p.c. is claimed to have a positive influence on human capital because the richer a country is the more money can be spent to improve the education system. (4) Further, better institutions should support the education system, too. In order to test these hypotheses, we estimate a modified ARDL model, the error correction model, using the PMG estimator. Human capital is measured by the average years of secondary schooling between 15 and 64 years and economic growth by GDP p.c., and as a proxy for institutions, we use the liberal democracy index, which indicates institutional constraints against arbitrary policy action of the state.

The model and the data seem to be suitable for analysing long-run equilibrium relationships between the variables GDP p.c., institutions, and human capital. As mentioned above, our results confirm the hypothesis that institutions and education positively affect the GDP p.c.; this effect is stronger for institutions compared to education. Furthermore, we find that in the long-run, GDP p.c. has a positive effect on institutions. However, the same is not true for the relationship between education and institutions. In addition, our results show that GDP p.c. significantly and positively affects secondary education. Again, this is not the case for the effect of institutions on education. These findings hold if we extend the basic model by including time dummies, if we exclude single countries from the sample and if we use different lag structures or average the data.

This paper has some limitations. Due to the panel structure of our dataset, the results are aggregated across countries. Thus, it is not possible to convincingly assign the coefficients to specific countries. Additionally, we try to approach causality by using a vector error correction model. Our results can be interpreted as being granger causal

TABLE 14 5-year average estimation.

		(1) GDP	(2) Institutions	(3) Education
Convergence coefficients		−0.1081*** (0.0267)	−0.1966*** (0.0499)	−0.1275*** (0.0314)
Long-run coefficients	<i>LogLiberalDemocracy_t</i>	1.5763*** (0.2935)		0.1006 (0.1097)
	<i>LogSecondaryEducation_t</i>	1.2454*** (0.0759)	−0.2837*** (0.0427)	
	<i>LogGDPp.c._t</i>		0.2950*** (0.0286)	0.7330*** (0.0207)
	WWI	−1.1019*** (0.2024)	0.1006*** (0.0264)	0.0127 (0.0423)
	WWII	−0.6326*** (0.1804)	−0.4422*** (0.0460)	0.1813*** (0.0627)
Short-run coefficients	$\Delta \text{LogGDPp.c.}_t$		−0.0454 (0.0704)	−0.0122 (0.0235)
	$\Delta \text{LogGDPp.c.}_{t-1}$	0.1355*** (0.0474)	−0.0930** (0.0373)	−0.0417 (0.0304)
	$\Delta \text{LogLiberalDemocracy}_t$	−0.5494** (0.2712)		0.0632 (0.0667)
	$\Delta \text{LogLiberalDemocracy}_{t-1}$	0.3140* (0.1680)	0.1889*** (0.0712)	
	$\Delta \text{LogSecondaryEducation}_t$	0.2750** (0.1131)	0.0759 (0.0649)	
	$\Delta \text{LogSecondaryEducation}_{t-1}$	−0.2092 (0.1477)	0.2069*** (0.0779)	0.6918*** (0.0410)
	Constant	0.8753*** (0.1978)	−0.3973*** (0.1009)	−0.7449*** (0.1855)
	Number of observations	514	514	515
	Number of countries	20	20	20
	Number of periods	26	26	26

Note: All specifications were estimated using the PMG estimator.

*Denotes significance at the 10% level.

**Denotes significance at the 5% level.

***Denotes significance at the 1% level.

(see, e.g., Yoo & Ku, 2009). This can be seen as an approach to a causal interpretation; however, one should never be thoroughly convinced. Another general empirical matter is the limited data availability over such a long time.

From a policy perspective, several conclusions can be drawn. As previous research indicates, human capital and institutions are important drivers of economic growth in the long-run. Thus, policymakers should invest in a country's human capital stock and advocate secured property rights. However, this poses some drawbacks. The effect is of a long-run nature, and politicians usually provide short-run oriented policies in order to get re-elected. Therefore, such

long-run reforms might not be of the highest priority for many governments. Though, if governments decide to implement these reforms it could start a virtuous cycle since economic growth positively affects human capital and institutions as well.

Based on our results, further research is necessary (a) to not only focus on GDP p.c. and its influencing variables but also to examine the mutual relationship of institutions, human capital and GDP p.c. more closely and (b) to shed more light on the different transmission mechanisms.

CONFLICT OF INTEREST STATEMENT

None.

ACKNOWLEDGEMENT

Open Access funding enabled and organized by Projekt DEAL.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Tim Röthel  <https://orcid.org/0000-0001-6443-763X>

REFERENCES

- Abdulla, K. (2021). Corrosive effects of corruption on human capital and aggregate productivity. *Kyklos*, 74(4), 445–462. <https://doi.org/10.1111/kykl.12279>
- Acemoglu, D., & Angrist, J. (2000). How large are human-capital externalities? Evidence from compulsory schooling laws. *NBER Macroeconomics Annual*, 15, 9–59.
- Acemoglu, D., & Johnson, S. (2005). Unbundling institutions. *Journal of Political Economy*, 113(5), 949–995.
- Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *American Economic Review*, 91(5), 1369–1401.
- Acemoglu, D., Johnson, S., & Robinson, J. (2004). *Institutions as the fundamental cause of long-run growth*. Cambridge, MA: National Bureau of Economic Research.
- Acemoglu, D., Johnson, S., Robinson, J. A., & Yared, P. (2005). From education to democracy? *American Economic Review*, 95(2), 44–49.
- Acemoglu, D., Johnson, S., Robinson, J. A., & Yared, P. (2008). Income and democracy. *American Economic Review*, 98(3), 808–842.
- Acemoglu, D., Naidu, S., Restrepo, P., & Robinson, J. A. (2018). Democracy does cause growth. *Journal of Political Economy*, 127(1), 47–100.
- Acemoglu, D., & Robinson, J. A. (2000). Why did the west extend the franchise? Democracy, inequality, and growth in historical perspective. *The Quarterly Journal of Economics*, 115(4), 1167–1199.
- Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, 19(6), 716–723.
- Apergis, N. (2018). Education and democracy: New evidence from 161 countries. *Economic Modelling*, 71, 59–67.
- Apergis, N., & Payne, J. E. (2017). From education to democracy: Evidence from long-run time-varying estimates. *International Review of Economics*, 64(4), 313–325.
- Baltagi, B. H. (2010). *Econometric analysis of panel data* (4th ed.). Chichester: Wiley.
- Barro, R. J. (2000). Inequality and growth in a panel of countries. *Journal of Economic Growth*, 5(1), 5–32.
- Barro, R. J., & Lee, J.-W. (2015). *Education matters: Global schooling gains from the 19th to the 21st century*. New York: Oxford Univ. Press.
- Bassanini, A., & Scarpetta, S. (2002). Does human capital matter for growth in OECD countries? A pooled mean-group approach. *Economics Letters*, 74(3), 399–405.
- Benos, N., & Zotou, S. (2014). Education and economic growth: A meta-regression analysis. *World Development*, 64, 669–689.
- Bjørnskov, C. (2009). Social trust and the growth of schooling. *Economics of Education Review*, 28(2), 249–257.
- Blackburne, E. F., & Frank, M. W. (2007). Estimation of nonstationary heterogeneous panels. *Stata Journal*, 7(2), 197–208 (12). <https://www.stata-journal.com/article.html?article=st0125>

- Bobba, M., & Coviello, D. (2007). Weak instruments and weak identification, in estimating the effects of education, on democracy. *Economics Letters*, 96(3), 301–306.
- Bolt, J., & Van Zanden, J. L. (2020). The Maddison project: Maddison style estimates of the evolution of the world economy. a new 2020 update.
- Brown, D. S., & Hunter, W. (2004). Democracy and human capital formation. *Comparative Political Studies*, 37(7), 842–864.
- Buchanan, J. M. (1975). *The limits of liberty: Between anarchy and leviathan*. Chicago: The Univ. of Chicago Press.
- Castelló-Climent, A. (2008). On the distribution of education and democracy. *Journal of Development Economics*, 87(2), 179–190.
- Choi (2001). Unit root tests for panel data. *Journal of International Money and Finance*, 20(2), 249–272.
- Colagrossi, M., Rossignoli, D., & Maggioni, M. A. (2020). Does democracy cause growth? A meta-analysis (of 2000 regressions). *European Journal of Political Economy*, 61, 101824.
- Coppedge, M., Gerring, J., Knutsen, C. H., Lindberg, S. I., Teorell, J., Alizada, N., Altman, D., Bernhard, M., Cornell, A., Fish, M. S., Gastaldi, L., Gjerløw, H., Glynn, A., Grahn, S., Hicken, A., Hindle, G., Ilchenko, N., Kinzelbach, K., Krusell, J., ..., & Ziblatt, D. (2022). V-DEM dataset 2022: Varieties of Democracy (V-Dem) Project.
- Dawson, J. W. (1998). Institutions, investment, and growth: New cross-country and panel data evidence. *Economic Inquiry*, 36(4), 603–619.
- Diamond, J. M. (1999). *Guns, germs, and steel: The fates of human societies*. New York, NY: Norton.
- Dias, J., & Tebaldi, E. (2012). Institutions, human capital, and growth: The institutional mechanism. *Structural Change and Economic Dynamics*, 23(3), 300–312.
- Djankov, S., Glaeser, E., La Porta, R., Lopez-de Silanes, F., & Shleifer, A. (2003). The new comparative economics. *Journal of Comparative Economics*, 31(4), 595–619.
- Duncan, G. J., Magnuson, K., & Votruba-Drzal, E. (2014). Boosting family income to promote child development. *The Future of children*, 24(1), 99–120.
- Easterly, W., & Levine, R. (2003). Tropics, germs, and crops: How endowments influence economic development. *Journal of Monetary Economics*, 50(1), 3–39.
- Efendic, A., Pugh, G., & Adnett, N. (2011). Institutions and economic performance: A meta-regression analysis. *European Journal of Political Economy*, 27(3), 586–599.
- Ehrlich, I., & Lui, F. T. (1999). Bureaucratic corruption and endogenous economic growth. *Journal of Political Economy*, 107(S6), S270–S293.
- Ehrlich, I., & Murphy, K. M. (2007). Why does human capital need a journal? *Journal of Human Capital*, 1(1), 1–7.
- Fortunato, P., & Panizza, U. (2015). Democracy, education and the quality of government. *Journal of Economic Growth*, 20(4), 333–363.
- Góes, C. (2016). Institutions and growth: A GMM/IV panel VAR approach. *Economics Letters*, 138, 85–91.
- Gerring, J., Bond, P., Barndt, W. T., & Moreno, C. (2005). Democracy and economic growth: A historical perspective. *World Politics*, 57(3), 323–364. <https://www.cambridge.org/core/article/democracy-and-economic-growth-a-historical-perspective/1BD38458A835E7F34F9A25191B68ECC7>
- Glaeser, E. L., La Porta, R., Lopez-de Silanes, F., & Shleifer, A. (2004). Do institutions cause growth? *Journal of Economic Growth*, 9(3), 271–303.
- Glaeser, E. L., Ponzetto, G. A. M., & Shleifer, A. (2007). Why does democracy need education? *Journal of Economic Growth*, 12(2), 77–99.
- Glewwe, P., & Jacoby, H. G. (2004). Economic growth and the demand for education: Is there a wealth effect?. *Journal of Development Economics*, 74(1), 33–51.
- Gründler, K., & Krieger, T. (2016). Democracy and growth: Evidence from a machine learning indicator. *European Journal of Political Economy*, 45, 85–107.
- Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, 37(3), 424.
- Gundlach, E., & Paldam, M. (2009). A farewell to critical junctures: Sorting out long-run causality of income and democracy. *European Journal of Political Economy*, 25(3), 340–354.
- Hanushek, E., & Woessmann, L. (2007). The role of education quality for economic growth.
- Hanushek, E., & Woessmann, L. (2012). Do better schools lead to more growth? cognitive skills, economic outcomes, and causation. *Journal of Economic Growth*, 17(4), 267–321.
- Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica*, 46(6), 1251.
- Hayek, F. A. (1960). *The constitution of liberty*. Chicago: Univ. of Chicago Press.
- Heid, B., Langer, J., & Larch, M. (2012). Income and democracy: Evidence from system GMM estimates. *Economics Letters*, 116(2), 166–169.
- Hobbes, T. (1651). *Leviathan: Matter, forme, and power of a common wealth, ecclesiastical and civil*. London.
- Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, 115(1), 53–74.

- Islam, N. (1995). Growth empirics: A panel data approach. *The Quarterly Journal of Economics*, 110(4), 1127–1170.
- Knowles, S., & Owen, P. D. (1995). Health capital and cross-country variation in income per capita in the Mankiw-Romer-Weil model. *Economics Letters*, 48(1), 99–106.
- Krueger, A. B., & Lindahl, M. (2001). Education for growth: Why and for whom? *Journal of Economic Literature*, 39(4), 1101–1136.
- Kuznets, S. (1965). *Economic growth and structure: Selected essays*. New York: Norton.
- Kuznets, S. (1966). *Modern economic growth, rate, structure and spread*. New Haven and London Yale University Press.
- Lee, K., & Kim, B.-Y. (2009). Both institutions and policies matter but differently for different income groups of countries: Determinants of long-run economic growth revisited. *World Development*, 37(3), 533–549.
- Lipset, S. M. (1959). Some social requisites of democracy: Economic development and political legitimacy. *American Political Science Review*, 53(1), 69–105.
- Locke, J. (1690). *An essay concerning humane understanding*. London.
- Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), 3–42.
- Machlup, F. (1972). *The production and distribution of knowledge in the united states* (1st ed.). Princeton paperbacks. Princeton, NJ: Princeton Univ. Press.
- Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, 107(2), 407–437.
- Marconi, G. (2018). Education as a long-term investment: The decisive role of age in the education-growth relationship. *Kyklos*, 71(1), 132–161. <https://doi.org/10.1111/kykl.12165>
- McGowan, M. A., & Andrews, D. (2017). Labor market mismatch and labor productivity: Evidence from PIAAC data. In Polachek, S. W., Pouliakas, K., Russo, G., & Tatsiramos, K. (Eds.), *Skill mismatch in labor markets*, Research in Labor Economics, Vol. 45: Emerald Publishing Limited, pp. 199–241.
- Milligan, K., Moretti, E., & Oreopoulos, P. (2004). Does education improve citizenship? Evidence from the united states and the united kingdom. *Journal of Public Economics*, 88(9–10), 1667–1695.
- Mo, P. H. (2001). Corruption and economic growth. *Journal of Comparative Economics*, 29(1), 66–79.
- Montesquieu, C. L. S. (1748). *De l'esprit des loix*. Geneva.
- Moore, B. (1967). *Social origins of dictatorship and democracy: Lord and peasant in the making of the modern world*. Boston: Beacon Pr.
- Natkhov, T., & Polishchuk, L. (2019). Quality of institutions and the allocation of talent: Cross-national evidence. *Kyklos*, 72(4), 527–569. <https://doi.org/10.1111/kykl.12211>
- Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica*, 49(6), 1417.
- North, D. C. (1990). *Institutions, institutional change and economic performance*, Political economy of institutions and decisions. Cambridge: Cambridge University Press. <https://www.cambridge.org/core/books/institutions-institutional-change-and-economic-performance/AAE1E27DF8996E24C5DD07EB79BBA7EE>
- O'Rourke, K. H., & Williamson, J. G. (1997). Around the european periphery 1870–1913: Globalization, schooling and growth. *European Review of Economic History*, 1(2), 153–190.
- Oketch, M. O. (2006). Determinants of human capital formation and economic growth of african countries. *Economics of Education Review*, 25(5), 554–564.
- Parente, S. L., Sáenz, L. F., & Seim, A. (2022). Income, education and democracy. *Journal of Economic Growth*, 27(2), 193–233.
- Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory*, 20(03), 597–625.
- Pellegrini, L. (2011). The effect of corruption on growth and its transmission channels. In Pellegrini, L. (Ed.), *Corruption, development and the environment*. Dordrecht: Springer Netherlands, pp. 53–74.
- Pellegrini, L., & Gerlagh, R. (2004). Corruption's effect on growth and its transmission channels. *Kyklos*, 57(3), 429–456.
- Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94(446), 621.
- Pesaran, M. H., & Smith, R. P. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, 68(1), 79–113.
- Pigou, A. C. (1920). *The economics of welfare*. London: Macmillan and Co.
- Röthel, T. (2023). Budget support to the health sector—The right choice for strong institutions? evidence from panel data. *Review of Development Economics*, 27(2), 735–770.
- Röthel, T., & Leschke, M. (2023). Do institutions matter in the very long-run? New evidence from OECD countries. *Applied Economics Letters*, 2023, 1–5.
- Rivera-Batiz, F. L. (2002). Democracy, governance, and economic growth: Theory and evidence. *Review of Development Economics*, 6(2), 225–247.
- Rodrik, D. (2000). Institutions for high-quality growth: What they are and how to acquire them. *Studies in Comparative International Development*, 35(3), 3–31.

- Rodrik, D., Subramanian, A., & Trebbi, F. (2004). Institutions rule: The primacy of institutions over geography and integration in economic development. *Journal of Economic Growth*, 9(2), 131–165.
- Romer, P. M. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002–1037.
- Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5, Part 2), S71–S102.
- Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal: Promoting communications on statistics and Stata*, 9(1), 86–136.
- Samuels, D., & Vargas, T. R. (2023). Democracy, rural inequality, and education spending. *World Development*, 162, 106136.
- Smith, A. (1776). *An inquiry into the nature and causes of the wealth of nations*. London.
- Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1), 65–94. <https://ideas.repec.org/a/oup/qjecon/v70y1956i1p65-94.html>
- Stasavage, D. (2005). Democracy and education spending in africa. *American Journal of Political Science*, 49(2), 343–358.
- Tian, J., Sim, N., Yan, W., & Li, Y. (2020). Trade uncertainty, income, and democracy. *Economic Modelling*, 90, 21–31.
- Tiongson, E. (2000). *Corruption and the provision of health care and education services*, IMF Working Papers, Vol. Working Paper No. 00/116. Washington, D.C: International Monetary Fund. [http://elibrary.imf.org/view/IMF001/01391-9781451853926/01391-9781451853926.xml](http://elibrary.imf.org/view/IMF001/01391-9781451853926/01391-9781451853926/01391-9781451853926.xml)
- Westerlund, J. (2005). New simple tests for panel cointegration. *Econometric Reviews*, 24(3), 297–316.
- Wooldridge, J. M. (2020). *Introductory econometrics: A modern approach* (Seventh edition). Boston, MA: Cengage. <https://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=2639179>
- Yoo, S.-H., & Ku, S.-J. (2009). Causal relationship between nuclear energy consumption and economic growth: A multi-country analysis. *Energy Policy*, 37(5), 1905–1913. <https://www.sciencedirect.com/science/article/pii/S0301421509000524>
- Zak, P. J., & Feng, Y. (2003). A dynamic theory of the transition to democracy. *Journal of Economic Behavior & Organization*, 52(1), 1–25.

How to cite this article: Röthel, T., & Leschke, M. (2025). Unveiling the mutual dynamics: Institutions, education and economic growth over 138 years in OECD countries. *Kyklos*, 78(1), 243–270. <https://doi.org/10.1111/kykl.12416>