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International Journal of Management and Economics 38, 7-30

2013

International Journal of Management and Economics (Zeszyty Naukowe KGŚ)
No. 38, April–June 2013, pp. 7–30; http://www.sgh.waw.pl/ijme/

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Abstract

This study aims at assessing to what extent institutional environment is responsible for worldwide differences in economic growth and economic development. To answer this question, we use an innovative approach based on a new concept of the institutions-augmented Solow model which is then estimated empirically using regression equations. The analysis covers 180 countries during the 1993–2012 period. The empirical analysis confirms a large positive impact of the quality of institutional environment on the level of economic development. The positive link has been evidenced for all five institutional indicators: two indices of economic freedom (Heritage Foundation and Fraser Institute), the governance indicator (World Bank), the democracy index (Freedom House), and the EBRD transition indicator for post-socialist countries. Differences in physical capital, human capital, and institutional environment explain about 70–75% of the worldwide differences in economic development. The institutions-augmented Solow model, however, performs slightly poorer in explaining differences in the rates of economic growth: only one institutional variable (index of economic freedom) has a statistically significant impact on economic growth. In terms of originality, this paper extends the theoretical analysis of the Solow model by including institutions, on the one hand, and shows a comprehensive empirical analysis of the impact of various institutional indicators on both the level of development and the pace of economic growth, on the other. The results bring important policy implications.

Keywords: economic development, economic growth, institutions, economic freedom, Solow model

Introduction

There are many factors that affect the pace of economic growth and the level of economic development, both from the theoretical and empirical perspective. Using one of the classifications, the factors can be divided into two groups: the demand-side and the supply-side determinants. The first group encompasses the components of aggregate demand, i.e. investment expenditures, government spending on goods and services, and net exports (consumption may be omitted because it is not an autonomous factor due to its direct dependence on output). The second group of factors includes the supply-side determinants which affect potential output; among these variables one may include physical capital, human capital, labor, and technology. Of course, both demand-side and supply-side variables can be more disaggregated, including various types of investments or government spending, or many more types of capital. All these factors (both demand-side and supply-side) can be called direct ones because they immediately transform expenditures or inputs into output.

Economic growth and economic development both depend, however, not only on these direct determinants but also on deep factors of production. Deep factors affect direct determinants and in this way they influence macroeconomic performance. Deep determinants are institutions that allow for interactions between output and measurable inputs.

The role of institutions in the process of economic growth and economic development is enormous. However, when assessing the impact of institutions on economic growth, the following questions or problems arise: first, which institutions are the most important growth factors; and second, how to measure institutions quantitatively in order to include them in empirical studies. The difficulty in answering these questions implies that there is still much room for theoretical and empirical studies that examine the relationship between institutions and economic growth.

The term 'institution' is very broad. There are a huge (perhaps almost infinite) number of variables that represent some kinds of institutions. For example, Sulejewicz [2009] provides many different concepts of institutions. Persson [2010] states that institutions are the rules of the game; some are upheld by law, others by mutual and spontaneous consent and a few by the (brute) force of privileged elites. Some institutions are informal, such as trust and commitment, while others—the limited liability corporation for example—needed coordinated action by lawmakers to get established. Rodrik [2007] points out that markets require institutions such as property rights, regulatory institutions (regulating conduct in goods, services, labor, assets, and financial markets), fiscal and monetary institutions for macroeconomic stabilization, institutions for social insurance, and institutions of conflict management (e.g. rule of law, a high-quality judiciary, representative political institutions, free elections, independent trade unions, social partnerships, and institutionalized representation of minority groups).

Hence, it is impossible to analyze in one empirical or theoretical study all the variables that may be treated as institutions. It is necessary to focus on a subset of them. Such an approach is applied in this study. The important role of institutions in the process of economic growth and economic development is also indicated by Wojtyna [2002, 2007] and Rapacki [2009].

Research hypotheses and the objectives of the paper refer to the following aspects. The first aim of the paper is to extend the neoclassical growth model to include institutions. Second, the study aims at assessing empirically the impact of institutions on economic development of the countries in the world. Third, the paper examines the empirical impact of institutions on the worldwide level of economic growth. Our fourth goal is to estimate the production function based on these results.

Since it is impossible to include in one empirical analysis all the possible types of institutions, it is necessary to introduce some constraints as to the number and the type of institutional indicators. Hence, the study focuses on the following indices that represent various areas of institutional environment: index of economic freedom, governance indicator, democracy index, and transition indicator. Economic development is measured by the level of GDP per capita at PPP while economic growth is its growth rate. Our study covers 180 countries but the particular models may be estimated based on a lower number of countries, depending on data availability.

The paper is composed of five points. In the following point, which appears after the introduction, we present the methodology by providing a concise description of the Mankiw-Romer-Weil model and the institutions-augmented Solow model, and we review the literature, describing other selected empirical studies on institutions-growth nexus. The next section describes the data used. Then, the results of the analysis are presented and discussed. The last point is the conclusion.

Background

The standard Solow model (1956) includes only one type of capital, according to the following production function: $Y = F(K, L, A)$, where Y denotes output, K – physical capital, L – labor, A – technology. Mankiw, Romer, and Weil [1992] extended the Solow model by introducing human capital (H), with the following production function: $Y = F(K, H, L, A)$. Nonneman and Vanhoudt [1996] further extended the Solow model, adding more types of capital; in empirical analysis they examined the model with three types of capital: physical capital, human capital, and technological know-how.

However, the value added of introducing more and more types of capital is diminishing, in our opinion. This results from the fact that economic growth and economic development both depend not only on direct factors, but also on deep determinants related to institutional environment. Thus, we propose extension of the macroeconomic production function in a way similar to that of Nonneman and Vanhoudt, but we argue that institutions should be included as new factors of production, and not different types of capital. Namely, following the initial study made by Próchniak [2013], we use the production function of the form: $F(K, H, L, A, I)$, where I is the qualitative index that measures the institutional environment. This approach is also shared by some other authors (e.g. [Hall and Jones, 1999]; [Eicher, García-Peñalosa, and Teksoz, 2006]), but in their works the introduction of institutional indicator is slightly different and/or the model is tested empirically under different assumptions.

(a) Theoretical background

In this section we compare the Solow model extended for human capital, i.e. the Mankiw-Romer-Weil (MRW) model, with our own concept of the institutions-augmented Solow model. For the sake of conciseness, only the most important assumptions and implications are presented here; some issues are examined more deeply by Próchniak [2013].

The MRW model assumes the following production function of the Cobb-Douglas form: $Y = K^{\alpha}H^{\beta}(AL)^{1-\alpha-\beta}$, where $\alpha > 0$, $\beta > 0$, $\alpha + \beta < 1$. This function exhibits constant returns to all the three inputs (physical capital, human capital, and effective labor) and the diminishing marginal product of both physical and human capital. Output may be devoted to consumption, accumulation of physical capital, or accumulation of human capital. The level of technology and the number of population both grow at constant exogenous rates: a and n. Let s_K be the investment rate in physical capital (i.e. the savings rate), and s_H the investment rate in human capital. Both types of capital depreciate at the same rate δ. Physical capital, human capital, and output per unit of effective labor, denoted by $k(t)$, $h(t)$, and $f(k(t),h(t))$, are defined as:

$$k \equiv \frac{K}{AL};\; h \equiv \frac{H}{AL};\; y \equiv f(k, h) \equiv \frac{F(K, H, AL)}{AL} \tag{1}$$

In order to find equations describing the behavior of the economy, we differentiate the definitions of k and h with respect to time. It yields:

$$\dot{k} = s_K y - (n + a + \delta)k = s_K k^{\alpha} h^{\beta} - (n + a + \delta)k \tag{2}$$

$$\dot{h} = s_H y - (n + a + \delta)h = s_H k^{\alpha} h^{\beta} - (n + a + \delta)h \tag{3}$$

The above equations are the basic equations describing the dynamics of the economy in the MRW model. The increase of capital per unit of effective labor equals actual investment net replacement investment. Based on the above formulas we can calculate the steady state, at which both types of capital and output per unit of effective labor are all constant. Setting (2) and (3) to zero, we can calculate the amount of physical capital (k^*), human capital (h^*), and output (y^*) in the steady state:

$$k^* = \left(\frac{s_K^{1-\beta} s_H^{\beta}}{n+a+\delta}\right)^{\frac{1}{1-\alpha-\beta}}; \; h^* = \left(\frac{s_H^{1-\alpha} s_K^{\alpha}}{n+a+\delta}\right)^{\frac{1}{1-\alpha-\beta}}$$

$$y^* = \left(\frac{s_K}{n+a+\delta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{s_H}{n+a+\delta}\right)^{\frac{\beta}{1-\alpha-\beta}} \tag{4}$$

Since output per unit of effective labor is equal to per capita GDP divided by the level of technology, then from (4) we can calculate the steady-state value of per capita output:

$$\frac{Y}{L} = A\left(\frac{s_K}{n+a+\delta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{s_H}{n+a+\delta}\right)^{\frac{\beta}{1-\alpha-\beta}} \tag{5}$$

The above equation indicates the determinants of economic development in long-run equilibrium according to the MRW model. Per capita income depends, among other factors, on the savings rate, the investment rate in human capital, and population growth. The relationship between the level of economic development and the accumulation of physical and human capital is positive, while that with the growth rate of population is negative. Formula (5), after taking logs, yields:

$$\ln\left(\frac{Y}{L}\right) = \ln A + \frac{\alpha}{1-\alpha-\beta}\ln s_K + \frac{\beta}{1-\alpha-\beta}\ln s_H - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n+a+\delta) \tag{6}$$

Estimating equation (6) allows us to find the determinants of economic development.

To find the determinants of economic growth, we assume that the countries are not in the steady state. Then, we carry out log-linearization of the equations describing the dynamics of the economy. After taking logarithms and time derivatives of the production function $y = k^{\alpha}h^{\beta}$ and using (2) – (3), we get the growth rate of output per unit of effective labor:

$$\dot{\ln y} = \alpha s_K k^{\alpha-1} h^{\beta} + \beta s_H k^{\alpha} h^{\beta-1} - (\alpha+\beta)(n+a+\delta) \tag{7}$$

Then we apply the first-degree Taylor extension around the steady state to find the approximate time path for ln$y$:

$$\dot{\ln y} = \dot{\ln y^*} + \left.\frac{d\dot{\ln y}}{d\ln k}\right|_{\text{steady-state}} \times (\ln k - \ln k^*) + \left.\frac{d\dot{\ln y}}{d\ln h}\right|_{\text{steady-state}} \times (\ln h - \ln h^*) \tag{8}$$

Calculating the respective derivatives and using the fact that steady state values for k and h are given by (4), from (8) we get:

$$\dot{\ln y} = -\alpha(1-\alpha-\beta)(n+a+\delta)(\ln k - \ln k^*) - \beta(1-\alpha-\beta)(n+a+\delta)(\ln h - \ln h^*) \tag{9}$$

Defining:

$$\lambda = (1-\alpha-\beta)(n+a+\delta) > 0, \tag{10}$$

equation (9) can be expressed as:

$$\frac{\dot{y}}{y} = \lambda(\ln y^* - \ln y) \tag{11}$$

Equation (11) informs that the pace of economic growth is proportionally dependent on the distance of a given economy from the steady state. The higher the distance is (i.e. the greater the difference between $\ln y$ and $\ln y^*$), the more rapid economic growth should be. This confirms the existence of real convergence (or income-level convergence) defined as the situation in which less developed countries (with lower GDP per capita) grow faster than more developed ones. Equation (10) shows the value of the so-called beta coefficient (this coefficient is denoted as λ because β is used here for human capital share in income).

Applying some mathematics, the MRW model allows us to calculate the formula for economic growth during the transition period towards the steady state. It is given by:

$$\ln y(t) - \ln y(0) = (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln s_K + (1 - e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln s_K + \\ - (1 - e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n + a + \delta) - (1 - e^{-\lambda t})\ln y(0) \tag{12}$$

As we can see, economic growth depends on initial income level (which suggests the existence of convergence) as well as on the factors determining output in long-run equilibrium (investment rate in physical and human capital, and population growth). Estimating equation (12) allows us to find the determinants of economic growth according to the MRW model.

Nonneman and Vanhoudt further extended the Solow model. However, as we argued earlier, the value added of introducing more types of capital is diminishing because macroeconomic performance depends not only on direct factors, but also on deep determinants related to institutional environment. Thus, we propose the extension of the macroeconomic production function, but in our opinion institutions should be included as new factors of production, and not different types of capital. The production function takes the following form:

$$Y = K^{\alpha}H^{\beta}(AL)^{1-\alpha-\beta}I^{\zeta} \tag{13}$$

or per unit of effective labor terms:

$$y = \frac{Y}{AL} = k^{\alpha}h^{\beta}I^{\zeta} \tag{14}$$

In the above formulas, I is the qualitative index measuring the institutional environment of the countries. One difference between our proposition (13) or (14) and the neoclassical production function is that our production function exhibits constant returns to all the quantitative (direct) inputs: physical capital, human capital, and effective labor. The institutional index has a separate power ζ because this variable refers to deep

GDP determinants which reveal an impact on direct ones. Thus, the exponent for the institutional variable should not be related with the rest of the exponents, representing conventional inputs.

Using a similar analysis as earlier, the time paths for physical and human capital are:

$$\dot{k} = s_K k^{\alpha} h^{\beta} I^{\zeta} - (n + a + \delta)k \tag{15}$$

$$\dot{h} = s_H k^{\alpha} h^{\beta} I^{\zeta} - (n + a + \delta)h \tag{16}$$

while the levels of physical capital, human capital, and output per unit of effective labor in the steady state are equal to:

$$k^* = \left(\frac{s_K^{1-\beta} s_H^{\beta} I^{\zeta}}{n + a + \delta}\right)^{\frac{1}{1-\alpha-\beta}} \tag{17}$$

$$h^* = \left(\frac{s_H^{1-\beta} s_K^{\beta} I^{\zeta}}{n + a + \delta}\right)^{\frac{1}{1-\alpha-\beta}} \tag{18}$$

$$y^* = \left(\frac{s_K}{n + a + \delta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{s_H}{n + a + \delta}\right)^{\frac{\beta}{1-\alpha-\beta}} I^{\frac{\zeta}{1-\alpha-\beta}} \tag{19}$$

The last formula shows determinants of economic development in the long run equilibrium according to the institutions-augmented Solow model. Apart from standard factors, per capita income also depends on institutions. The relationship between the quality of institutions and the level of economic development is positive, implying that countries with a better institutional environment should be more developed than those with poor-quality institutions.

Logarithmizing equation (19) yields:

$$\ln\left(\frac{Y}{L}\right) = \ln A + \frac{\alpha}{1-\alpha-\beta}\ln s_K + \frac{\beta}{1-\alpha-\beta}\ln s_H + \\ - \frac{\alpha+\beta}{1-\alpha-\beta}\ln(n + a + \delta) + \frac{\zeta}{1-\alpha-\beta}\ln I \tag{20}$$

Equation (20), estimated as the linear regression equation, allows us to verify and quantify empirically the impact of institutions on economic development.

Similarly, formula (12), augmented for institutions, becomes the following:

$$\ln y(t) - \ln y(0) = (1 - e^{-\lambda t})\frac{\alpha}{1-\alpha-\beta}\ln s_K + (1 - e^{-\lambda t})\frac{\beta}{1-\alpha-\beta}\ln s_K + \\ + (1 - e^{-\lambda t})\frac{\zeta}{1-\alpha-\beta}\ln I - (1 - e^{-\lambda t})\frac{\alpha+\beta}{1-\alpha-\beta}\ln(n + a + \delta) - (1 - e^{-\lambda t})\ln y(0) \tag{21}$$

Equation (21) shows that, according to the institutions-augmented Solow model, economic growth depends on institutions as well as standard factors. The better institutions are, the more rapid is economic growth. Estimating equation (21) using linear regression allows us to check empirically the impact of institutions on economic growth. Of course, some assumptions as to the specification of the regression model and the methods of estimation have to be imposed. For example, Białowolski, Kuszewski, and Witkowski [2010] assume that all the macroeconomic relationships are linear.

This way of finding economic growth determinants, namely the estimation of the regression equation, is not the only way of finding the variables that affect economic growth. Another type of research aiming at verifying growth determinants is the growth accounting exercise. Growth accounting is an empirical exercise aimed at calculating how much economic growth is caused by changes in measurable factor inputs (such as labor, physical capital, or human capital) and in the level of technology. The unexplained part of economic growth, measured as a residual, is called the Solow residual and it is interpreted as the proxy of technical progress or the increase in total factor productivity (TFP). Estimation of the regression equation and carrying out the growth accounting framework involve different econometric methodology and they cannot be directly compared because based on this study, we cannot easily state which portion of the Solow residual is attributed to institutions and which to elements other than institutions. For the studies in which a growth accounting exercise is carried out, see e.g. Rapacki and Próchniak [2006].

We can find in the literature some other papers in which the authors develop theoretical models of economic growth to include institutions. For example, Hall and Jones [1999] consider a model in which the institutional indicator (social infrastructure) is included as the endogeneous variable into the model: it affects and is affected by the level of GDP. Acemoglu, Johnson, and Robinson [2001] consider a multi-equation model incorporating the relationship between, among others, current institutions, early institutions and economic development. Eicher, García-Peñalosa, and Teksoz [2006] also propose a production function that includes both inputs and institutions. They assume that the level of productivity is a function of institutions: $A_i = Ae^{\gamma I}$. Given the standard neoclassical production function in the form of $Y = AK^{\alpha}H^{\beta}L^{1-\alpha-\beta}$, per capita output after taking logs is the following: $\ln y = \ln A + \alpha \ln k + \beta \ln h + \gamma I + \varepsilon$, where ε is the error term. However, unlike in our research, those authors consider neither the dynamics of the model nor the steady-state characteristics; they just limit themselves to estimate econometrically the production function in a logarithmized form, whatever the remaining assumptions of the model would be. On the other hand, Aghion (2006) develops another theoretical model of "appropriate institutions" and economic growth that shows the relative importance of innovation for productivity growth.

(b) Empirical background

Since there is no unique method to measure institutions, in the literature we find a lot of empirical studies that analyze the relationship between institutions and economic growth (or economic development). There number of these studies is too high to discuss even a small portion of them in one paper. For the sake of conciseness, we limit ourselves to presenting a brief comparison of selected empirical studies in Table 1. In the quoted studies, the authors analyze the impact of institutional environment on macroeconomic performance. Most of the institutional indicators are related to economic freedom, the level of democracy, and political stability.

TABLE 1. **The review of selected empirical studies**

Authors	Institutional variables	Countries and period	Main findings
Barro, 1996	The rule of law index; political rights index compiled by Gastil et al.	Ca. 100 countries, 1960–1994	The rule of law index is positively and significantly correlated with economic growth; political freedom reveals a nonlinear correlation with economic growth: once a certain level of democracy is achieved, a further rise of political rights hampers economic growth
Feng, 1997	Democracy index according to Gurr and Bollen	96 countries, 1960–1980	The direct impact of democracy on economic growth is negative, but an indirect impact - via the probability of government changes - is positive
Leblang, 1997	Democracy index according to Gurr	91 countries, 1960–1989	The initial level of democracy has positive and significant impact on subsequent economic growth rate
De Haan, Siermann, 1998	9 indices of economic freedom constructed by Scully and Slottje	78 countries, 1980–1992	Some indices of economic freedom reveal a positive relationship with economic growth; others exhibit no correlation
Hall, Jones, 1999	Social infrastructure (index of government anti-diversion policies and openness to international trade)	127 countries, 1960/1986–1995	Differences in social infrastructure cause large differences in income across countries

Authors	Institutional variables	Countries and period	Main findings
Wu, Davis, 1999	Index of economic freedom based on the factor analysis applied to component indicators of the Gwartney et al. index of economic freedom; index of political freedom based on political rights and civil liberties according to Gastil et al.	Ca. 100 countries, 1975–1992	Economic freedom positively affects economic growth; for a given level of economic freedom, economic growth does not depend on political freedom
De Haan, Sturm, 2000	Indices of economic freedom: Fraser Institute; and The Heritage Foundation/Wall Street Journal	80 countries, 1975 – 1990	Higher scope of economic freedom accelerates economic growth; the initial level of economic freedom does not affect GDP dynamics
Heckelman, Stroup, 2000	Component indicators of the Gwartney et al. index of economic freedom	49 countries, 1980–1990	Not all the component indicators of the index of economic freedom are positively correlated with economic growth
Mo, 2001	Corruption (according to Transparency International)	46 countries, 1970–1985	There is a negative relationship between corruption and economic growth
Pitlik, 2002	Standard deviation of time changes of the Fraser Institute index of economic freedom	82 countries, 1975–1995	Higher stability of the liberalization path (lower standard deviation) positively affects economic growth
Rivera-Batiz, 2002	Government quality index compiled by Hall and Jones; democracy index (political rights) compiled by Freedom House	59 countries, 1960–1990	Quality of governments positively and significantly affects economic growth; democracy significantly contributes to economic growth only when it is associated with improved quality of governments
Scully, 2002	The Gwartney et al. index of economic freedom	26 countries, 1975–1990	Economic freedom has a positive and significant influence on economic growth; economic freedom decreases income inequalities
Sturm, Leertouwer, de Haan, 2002	Index of economic freedom compiled by the authors based on the factor analysis applied to component indicators (instead of constant weights)	49 countries, 1980–1990	Index of economic freedom built by the authors is not strongly correlated with economic growth
Weede, Kämpf, 2002	The Gwartney et al. index of economic freedom	72 countries, 1970–1995	Higher economic freedom positively affects economic growth

Authors	Institutional variables	Countries and period	Main findings
Plümper, Martin, 2003	The level of democracy	83 countries, 1975–1997	The level of democracy exhibits a nonlinear impact on economic growth: the most rapid economic growth occurs in the countries with intermediate level of democracy
Eicher, García-Peñalosa, Teksoz, 2006	Social infrastructure compiled by Hall and Jones	More than 100 countries	The coefficient on institutions is positive and significant; when allowing for interactions, institutions matter more for growth in low human capital countries
Rapacki, 2007, 2009	Index of economic freedom	27 post-socialist countries, 1989–2005	Economic freedom led to rapid economic growth in transition countries
Rodrik, 2007	Democracy index (average of civil liberties and political rights)	90 countries, 1970–1989	Despite the positive and statistically significant relationship between democracy and economic growth, after removing Botswana (outlier) there is no strong, determinate relationship between political participation and economic growth
Qian, Wu, 2008	EBRD institutional quality index	Transition countries, including China	There is a positive relationship between per capita income and institutional quality
Tridico, 2011	EBRD transition indicator; democracy index (average of civil liberties and political rights)	28 transition countries, 1989–2009	EBRD index is insignificantly correlated with economic growth (but the nonlinear relationship is visible); the level of democracy has a positive impact on the level of development (measured by HDI)
Próchniak Witkowski, 2012a; 2012b, 2013	Index of economic freedom (Heritage Foundation) and democracy index (Freedom House)	127 countries, 1970-2009; EU countries, 1993–2010	Economic freedom exhibits a positive impact on economic growth while the results for democracy are ambiguous
Rapacki, Próchniak, 2012	Index of economic freedom	38 countries, 1993–2007	There is a positive relationship between economic freedom and economic growth
Próchniak, 2013	Index of economic freedom, democracy index, doing-business indicator, governance indicator	153 countries, 1994–2009	There is a large positive impact of the quality of institutional environment on the level of economic development (but sometimes nonlinearities are present)

Source: Own elaboration.

The literature review shows a huge diversity of the methods of analysis, including various theoretical models, various institutional indicators, various samples of countries and time periods, as well as various ways of econometric modeling. Despite the fact that some clear tendencies appear (such as the positive impact of economic freedom on economic growth), some other questions are not yet resolved (e.g., whether the impact of institutions on growth is linear or nonlinear). Hence, there is still much room for the empirical studies on the relationship between institutions and economic growth. In this paper we would like to test the appropriateness of the institutions-augmented Solow model in explaining differences in the rates of economic growth and in the levels of economic development and, based on these results, to estimate the macroeconomic production function.

In the light of the literature review, the value added of this study refers to the following areas. First, the study does not include as many explanatory variables in the regression model as possible; instead, it focuses on those factors that can be explained by a theoretical structural model. Namely, a lot of authors include in the regression analysis the variables representing both the demand- and supply-side of the economy. In such a case, the variables are a little bit mixed because the demand-side factors affect the short run rate of economic growth while the supply-side factors influence the long run pace of GDP dynamics. In this study, we are based on the Solow-type model of economic growth and the variables involved are of a similar type (investment in physical and human capital) and we omit some other variables that represent different areas (government expenditure). Second, a similar approach is carried out to analyze the determinants of economic growth and economic development. Most of the other studies focus on either the factors of economic growth or the factors of economic development. Since various empirical studies are not easily comparable due to different time periods and samples of countries and different sets of explanatory variables, as well as different and often completely incomparable econometrician methods, one cannot conclude based on the literature review which aspect of macroeconomic performance (economic growth or economic development) is more affected by institutions. Third, this study permits direct comparison of various institutional indicators since they are included in the same model. Fourth, unlike some advanced econometrician methods which involve a lot of changing variables that make the original time series barely interpretable, this study shows the assessment of a simple linear relationship (correlation) between institutions and macroeconomic performance. Fifth, unlike some papers in which the authors estimate a lot of models and choose the best one for interpretation, this study is in line with the alternative approach in which the estimation of one model is sufficient to find economic growth determinants (see e.g. [Hendry and Krolzig, 2004]).

Data

The analysis covers 180 countries and the 1993–2012 period (but in some areas the sample includes fewer countries or a shorter time period). Since the study is based on the family of Solow models, only the equations that can be obtained from the theoretical analysis of the model are subject to estimation. Those are (6) and (12) for the MRW model and (20) – (21) for the institutions-augmented Solow model. Moreover, we estimate the analogous equations for the standard Solow model with physical capital only. We assume that the sum of the rates of technical progress and depreciation equals 0.05 (i.e. 5%) which is a common assumption in such analyses and shouldn't lower the reliability of the results (see e.g. [Mankiw, Romer, Weil, 1992]; [Nonneman and Vanhoudt, 1996]). The aim of this study is to assess the impact of institutions (and some other factors) on economic growth and economic development. The sum $a + \delta$ appears in the explanatory variable $\ln(n + a + \delta)$. Even if the assumption of $a + \delta = 0.05$ is partly missing, it will not affect the estimates of the parameters standing on the remaining variables and the overall significance of the model at all, because adding a different amount to one of the explanatory variables influences only the estimated constant term. Hence, it makes no difference whether we assume $a + \delta = 0.05$ or any other value because nothing except the constant term is affected. On the other hand, in the globalized world it is reasonable to assume that the rate of technical progress does not vary across the whole world and the average rate of depreciation is the same across the economies because it depends on physical properties of capital.

In the analysis of the determinants of economic development, economic development is measured by GDP per capita at purchasing power parity (PPP), calculated as the 2010-2012 average. The average is taken in order to be robust to business cycles and, especially, the implications of the global crisis (Śledziewska and Witkowski [2012] analyze some of its effects). In the analysis of economic growth determinants, economic growth is measured by the growth rate of real GDP per capita at PPP between 1993 and 2012.

The explanatory variables are calculated as 10-year arithmetic averages in the case of determinants of economic development and 20-year arithmetic averages in the case of determinants of economic growth. If the available time series are shorter, which occurs especially in the case of institutional indicators, the average covers a shorter period.

The variable s_K is measured by gross fixed capital formation (% of GDP). n is the growth rate of population. The investment rate in human capital is not so easy to find due to the lack of one unique and commonly accepted measure of human capital. In empirical studies, various indices are used depending on the research methodology and data availability. In this analysis, we treat the variable s_H as the secondary school enrollment ratio (% gross), justifying our choice based on experience.

The following institutional indicators are used in this study: the Heritage Foundation index of economic freedom, the Fraser Institute index of economic freedom, the World

Bank governance indicator, the Freedom House democracy index (average of civil liberties and political rights), and the EBRD transition indicator. We are aware of the fact that many institutional-related aspects are omitted in this analysis, such as transaction costs (discussed by Sulejewicz and Graca [2005]), income inequalities (see Graca-Gelert [2012] for details), or EU enlargement (see Rapacki and Próchniak [2009, 2010]).

Since institutional indicators take values from different scales, for comparability purposes all of them have been recalculated to the 0-10 scale where 10 represents the highest quality of institutional environment. (Investment rates in physical and human capital have also been adjusted to 0-10 scale; this transformation, however, does not affect the regression estimates except the coefficient standing for the constant term).

Of course, we are aware of the fact that there is a wide choice for proxies used for right-hand side variables. However, in order not to extend the article for testing various types of proxy variables, we are forced to choose specified variables to the analysis. In the case of physical capital, the choice of gross fixed capital formation is rather obvious. In the case of human capital, we are partly constrained by the availability of data. The best source of information for cross-sectional empirical studies is the Barro-Lee dataset which includes a number of variables on education. Among those variables, we have chosen secondary school enrollment ratio because of our belief that in the case of analysis of the world economies, the differences in secondary enrollment may better influence the differences in macroeconomic performance than differences in primary or tertiary school enrollment. In the case of EU countries or OECD countries, it is likely that we would choose tertiary school enrollment ratio as developed countries achieve comparable outcomes in terms of secondary education and this variable may have no explanatory power. Similarly, the choice of institutional variables depends on data availability published by specialized institutions.

The data, except the institutional variables, are taken from the Penn World Table (PWT) 7.0 Database [Heston, Summers, Aten, 2011], the World Economic Outlook Database [IMF, 2012], and the World Development Indicators Database [World Bank, 2013].

Results

In this section, we verify the validity of the institutions-augmented Solow model to explain the differences in economic development and economic growth between the countries. We begin the analysis with the determinants of economic development. Then we switch to the analysis of economic growth determinants.

Table 2 illustrates the regression estimates that are used to find the determinants of economic development. According to the institutions-augmented Solow model, the level of economic development depends on investment rates in physical capital and human capital, the quality of institutions, and the growth rate of the population. The relationship between economic development and physical and human capital as well as the institutional environment is obviously positive, while the link with population growth should be rather negative. In order to check the robustness of the results, we verify not only the institutions-augmented Solow model, but also the standard Solow model and the Mankiw-Romer-Weil model. The basic Solow model includes one type of capital as the explanatory variable: $\ln s_K$; the MRW model includes two such variables: $\ln s_K$ and

TABLE 2. **Estimation results: the determinants of economic development**

		Standard Solow model	MRW model	Institutions-augmented Solow model				
				A	B	C	D	E
$\ln s_K$	*coef.*	1.26	0.32	0.24	0.22	0.02	0.24	0.79
	t-statistics	5.82	1.97	1.68	1.05	0.15	1.45	2.76
	p-value	0.000	0.051	0.094	0.297	0.880	0.149	0.012
$\ln s_H$	*coef.*		2.09	1.67	1.69	1.54	2.08	3.75
	t-statistics		15.56	13.07	10.37	11.97	15.79	2.37
	p-value		0.000	0.000	0.000	0.000	0.000	0.028
$\ln I$	*coef.*			2.80	2.86	1.48	0.22	0.83
	t-statistics			7.93	4.88	8.71	2.84	2.17
	p-value			0.000	0.000	0.000	0.005	0.042
$\ln(n + 005)$	*coef.*	−2.06	0.52	0.50	0.69	0.80	0.83	−1.65
	t-statistics	−4.72	1.59	1.76	2.17	2.89	2.47	−2.11
	p-value	0.000	0.114	0.080	0.032	0.004	0.015	0.047
constant	*coef.*	1.83	6.90	2.52	2.66	6.48	7.47	−4.67
	t-statistics	1.49	8.01	2.77	2.00	9.05	8.71	−1.39
	p-value	0.137	0.000	0.006	0.047	0.000	0.000	0.179
R^2 adj.		22.72%	67.29%	76.23%	74.82%	77.46%	68.93%	58.87%
R^2		23.59%	67.87%	76.82%	75.58%	77.99%	69.67%	65.45%
N		180	170	163	134	170	168	26
F statistics		27.32	116.87	130.88	99.82	146.18	93.60	9.95
	α	0.56	0.09	0.08	0.07	0.01	0.07	0.14
	β		0.61	0.57	0.58	0.60	0.63	0.68
	ζ			0.96	0.98	0.58	0.07	0.15

OLS estimates. Dependent variable: the level of GDP per capita at PPP (2009-2012 avg.). Explanatory variables (2003-2012 avg.): s_K – investment rate, s_H – secondary school enrollment ratio, I – institutional variable (model A: the Heritage Foundation index of economic freedom, model B: the Fraser Institute index of economic freedom, model C: the World Bank world governance indicator, model D: the Freedom House democracy index, model E: the EBRD transition indicator), n – population growth rate. N indicates the number of countries. α, β and ζ are the exponents in the production function standing for physical capital, human capital and institutional variable respectively.

Source: Own calculations.

$\ln s_H$; while the institutions-augmented Solow model includes, apart from $\ln s_K$ and $\ln s_H$, also the institutional indicator $\ln I$. The top rows of Table 2 show regression coefficients with t-statistics and p-values. Below are R-squares (both standard and adjusted), the number of observations (N), and the results for F test. The bottom part presents the estimated parameters of the production function (those are calculated based on equation (6), (20), or the analogous equation for the standard Solow model).

The data in Table 2 indicate that the institutions-augmented Solow model performs extraordinarily well in explaining worldwide differences in income levels. Regardless of the institutional indicator, all the regression equations have very high R-squares while estimated coefficients, in terms of their sign and significance, correspond to our expectations and the theoretical analysis. For example, variant A indicates that differences in physical capital accumulation, human capital accumulation, population growth, and the scope of economic freedom (measured by the Heritage Foundation index of economic freedom) explain about three-fourths of worldwide differences in economic development. All the explanatory variables are statistically significant (but the sign for population growth is, contrary to the theory, positive). If we use another index of economic freedom as the institutional indicator, compiled by Fraser Institute, the results are similar in terms of explaining worldwide income level differences (R-square is about three-fourths); physical capital, however, becomes an insignificant variable, but human capital and institutions retain their significance. In variant C, in which the institutional variable is the world governance indicator compiled by World Bank, the results are similar to those in variant B (high R-square, significant explanatory variables except physical capital which is completely insignificant).

In the two remaining variants (D and E) physical capital retains its significance but the R^2 coefficient falls a little bit. Variant D includes the democracy index; in this model, lower R-square may result from the fact that, given the whole world, the impact of democracy on economic development is likely to be nonlinear (some authoritarian regimes may be as rich as the most democratic countries). The last model (variant E) includes only the post-socialist countries ($N = 26$). It turns out that differences in physical capital and human capital accumulation, population growth, and the progress of market reforms (measured by the EBRD transition indicator) explain 65% of the differences in economic development.

As we can see, the institutions-augmented Solow model yields very good results in terms of explaining the determinants of economic development. More intensive accumulation of physical capital, better education and better institutional framework all lead to higher wealth of society. Taking into account the fact that the models are estimated for a very large sample of countries (except variant E), the results are in no way a coincidence; they represent a stable, long-run relationship.

The inclusion of institutions improves the findings obtained on the basis of simpler variants of the Solow model. The standard Solow model, with physical capital only, is responsible for explaining almost 25% of worldwide income level differences. Introduction of human capital increases this figure to almost 70% as shown by the MRW model. In both the standard Solow formula and the MRW approach, the coefficients standing for $\ln s_K$ and $\ln s_H$ are positive and significant, which is in line with the theory. Adding institutions further increases the *R*-square coefficient to 70% or more while the parameter standing for the institutional indicator is always positive and statistically significantly different than zero, and the remaining estimated parameters are mostly unaffected (with some exceptions belonging mainly to physical capital).

Let us now switch to the analysis of economic growth determinants. According to the institutions-augmented Solow model, economic growth depends on the investment rate in physical and human capital, institutional variable, population growth rate, and initial per capita income level which measures the impact of initial conditions on the subsequent rate of economic growth. Like in the case of determinants of economic development, we consider, along with the institutions-augmented Solow model, the standard Solow model (with physical capital only) and the MRW model.

The results are shown in Table 3 which, in terms of the structure, is analogous to Table 2. In the case of economic growth determinants, the explained variable is the growth rate of GDP per capita at PPP. We include the growth rate for the 1993–2012 period, which in our opinion is a relatively long time interval to show the long-term (or at least medium-term) relationships between the variables involved. A 20-year period is free of short-term cyclical fluctuations, representing reactions of the economies to internal and external shocks arising from both the demand-side and supply-side perspectives. Such shocks are short-term in their nature and institutional variables (as well as the other supply-side factors) do not have sufficient explanatory power to analyze GDP growth rates (or rather GDP fluctuations) caused by such shocks. That is why the considered time span should be sufficiently long to obtain reliable results.

According to the theoretical analysis, the relationship between the rate of economic growth and the initial GDP per capita level should be negative. Such a phenomenon confirms the existence of convergence. The appearance of the catching-up effect leads to diminishing income differences between countries. As regards the other economic growth determinants, the impact of physical capital and human capital accumulation as well as that of institutions on the rate of economic growth is positive while the relationship between population growth and output dynamics should be rather negative.

Our results suggest that the explanatory power of the institutions-augmented Solow model in explaining differences in the rates of economic growth is not as high as in the case of differences in economic development. As to effect, most of the explanatory variables representing institutions turn out to be statistically insignificant. Therefore, Table 3 lists only one variant of the institutions-augmented Solow model, namely variant B, which includes the Fraser Institute index of economic freedom as the institutional indicator. The latter index is the only institutional variable (out of five variables considered here) that is statistically significant in empirical estimation.

TABLE 3. **Estimation results: the determinants of economic growth**

		Standard Solow model	MRW model	Institutions-augmented Solow model
				B
ln$y$(0)	*coef.*	−0.11	−0.17	−0.19
	t-statistics	−4.72	−5.04	−5.43
	p-value	0.000	0.000	0.000
lns_K	*coef.*	0.38	0.34	0.33
	t-statistics	4.93	4.46	3.96
	p-value	0.000	0.000	0.000
lns_H	*coef.*		0.20	0.15
	t-statistics		2.34	1.90
	p-value		0.021	0.059
ln$I$	*coef.*			0.70
	t-statistics			2.77
	p-value			0.006
ln(n + 005)	*coef.*	−0.60	−0.39	−0.46
	t-statistics	−3.95	−2.15	−2.82
	p-value	0.000	0.033	0.005
constant	*coef.*	−0.65	0.22	−1.05
	t-statistics	−1.61	0.41	−1.75
	p-value	0.109	0.684	0.083
R^2 adj.		17.72%	20.02%	28.60%
R^2		19.11%	21.85%	31.16%
N		179	176	140
F statistics		13.78	11.95	12.13
	α	0.77	0.48	0.49
	β		0.28	0.22
	ζ			1.05
λ (convergence parameter)		0.6%	1.0%	1.1%

OLS estimates. Dependent variable: the growth rate of GDP per capita at PPP (1993-2012 avg.). ln$y$(0): the 1993 GDP per capita level. The other explanatory variables (1993-2012 avg.): s_K – investment rate, s_H – secondary school enrollment ratio, I – institutional variable (model B: the Fraser Institute index of economic freedom), n – population growth rate. N indicates the number of countries. α, β and ζ are the exponents in the production function standing for physical capital, human capital and institutional variable respectively. λ is the convergence parameter that measures the speed of convergence.

Source: Own calculations.

When analyzing the models listed in Table 3, it turns out that all the explanatory variables are statistically significant and have a 'correct' sign of the estimated regression parameter (a positive sign for investment rate, human capital accumulation and institutions, while a negative one for initial income level and population growth). It means that all the explanatory variables considered here have an impact on the rate of economic growth of the countries under study. However, R-squared coefficients are lower than in the case of the models in which economic development was a dependent variable. Now, R-squared coefficients range from about 20% (for the standard and human capital-augmented Solow model) to 30% (for the institutions-augmented Solow model). Such low values of R^2 mean that the variables involved do not explain much of the variance of economic growth rates between the countries.

Hence, our analysis shows that the Solow model extended for institutional variables is better in explaining worldwide differences in economic development than differences in economic growth rates. This results from the fact that the institutional environment as well as the other two variables representing inputs (investment rate and human capital accumulation) are related to the supply side of the economy and influence potential output to a large extent. Indeed, the theoretical analysis of the Solow model associates output with potential output. Meanwhile, economic growth rates of the countries in the world, in our opinion, are influenced by many demand-side factors as well as the other forces implying that they do not well reflect fluctuations in potential output. Hence, our institutions-augmented Solow model better explains differences in economic development than in the rates of economics growth. Another explanation refers to the fact that institutional variables exhibit rather long run effects. The current level of economic development is the result of a long run behavior of a given economy and that is why institutional variables may explain it well. Conversely, economic growth, even averaged over a number of years, does not reveal long-run tendencies and that is why institutional variables may provide a weak explanation.

When interpreting the results of the regression estimates, it is necessary to point out that robustness of the analysis is the same as any other econometric methodology of this type. Namely, we are constrained in estimating a low number of models of economic growth using a specified variety of explanatory variables. This approach is contrary to some other alternative methods of estimation which refer to Bayesian model averaging (in those methods the researcher may use as many explanatory variables as possible and includes them randomly in the regression equations; in such a case, the final results are the averages calculated over a huge number of regression estimates). Given this approach, we cannot be sure that the results will be maintained based on a different set of control variables. This remark concerns any regression analysis and not just this particular research. Similarly, when interpreting the results based on the R-squared coefficients, the assessment of the model on the basis of only the R^2 has its weaknesses. That is why in order to assess the validity of the model, it is also necessary to analyze the significance of explanatory variables, which we do in the current study. In any case, any quantitative method applied to the analysis cannot guarantee that a given relationship in the causal sense really holds. Even if Granger causality tests were carried out, there would be no guarantee that a given association would indeed occur. Thus, a reference to the theoretical structural model always has to be made as in the current study.

All the estimated regression equations shown in Table 3 confirm the existence of conditional convergence. The convergence coefficient calculated in this study (the so-called beta coefficient) equals 0.6% for the standard Solow model, 1.0% for the Mankiw-Romer-Weil model and 1.1% for the institutions augmented Solow model. This result is in line with the general view on the process on convergence, namely that in terms of the whole world, the catching-up process is not very fast. Some authors, such as Barro and Sala-i-Martin [2003], point to a 2.5% worldwide rate of convergence. They, however, include more explanatory variables; if we added more control factors to the model, we would likely obtain a similar convergence parameter. Hence, our model does not give any unbelievable results.

When interpreting the results, the theoretical causal relationship between explanatory variables and the level of economic development is assumed to be as follows: past values of explanatory variables affect the current state of development. In reality, many macroeconomic relationships have mutual causality, which is partly caused by the fact that some variables are endogenous by nature. For example, rich countries may also have greater opportunities to save, to invest in human capital, and to have friendly regulations and institutions just because they are rich. An endogenic approach requires, however, more in-depth analysis, with more advanced econometric techniques, which could be a subject for further research.

Last but not least, let us estimate the production function. In order to be robust to different specifications of the model, we calculate the final values of parameters as arithmetic averages for all the estimated variants of the regression equation. According to the analysis of economic development determinants, physical capital share in income ranges between 0.01 and 0.56 (the former value is however spurious), giving an average of 0.15. Human capital share in income is higher ranging between 0.57 and 0.68, which yields a mean value of 0.61. The institutional share amounts to 0.55 on average (but also reveals high variation between the respective models). Hence, the production function derived from model estimations is supposed to be following:

$$\hat{Y} = K^{0.15} H^{0.61} L^{0.24} I^{0.55} \tag{22}$$

The exponent for L is calculated as $1 - \alpha - \beta$ (in line with the assumption of constant returns to K, H, and L).

The production function estimated on the basis of models representing economic growth determinants can be derived in an analogous way. It has the following form:

$$\hat{Y} = K^{0.58} H^{0.25} L^{0.17} I^{1.05} \tag{23}$$

The above formulas seem to yield slightly contradictory results. The first one emphasizes a significant role of human capital in the process of economic development while the latter one gives more importance to physical capital accumulation. This outcome may be explained by the fact that the former formula was obtained based on the determinants of economic development. In explaining differences in economic development, human capital is more important. The level of economic well-being is the result of the long-term process of economic growth which depends to a large extent on human capital accumulation over the past decades. Therefore, the countries which are human capital abundant achieve higher levels of economic development.

On the other hand, in the process of medium-term economic growth physical capital seems to be more important. It is investment in physical capital rather than investment in human capital which leads to an immediate acceleration of economic growth. The effects of human capital accumulation take more time and that is why in the process of economic growth physical capital is a more significant variable. This view is also shared by some models of economic growth (e.g. the Uzawa-Lucas model) which states that the pace of economic growth of a given less-developed country depends on whether this country is physical capital scarce or human capital scarce.

Our results imply that institutions are important in forming GDP regardless of the model. Institutional elasticity of output equals 0.55 or 1.05 on average indicating that institutions are one of the most important factors determining output. Most of the individual models also confirm this view.

Conclusion

Despite some ambiguities, our study gives some valuable recommendations for politicians and policy makers. The government should focus on improving institutional environment, investing in education, and stimulating investments. The empirical analysis clearly confirms that these factors are necessary for rapid economic development. Politicians should act so as to improve all the areas of institutional environment, especially the quality of governance, economic freedom, democracy, and structural reforms. All these variables explain an enormous part of worldwide differences in income levels and are necessary for rapid economic development. The components of our institutional indicators specify the exact areas that should be improved and strengthened by the government. The priorities are high economic freedom and good governance. The most important reforms concern the following areas: to raise business, trade, investment, and financial freedom; to carry out high-quality fiscal and monetary policy; to enforce property rights; to raise labor market elasticity; and to control corruption. The application of structural reforms such as privatization or price liberalization should be carried out in transition countries. Without positive changes in institutional environment, it is very difficult for societies to achieve strong and sustainable well-being. To enrich the country, policy makers should focus on institutional reforms that affect GDP via supply-side and demand-side determinants. According to the theoretical structural model and our empirical study, all these changes lead to better macroeconomic performance in the sense of more rapid economic growth and a higher level of economic development. This should be the primary goal for governments.

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