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CONDITIONAL CONVERGENCE AND FUTURE TFP GROWTH IN ISRAEL[1]

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Abstract

This study formulates and estimates a model for long-term forecasting of the total factor productivity (TFP) component of Israel's GDP and for assessing the impact of policy variables on it. To do this, we first estimate GDP per worker in a cross-sectional regression of 66 countries, including Israel, where the explanatory variables are fundamental factors such as geography and culture, as well as policy-influenced variables such as human capital quality, infrastructure levels, and institutional quality. We then calculate for each country the gap between the predicted GDP per worker, based on the values of the explanatory variables in 2010 and the regression coefficients, and the actual GDP per worker. This gap reflects the potential for Israel's GDP per worker to grow faster than the average global growth rate, particularly through faster TFP growth. In the second stage, we estimate TFP growth equations where the TFP growth rate depends on the initial labor productivity gap. The use of fundamental variables and policy variables together in a conditional convergence framework is a novel contribution to the economic growth literature. We find that Israel's average gap between predicted and actual GDP per worker is positive but small. From this, we conclude that Israel's TFP has very limited potential to grow faster than the global average without changes in policy variables. The baseline TFP growth forecast for 2020–60 is 0.55%, slightly lower than Israel's historical TFP growth rate in 2000–19.

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1. INTRODUCTION

This research uses a framework of conditional convergence between countries to formulate and estimate a model for long-term forecasting of Israel's total factor productivity (TFP), and to examine how policy changes may affect it. There are large differences in living standards and productivity across countries. Models based on the accumulation of production factors predict that poor countries will eventually converge to the living standards that characterize rich areas (Solow, 1956). However, this phenomenon has barely been observed in international data, leading the literature to focus on "conditional convergence" rather than "global convergence". Barro (1991) found, in cross-sectional regressions, that the growth rate of real GDP per capita is negatively correlated with the initial level of real GDP per capita only after controlling for each country's human capital. Barro and Sala-i Martin (1992) emphasized that it is more informative to look at the distribution of wealth conditional on various characteristics of each economy, such as government spending and political stability. They found that the importance of including these characteristics increases the more heterogeneous the sample of economic units is: The inclusion of background characteristics was not important at all in a sample of US states, it increased the degree of estimated convergence in a sample of OECD countries, and it was essential for finding convergence in a sample of 96 countries around the world.

The current work uses variables of the fundamental roots of economic growth and variables dependent on economic policy in order to explain the differences in GDP per worker (also referred to as productivity or productivity per worker) between countries and the growth of total factor productivity (TFP). We first estimate the determinants of productivity in a regression with variables of geography, genetic diversity, culture and other common fundamental variables, together with variables that are affected by economic policy such as the quality of human capital, the level of infrastructure and the quality of institutions. We then calculate for each country the gap between the predicted GDP per worker, based on the values of the explanatory variables in 2010 and the regression coefficients, and the actual GDP per worker. This gap reflects the potential for Israel's GDP per worker to grow faster than its average growth rate in the world, particularly through faster growth in total factor productivity. In the second stage, we estimate convergence equations in which the growth rate of total factor productivity depends on the GDP per worker gap at the beginning of the period. Our analysis demonstrates that TFP growth is the main driver of labor productivity convergence, rather than physical or human capital accumulation.

The weakness of cross-sectional convergence regressions is that the estimate of the convergence rate may be biased in the case of omitted variables that are correlated with the initial level of GDP per capita. Islam (1995) used a panel regression framework with country fixed effects as a means of controlling for the unobserved basic characteristics of each country. In this way, he found a much stronger degree of convergence and concluded that indeed, omitted variables were positively correlated with the initial level of GDP per capita.

In a later study, Islam (2003) argued that the omitted variable bias problem led the convergence literature to deviate from the cross-sectional framework. However, while the panel regression framework can more accurately identify the speed of convergence, the country fixed effect predetermines the steady-state level of the economy, unlike the cross-sectional formulation which defines the steady-state level of each country based on the typical GDP per capita of countries with similar characteristics. Battisti, di Vaio, and Zeira (2018) use labor-augmented TFP[2] in a framework that avoids the use of endogenous explanatory variables. They argue that β-convergence should be interpreted as the convergence of each country's GDP per worker to its own potential productivity, but not across countries.

In recent years, the growth literature has abandoned the use of standard characteristics in convergence regressions (Durlauf, 2009), and has focused on the fundamental factors of growth, such as geography, culture, institutions, and policies. Our work exploits this growing literature to improve cross-sectional convergence regressions, in order to properly predict the typical potential path of each country, with a reduced risk of omitted variable bias. The use of deep roots of growth has an advantage in this sense, as some of the variables used in classic convergence regressions (for example, human capital) may be the result of the growth process rather than its cause.

Our analysis has two goals: First, our study balances estimating the "clean" causal effect of policy variables on the level of productivity with achieving estimates that have external validity. Estimating the effect of policy variables on productivity levels using cross-sectional regressions, after controlling for fundamental factors, brings us closer to the causal effect of policy measures on long-term living standards. In this way, we measure the long-term productivity of each country—as in Battisti, di Vaio, and Zeira (2022)—but based on a broad set of explanatory variables. We verify the efficiency of our methodology by running panel regressions that include policy variables for which historical data is available. In the trade-off between achieving a "clean" causal effect and achieving estimates with external validity, our estimates will have higher external validity compared to research that exploits a specific exogenous event to find a causal relationship between policy and growth, and higher internal validity compared to cross-sectional regressions with policy variables alone. However, due to limitations of internal validity, we treat the estimated effects reported here with caution: While the basic differences between economies were well controlled for using the fundamental variables (deep roots of growth) and the panel formulations, the threat of reverse causality in the policy-dependent variables cannot be ignored. We cannot rule out, for example, the possibility that growth processes lead to better policy.

[2] Labor-augmented TFP is a formulation of total factor productivity in which it is multiplied directly by labor input and not by all inputs. For example, in the formulation $Y=K^{\alpha}(A*L)^{(1-\alpha)}$, A is the labor-augmented total factor productivity.

The second goal is to examine fundamental variables of deep roots of economic growth and policy variables within a single conditional convergence framework, as it allows us to predict the future development of countries given a country's basic and current set of policies. This framework will also allow us to pose questions about changes in a given country's growth potential following policy changes.

This study is part of a broad project of constructing a long-term growth model for forecasting Israel's GDP growth over a horizon of approximately 50 years, given various assumptions. Among other things, it is constructed to assess how different exogenous developments or policy measures are expected to affect the long-term growth rate (Argov and Tsur, 2019). Previous projects in Israel were carried out by Geva (2013) and Braude (2013), and global projects focusing on TFP forecasting were more recently carried out by Cette, Lecat, and Ly-Marin (2016) and Guillemette et al. (2017). The aforementioned growth model is built from several connected building blocks, each oriented to describe a specific component in the aggregate production function (human capital, the development of physical capital, etc.). The current study describes in detail the building block of the total factor productivity model.

In 2017, productivity in Israel was 13% lower than the average productivity among OECD countries. Since the OECD group of countries is very heterogeneous, Hazan and Tsur (2020) focused their comparison on six small and wealthy countries. Using a development accounting framework, they showed that productivity in Israel is 30% lower compared to these countries due to a lower level of physical capital and a lower quality of human capital. In the current study, we forecast that productivity in Israel will get closer to the average of OECD countries and the six comparison countries, due to faster TFP growth in Israel compared to this group of countries (whose TFP is expected to grow less than the global average). Faster and more complete reduction of the gap can occur if policy in Israel improves faster than policy among the comparison countries.

The rest of this paper is organized as follows: Section 2 discusses the deep determinants of income differences between nations. Section 3 describes the data used in this paper. Section 4 demonstrates the difference between global and conditional convergence based on the data and variables we use in the paper. Section 5 sets the empirical model for GDP per worker and TFP growth and shows the results. Section 6 illustrates future convergence patterns based on our results and focuses on the forecast for Israel, and Section 7 concludes.

2. LITERATURE REVIEW ON FUNDAMENTAL VARIABLES DETERMINING INCOME DIFFERENCES

In the introduction (Section 1), we described the evolution of the literature from predicting global convergence following Solow (1956) to predicting "club" or conditional convergence (Barro and Sala-i Martin, 1992). This evolution was accompanied by literature that criticized growth theory for focusing solely on proximate causes rather than fundamental causes of economic growth. As North and Thomas (1973) put it, "The factors we have listed (innovation, economies of scale, education, capital accumulation, etc.) are not causes of growth; they are growth".

Acemoglu (2008) defines four groups of fundamental causes: geography, institutions, luck and multiple equilibria, and culture. Let us briefly survey a small sample of key papers regarding these fields.

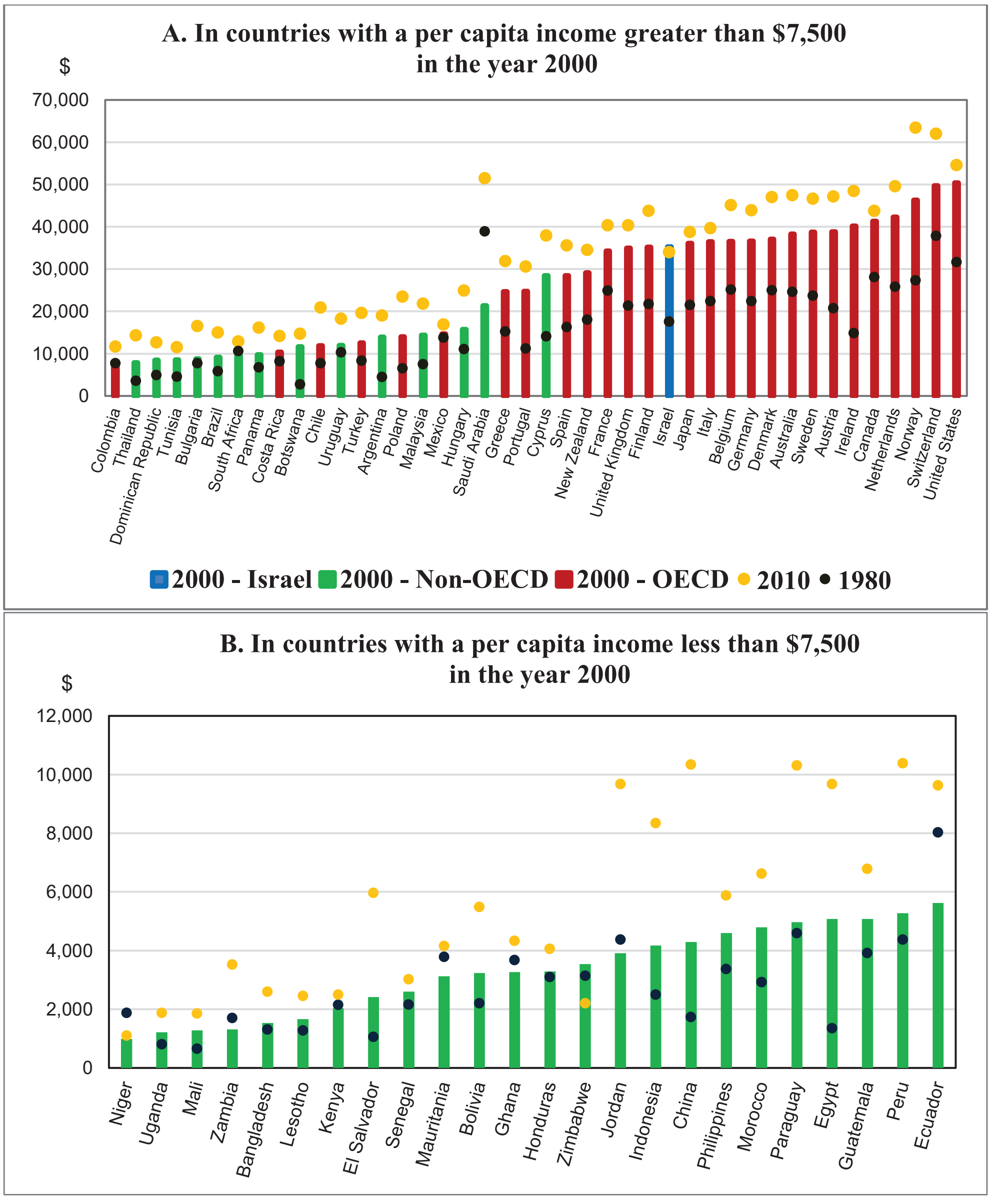
The professional and popular book by Diamond (1997), "Guns, Germs, and Steel", argues that differences in soil quality and fertility between Eurasia and other areas around the globe affected the ability of nations to build complex organizations and hierarchies that positively influenced economic prosperity. Acemoglu, Johnson, and Robinson (2005) claimed that institutions, as broadly designed by European colonialism, have shaped economic differences between countries. Furthermore, they showed that there has been a reversal of fortune in income levels among former colonies. Jones and Olken (2005) found that leaders affect the economic growth of countries, and conclude that luck played a major role in cross country income differences. However, Acemoglu (2008) claims that the selection and the policy of leaders are part of the institutional explanations. Ashraf and Galor (2013) found that there is an optimum of genetic diversity within a country. They use the genetic diversity predicted by the prehistoric exodus of Homo sapiens out of Africa, and claim that there is a "tradeoff between the beneficial and the detrimental effects of diversity on productivity". Becker and Woessmann (2009) claim that Protestant economies prospered because the tradition of reading the Bible increased human capital. They found that Protestantism indeed led to higher economic prosperity and better education. A related study relevant for the Israeli context (Botticini and Eckstein, 2007) suggests that Judaism enforced a religious norm of studying that has influenced Jewish economic and demographic history. Our study uses variables from the groups of causes we briefly reviewed above, as deep explanatories of the level of productivity.

3. THE DATA

The model will be based on an econometric analysis relying on a sample of 66 developing and advanced economies, including Israel, for which data was found as detailed below. Figure 1 presents the GDP per capita of these economies (in 1980, 2000, and 2010) with a distinction between the 42 countries where GDP per capita in 2000 (in 2017 US dollars) was above $7,500 ("rich countries") and the countries where it was below ("poor countries"). This distinction is presented because the coefficients we adopt for the forecast are calculated both based on estimates on a partial group that includes only rich countries and based on regressions on all countries in the sample. Although it is clear that Israel is in the group of rich countries, as seen in Figure 2, where its position in the ranking of GDP per worker was around the 20th place both in 1980 and in 2010[3], relying only on the rich countries for the cross-sectional regressions (first stage regressions) leaves us with a small number of observations, which impairs the degrees of freedom. The regression on all countries yields coefficients that do not suffer from this problem. In weighing the trade-offs between using only a more homogeneous sample that is more suitable for Israel, versus combining it with the use of a larger sample to utilize a larger number of observations, we preferred to rely also on the sample of all countries because the variation in the broader sample provides valuable information. Since we are dealing with long-term development processes, the wealth of countries changes significantly and not always uniformly across variables and population groups. Although the effects are not linear, we believe that the information on the contribution of policy in a particular area to growth is valuable, especially while controlling for other variables. It is also worth noting that even among the poorer countries, there are countries like China and Ecuador that are not "third world countries" and have experienced rapid growth in recent decades, partly thanks to successful policies.

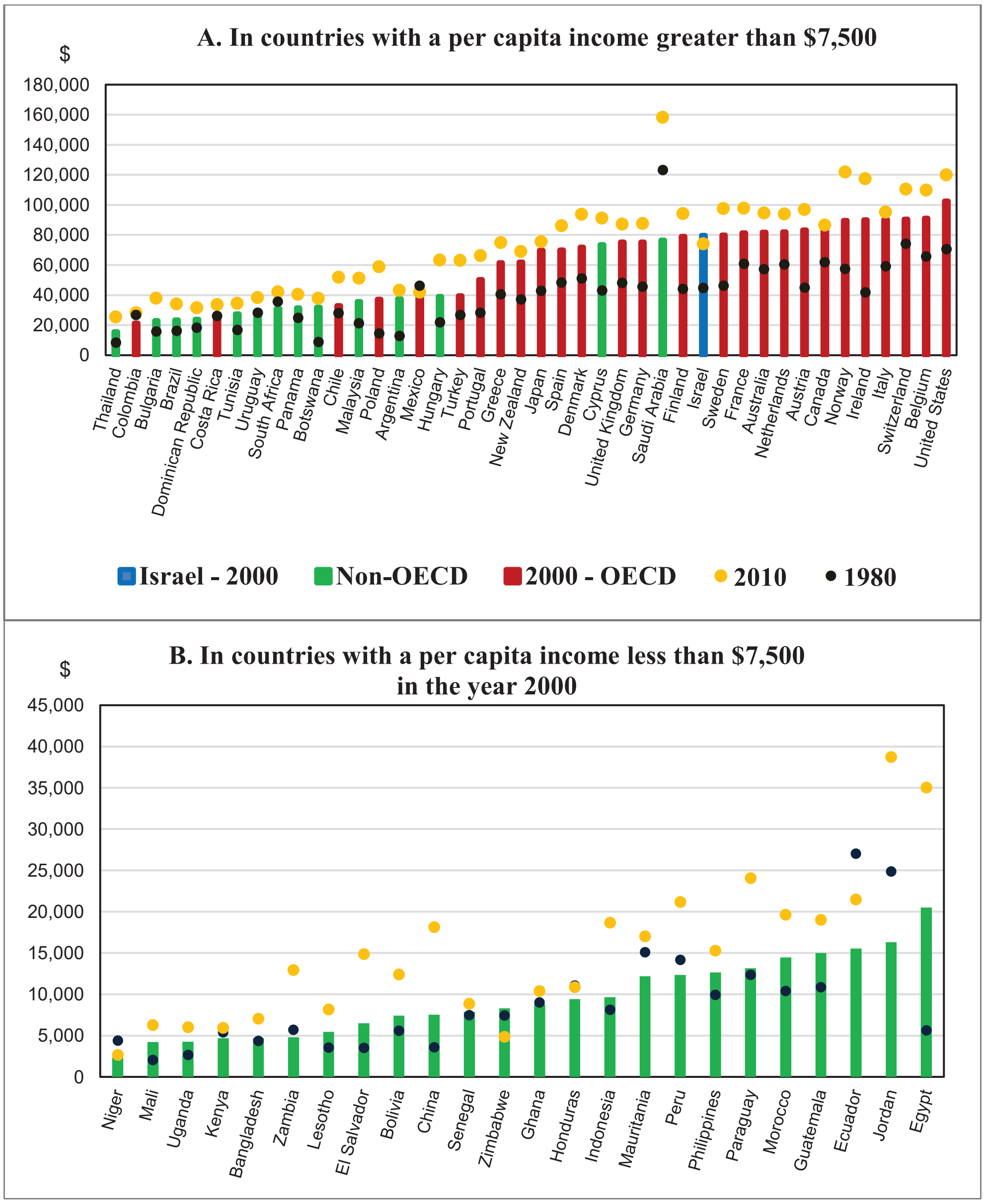
[3] The figures also show the year 2000, a peak year in the output of start-up companies in which Israel recorded an exceptionally high output; therefore, caution should be exercised with this data and the changes relative to it.

Figure 1
Income per capita in 1980, 2000, and 2010



Gross Domestic Product (GDP) per capita in current prices and PPP, translated to 2017 US prices.
Source: Penn World Tables 10.

Figure 2
GDP per worker in 1980, 2000, and 2010



1. Gross Domestic Product (GDP) per capita in current prices and PPP, translated to 2017 US prices.

Source: Penn World Tables 10.

The initial level for the forecast of the productivity gap for each country, as well as the variables that determine the marginal effect of various variables on productivity, are derived from a cross-sectional regression of the (log) level of actual GDP per worker in 2010 on a set of fundamental variables as well as policy influenced variables.

Country level macro data, such as GDP per worker and total factor productivity are taken from Penn World Tables 10. The fundamental variables are taken from a variety of studies that explored the deep roots of growth, as organized in Ashraf and Galor (2013): (1) Neolithic transition is the number of years (in thousands) that have passed since agriculture became the primary mode of subsistence in the country; (2) Arable land is the share of total land area that is Arable, as reported by the World Bank's World Development Indicators; (3) Population in Tropical zones is the percentage of the country's population in 1996 that lives in tropical areas; (4) Distance to waterways is the average across a country's grid cells, in thousands of kilometers, from an ice-free coast or navigable river; (5) Natural resource rents as a percentage of GDP (in the regression year). Includes rents from oil, natural gas, coal, minerals and forests. This data is taken from the World Bank Indicators; (6) Genetic diversity is the heterozygosity (genetic diversity) between ethnic groups in the country, as calculated and presented by Ramachandran et al. (2005) based on the Human Genome Diversity Cell Line Panel database. To ensure exogeneity, it is calculated as the predicted value from a regression of the genetic diversity for each region on the migration distance of humans from East Africa to that region (Ashraf and Galor, 2013); (7) Ethnic fractionalization is calculated as the probability that two randomly selected individuals from the same country will belong to different ethnic groups as calculated and presented by Alesina et al. (2003); (8) Religion controls that represent the share of Muslims, the share of Catholics and the share of Protestants in the country's population.

As for the policy variables: (1) Doing Business is the country's "Distance from the Frontier" (in reverse order) in the World Bank index that measures the ease of doing business in several areas; (2) Economic Freedom is an index that covers 12 areas, such as property rights and financial freedom, in 186 countries since 1970; (3) Road quality—based on the first principal component[4] of several indices on road quality, taken from the International Road Federation data; (4) Data on communication infrastructure—number of main telephone lines and mobile phones per thousand workers, as published by the World Bank, data based on the International Telecommunications Union; (5) Data on education quality: Test scores for the years 1995-2010, standardized over time, across subjects (mathematics, reading and science), schooling levels and various international and regional assessments. This data was obtained from the World Bank, based on research conducted by Angrist, Patrinos, and Schlotter (2013); (6) Inequality in education is represented by Gini coefficients for education obtained from Ziesemer (2016) for 146 countries for the years 1960-2010, based on data from

[4] The first principal component is a common statistical method by which one series, that describes most of the variance in a group of series, is extracted.

Barro and Lee (2013). These Gini coefficients were calculated based on the methodology first developed by Thomas, Wang and Fan (2001) as well as Costello and Domenech (2002).

Figures 3–5 present the order of the rich countries (with GDP per capita greater than $7,500) on the policy variables described above. Israel's transportation infrastructure is in the middle of the distribution of OECD countries, whereas its communication infrastructure is at the top of the distribution. Regarding the quality of institutions, Israel is in the middle of the distribution of rich countries, but it is at the bottom of the distribution of OECD countries. Israel is at the bottom of the distribution of the scores in international tests of the education system, and among OECD countries, its scores are better only than Mexico and Turkey. Israel is in a better place when looking at the inequality of years of schooling, but indicators for inequality in the quality of education, which are not presented and not analyzed in this study, show that educational opportunities in Israel are low.

Figure 3
Quality of infrastructure in countries with GDP per capita greater than $7,500

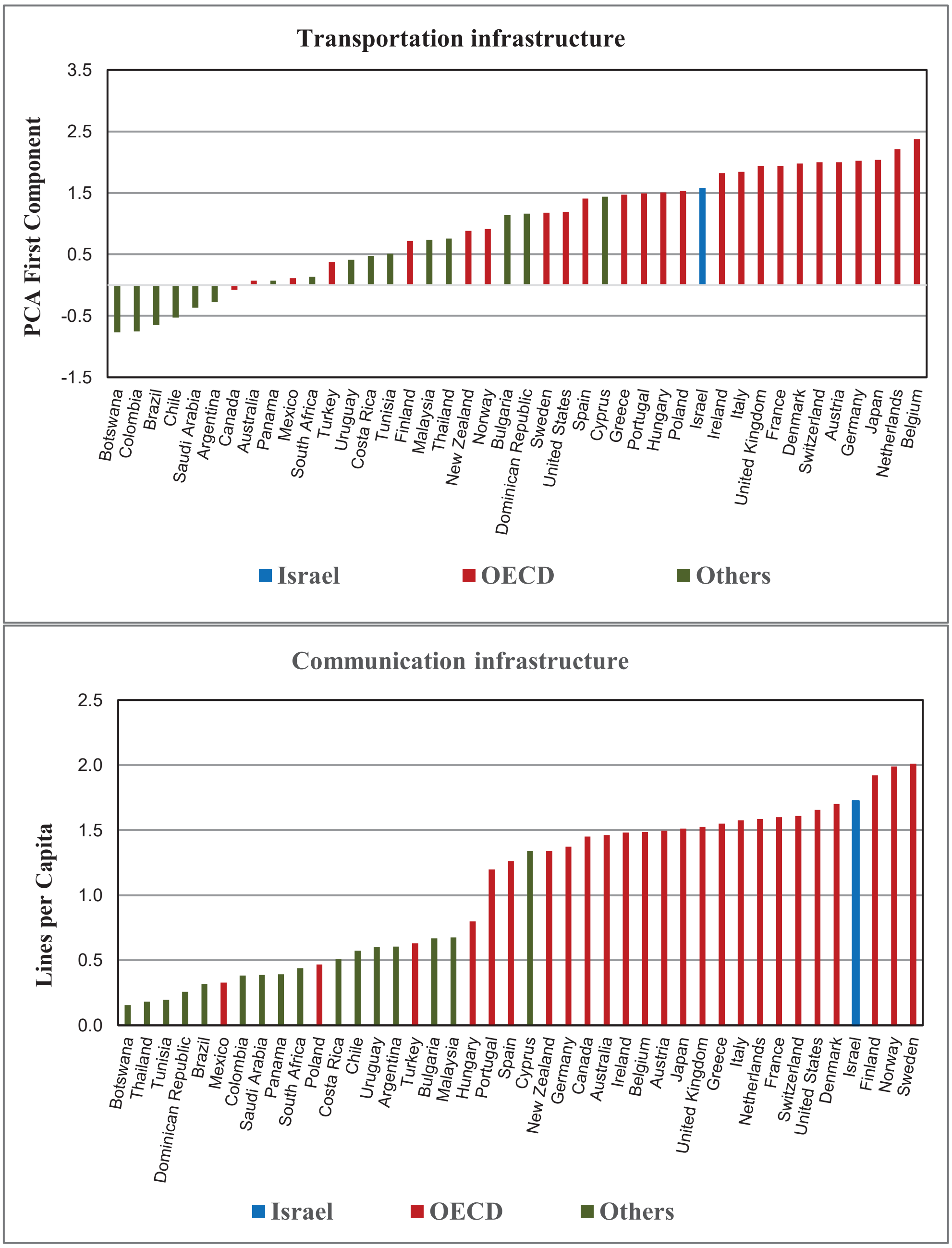


Figure 4
Quality of institutions in countries with GDP greater than $7,500

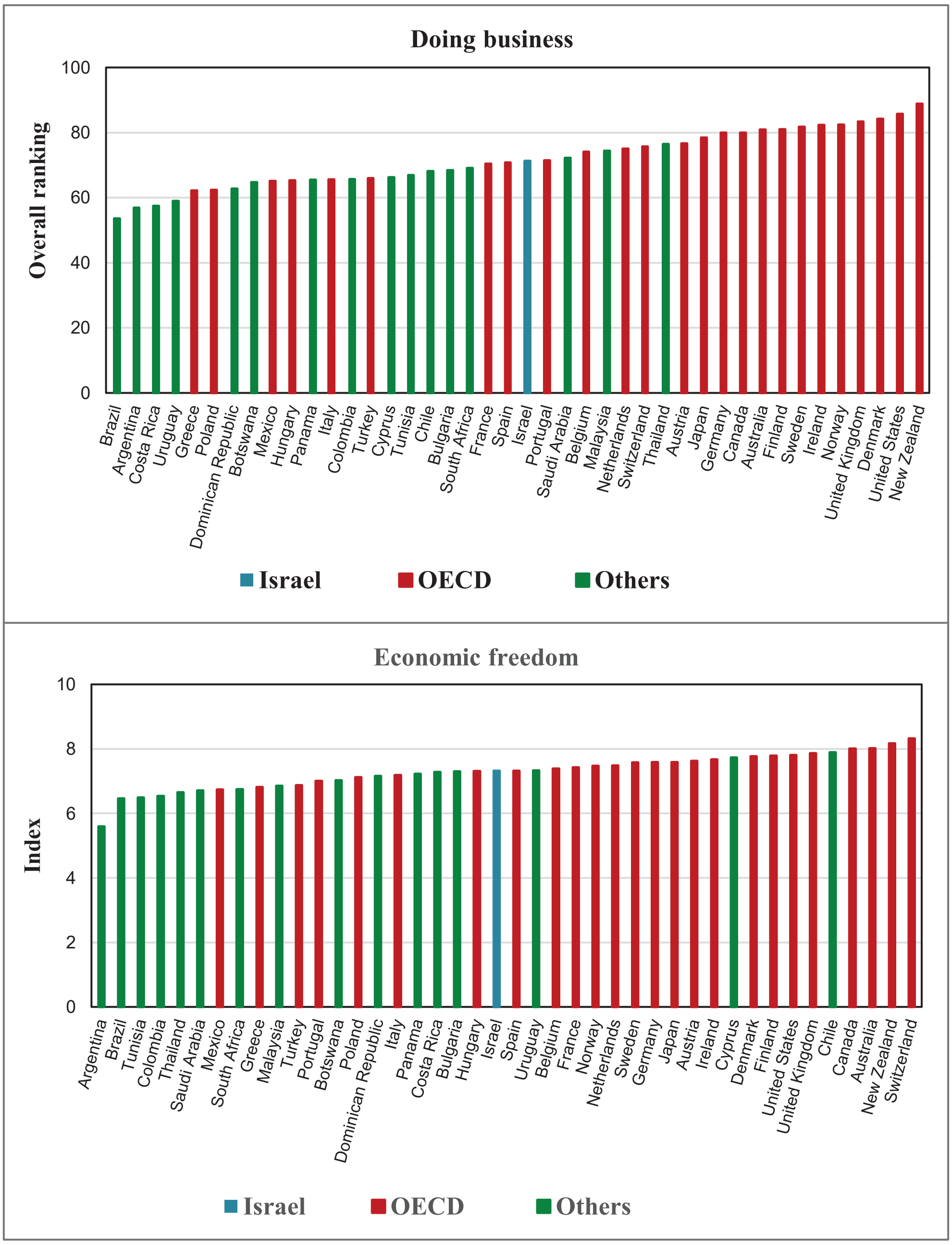
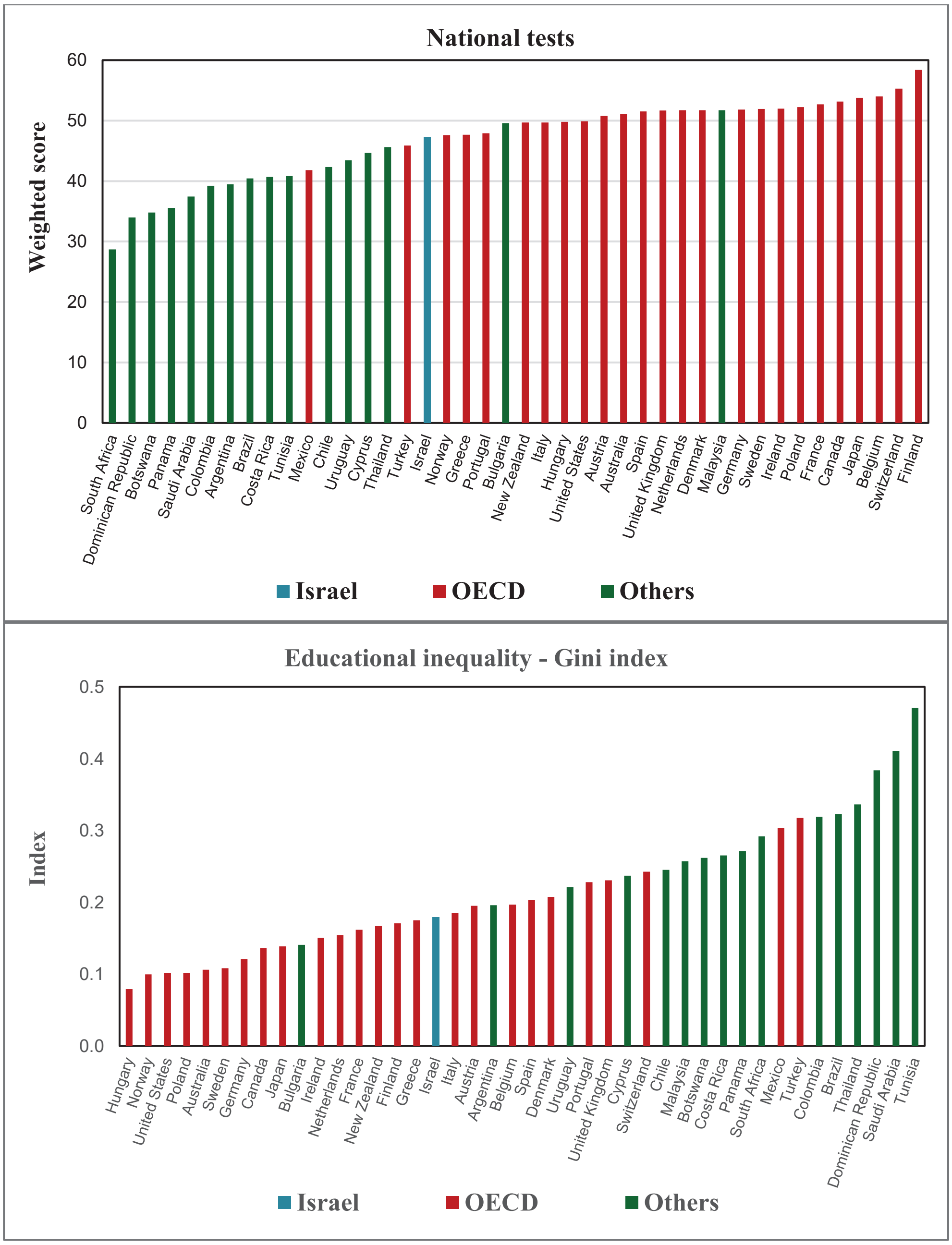


Figure 5
Quality of education in countries with GDP per capita greater than $7,500



4. PAST CONVERGENCE PATTERNS

We begin the empirical analysis with basic convergence regressions, in cross-section, using the fundamental variables of the deep roots of growth that our study uses (as described in Section 3). These variables are organized in Ashraf and Galor (2013) as part of a larger set of control variables, and we reduced the list by omitting variables with negative adjusted-R^2 in a partial regression analysis. The variables that survived this analysis will also be used in the rest of the regressions.

Table 1 presents the results of regressions that are represented by the equation:

$$(1) \qquad \Delta prod_{i(1980-2010)} = a. + \beta prod_{i1980} + \gamma Fundamentals_i$$

Where:

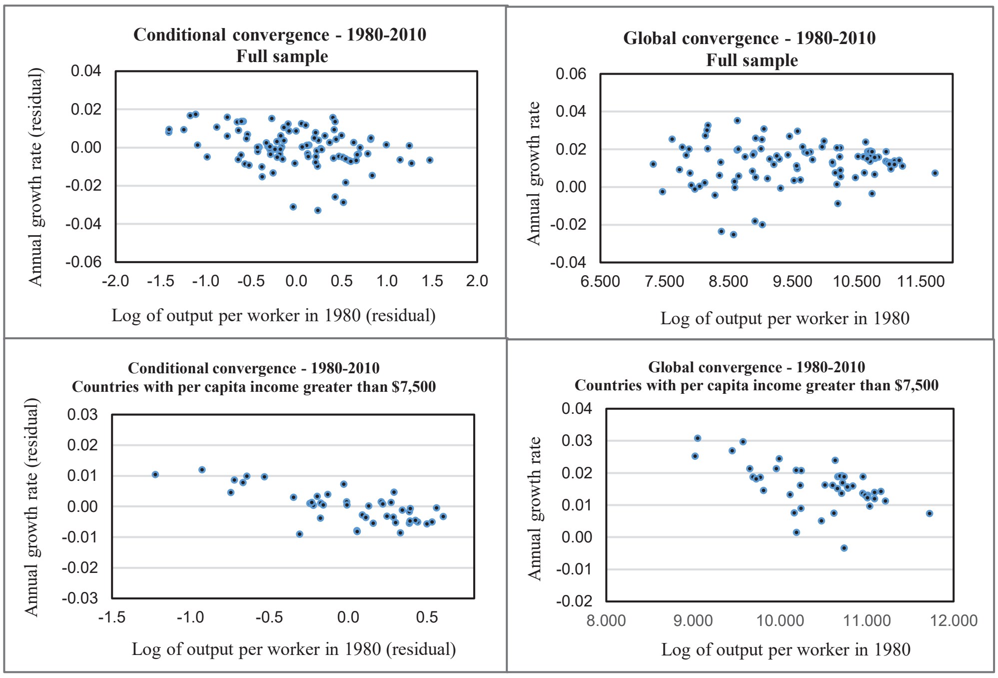
$prod_{i1980}$ - is GDP per worker in country i in 1980, and $\Delta prod_{i(1980\text{-}2010)}$ is the average annual growth rate in the period 1980-2010.

$Fundamentals_i$ - is the set of country-level fundamental variables.

β - is the convergence coefficient.

Only this analysis includes 96 countries, of which 45 are rich, since it is not limited by the availability of policy variables. The results show that "global convergence" - the value of β without conditioning on $Fundamentals_i$ - is not significant among the full sample of countries. However, controlling for the variables in the group $Fundamentals_i$ yields a significant negative estimate for "β-convergence": a country's growth rate is lower the higher its initial productivity was in 1980. These findings can also be seen graphically in Figure 6: without controlling for fundamentals, no relationship between the growth rate and the initial income level can be shown, whereas after controlling, we see a clear negative slope.

Figure 6



As for the sample of rich countries (with annual GDP per capita greater than $7,500), "$\beta$-convergence" can also be found without controlling for fundamentals, but here too the β coefficient is larger (in absolute value) after adding the control. These findings are consistent with those of Barro et al. (1991), but as explained above, the use of fundamental variables of growth in our regression is more useful, since some of the variables used in the classic convergence regressions may be the result of the growth process and not those that cause it.

5. EMPIRICAL MODEL FOR TFP GROWTH

a. Description of the Empirical Model

The empirical model presented here is built to estimate the marginal effect of various fundamental and policy variables on output per worker, and the distance of each country from its own unobserved frontier. The estimation of these will be performed in the first stage regression. The estimation of the global growth rate of total factor productivity, and the speed of convergence to the frontier, will be performed within the framework of the second stage growth regression.

First stage regression. For each of the years t = 1965, 1970, ..., 2010, we estimate level regressions of GDP per worker on a large set of fundamental variables and policy variables:

$$(2) \quad prod_{i,t} = \alpha + \beta_{t,1}\ \overline{Fundamentals_i} + \beta_{t,2}\,\overline{Policy_{it}} + \epsilon_{i,t}$$

Where:

$prod_{i,t}$ - is GDP per worker in country i in year t;

$\overline{Fundamentals_i}$ - is a group of country-level fundamental variables such as geography, culture, genetic diversity and other determinants (as described in Section 3);

$\overline{Policy_{it}}$ - is a group of policy influenced variables such as institutions (as detailed in Section 3) in country i in year t;

$\epsilon_{i,t}$ - is the random error.

Using the estimated coefficients from equation (2), allows us to fit for each country i a predicted value for GDP per worker in year t, as a function of its fundamental variables and its policy variables:

$$(3) \quad \widehat{prod}_{i,t} = \alpha + \widehat{\beta_{t,1}} \times \overline{Fundamentals_i} + \widehat{\beta_{t,2}} \times \overline{Policy_{i,t}}$$

The difference between the predicted GDP per worker in a particular country, and the actual one, represents the gap in labor productivity from its frontier path, given the fundamental conditions and policy variables in the country:

$$(4) \quad Gap_{it} = -\widehat{\epsilon}_{it} \times = \widehat{prod}_{it} - prod_{it}$$

Second stage regression. In order to estimate the speed of convergence to the frontier path, and the basic global growth rate of TFP, we will formulate an equation for the TFP growth of country i in period t, as a function of the productivity gap in period t-1:[5]

$$(5) \quad \Delta TFP_{i,t} = \delta_{g,t} + \rho Gap_{i,t-1} + \lambda_{i,t}$$

Where:

$\delta_{g,t}$ - is the basic global growth rate that can get a differential value according to the specific period t, by using dummy variables for each period.

[5] It should be clarified that the model works in 5-year period jumps. Therefore, the dependent variable is the rate of change in total factor productivity over 5 years, and the main explanatory variable is the labor productivity gap at the beginning of those 5 years.

The labor productivity gap, Gap in equation (5), is calculated from a formula parallel to equation (4), except that the variables that determine $\widehat{prod}_{it}$, besides the fundamental variables, are only policy variables with enough historical data: Economic Freedom Index, road quality and inequality in education and schooling.[6] The estimator of ρ represents the speed of convergence. By this we assume that the convergence in labor productivity is achieved through total factor productivity. We will present the empirical basis for this assumption in the next section.

$\lambda_{i,t}$ - in equation (5) is the error term which represents a random shock for the TFP growth of country *i* in period *t*.

After an econometric estimation of equation (2), calculation of Gap_{it} according to equations (3) and (4), and estimation of equation (5) - we can make a forecast for the TFP growth ΔTFP of country *i* in period *t*+1:

$$(6) \qquad \Delta TFP_{i,t+1} = \delta_{g,\tilde{t}} + \rho \times Gap_{i,t}$$

Where:

$\delta_{g,\tilde{t}}$ is an average of dummy variables for selected periods.

From the forecast for TFP growth, the productivity gap, Gap, can be updated for period *t*+1 (assuming no change in policy variables):

$$(7) \qquad Gap_{i,t+1} = Gap_{i,t} - \left(\frac{1}{1-\alpha}\right)\left(\Delta TFP_{i,t+1} - \delta_{g,\tilde{t}}\right)$$

According to equation (7), the labor productivity gap decreases as total factor productivity grows faster than the basic global growth rate. α is the output elasticity with respect to the capital stock in a standard CES production function which we calibrated to 0.45 according to Israel's capital share in output. The multiplication by $\left(\frac{1}{1-\alpha}\right)$ reflects the long-term relationship between labor productivity growth and total factor productivity growth when there is an endogenous adjustment of the capital stock.

Iterations on equations (6) and (7) allow calculating a forecast for TFP growth up to the desired horizon.

b. Regression Results

Table 2 presents the results of regressions that include only the fundamental variables we control for. The first four columns report specifications in which three groups of variables

[6] A full panel of policy variables is not available.

are gradually introduced: Geography variables, Genetic Diversity variables and Culture variables. The time that has passed since the Neolithic transition is positively correlated with GDP per worker (*prod*), and after controlling for it, two additional variables that are related to agricultural intensity, the share of arable land and proximity to waterways, are negatively correlated with GDP per worker. Similar results were obtained by Ashraf and Galor (2013) as well. This result may be consistent with the "reversal of fortune" theory of Acemoglu, Johnson and Robinson (2002) according to which some of the countries that were considered rich until 1500 due to thriving agriculture are considered relatively poor ("developing") today, while some of the rich countries today were poor until then. The share of revenues from natural resources is not correlated with productivity. The genetic diversity variables, as explored by Ashraf and Galor (2013), affect GDP per worker positively for low enough values, and negatively for high values. Most variables remain significant and with the same sign in the specification that includes the full set of fundamental variables, except for ethnic fractionalization which loses significance. The last line in the table shows the Israel's regression residual. From this line it can be learned that genetic diversity alone (column 2) or ethnic diversity alone (column 4) do not successfully explain the actual value of productivity in Israel, and therefore the gap is large. In contrast, the geographical variables successfully explain, even alone (column 1), Israel's relative productivity situation.

In Section 3 we described six policy-dependent variables. Together with eleven fundamental variables (which are grouped into eight categories, of which three variables belong to the category of religious distribution in the country and two to the category of genetic diversity) we have a total of seventeen control variables. Including all of them in one regression yields a number of insignificant variables. Table 3 presents the results of the estimation for a specification that includes policy variables without controlling for fundamental variables, and results for specifications that include each policy variable separately when controlling for fundamental variables. In most cases, the coefficients of the policy variables were found to be significant with the expected sign. Since the degrees of freedom are very limited in our cross-section of countries, it is not possible to include all the variables together. Alternatively, there is a huge number of combinations of variables, and the choice between them may be arbitrary and simplistic. Therefore, we decided to focus on specifications with the complete set of fundamental variables, one institutional variable, one physical infrastructure variable and one educational variable. This strategy is somewhat similar to the one adopted by Sala-i Martin (1997), who ran about 2 million regressions in order to examine which variables are most correlated with economic prosperity. Sala-i Martin (1997) decided to include three fixed variables and three variables that changed from one specification to another.

The eight columns in Table 4 are the results of the eight combinations that our rule created. Tables 5-7 repeat the above analysis, which is presented in Tables 2-4, for a smaller sample of 42 countries with GDP per capita greater than $7,500 (in 2000).

The significance of the fundamental variables varies between specifications, but in most cases they remain with the same sign and with reasonable explanatory power. Regarding the policy variables, it seems that the coefficients of the doing business variable as well as the communication and transportation infrastructure variables are the most stable. The coefficient of the economic freedom variable is significant in most of the full sample specifications, but it is not significant among the rich countries alone. It seems that the coefficients of the two education variables are highly correlated with productivity only in the full sample. The positive and significant estimates based on the full sample are more consistent with recent studies, such as Hanushek and Woessmann (2012), who found a close relationship between educational achievement and output growth. The relationship they identified is stable across different samples of countries and is based on specifications that address causality. They conclude that quality education can be an important tool for enhancing economic growth.

In order to check the robustness of the estimates to biases arising from basic differences between the economies in the sample, which were not captured in the fundamental variables, we also estimated panel regressions with policy variables and country fixed effects. Table 8 presents the results of these regressions with several combinations of policy variables for which we have enough historical data. The estimate of the economic freedom variable ranges between 0.05 and 0.08, and it is significant in most specifications, and in particular the one that includes the other two policy variables and is estimated on a sample of rich countries. The estimated coefficients of the road quality variable are higher in the sample of rich countries, while the coefficients of inequality in education are higher (in absolute value) in the full sample - but not always significant. Overall, the size of the estimated coefficients of the three policy variables is very similar to the sizes obtained for them in the cross-sectional regressions that include control for fundamental variables. This match indicates that the control for fundamental variables improved the validity of the estimates for the policy variables available both in the panel and in the cross-sectional regressions, and probably also the validity of the estimates of policy variables that are available for use only in the cross-sectional regressions.

In the tests we presented now, we used the GDP per worker of the entire economy. However, this aggregate includes the output of the public sector and the output of housing services which are measured differently from the output of the business sector. It might have been preferable to perform the estimates and forecast for business output, but business output data are not available in the Penn World Tables. Business output data are available in the KLEMS database for European Union countries, the US and Japan, and in total for 19 of the countries in our sample, not including Israel. Although the forecasts for Israel's total factor productivity cannot be performed using this data, in order to test the robustness of the coefficients to the use of business output we examined the effect of policy variables on the business output of the 19 countries for which data are available. Due to the low number of observations we ran the regressions without controlling for fundamental variables and refer to the coefficients obtained only as an indication of the robustness of the coefficients in the work. However, due to the fact that the 19 countries in the sample are very advanced, we believe that they are from the same "club" and therefore the control for fundamental variables is not as essential as in the larger sample we examine in the rest of the estimates in the work. Indeed, running a regression that includes only the 6 policy variables as explanatory variables yields coefficients very similar to the coefficients obtained in Table 6 for the 42 countries with output greater than $7,500. Figure 7 presents a comparison between the coefficients from the estimation on the business output and the coefficients from the estimation on the general output. The coefficients are almost identical for 4 out of 6 policy variables, identical in terms of direction and strength in the communication variable, and somewhat different only in the doing business variable (the coefficient in the regression on the business sector is zero). An estimation we performed for the general output only on the 19 countries for which the business output data is available and in the same specification (policy variables only) also yields similar results.

Figure 7
Estimates of Policy Variables from Regression on Business Output Compared to Estimates from Regression on General Output
(The vertical lines are confidence intervals for business output)

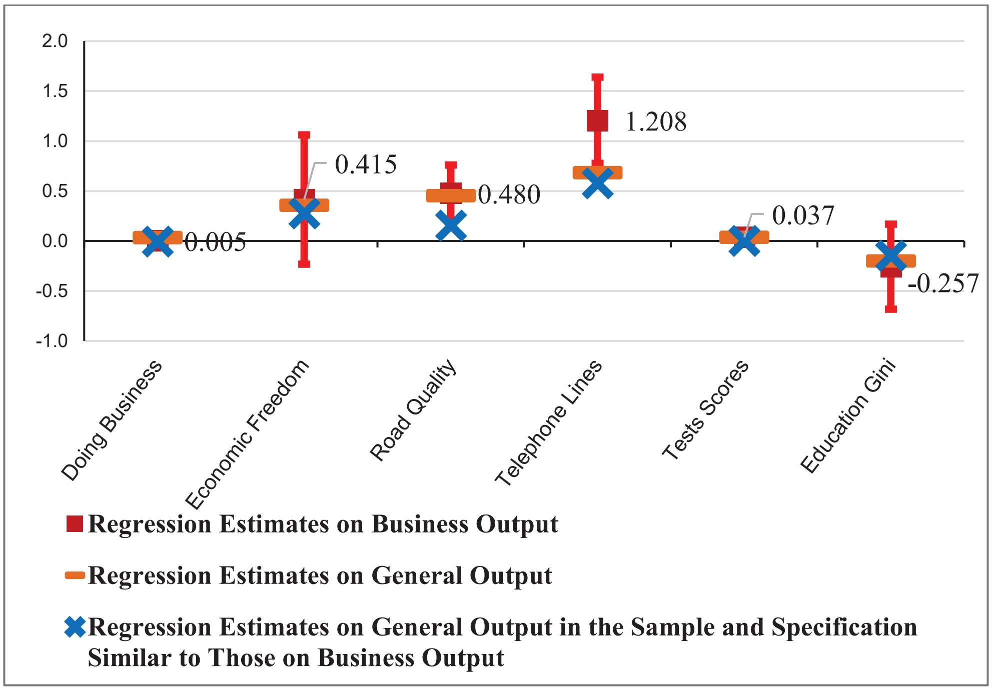


Table 9 presents the estimate for the speed of convergence of productivity, through total factor productivity, for the period 1980-2010. The coefficient of the lagged gap represents ρ from equation (5), and the constant represents δ. The period omitted from the year dummy variables is 1980, so δ is the average growth in the years 1975–80. When approaching the forecast, δ should be added to the coefficients of the period dummy variables according to the assumptions regarding the fit between the patterns of average growth in the world in the past and the patterns in the future. The estimate is higher, and more significant, when we include policy variables in the first stage regression (those available for all years). When interpreting the speed of convergence, the meaning of the estimate (from equation 4) is an annual estimate of 0.0074 (because the regressions use five-year intervals), leading to the conclusion that slightly less than 1% of the country's productivity gap is added to its growth rate over the average global growth rate.

There may be a concern that the estimate of $\hat{\rho}$ reflects policy designed to narrow the productivity gap, and not TFP growth based only on the convergence potential that fundamental variables and past policy variables yield. In order to deal with this concern, we estimated growth regressions that include the change in policy variables (road quality, economic freedom and inequality in education) during each five-year period (not shown). We found that the estimate for the effect of the change in economic freedom on the growth of TFP is positive and significant; that is, some of the convergence indeed occurs through the effect of better policy in the short run. Nevertheless, we find that the estimate of $\hat{\rho}$ does not change significantly after the addition of the change in policy variables.

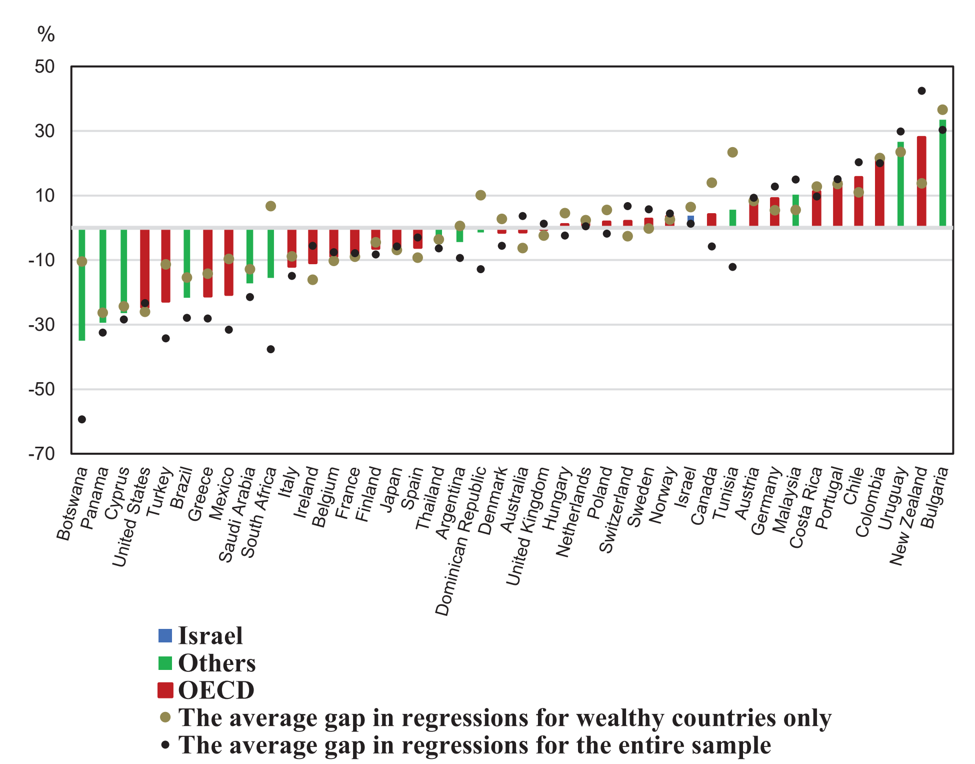
Tables 10 and 11 present the estimate for the speed of convergence of productivity through physical capital and human capital (and not through total factor productivity). The estimates that are parallel to $\hat{\rho}$ are not stable in the various specifications, they are not significant in almost all of them, and some of the estimates yield negative coefficients. These empirical findings support our assumption that the convergence in labor productivity is achieved mainly through total factor productivity.

6. PREDICTIONS

a. The Predicted Gap

As explained in the previous section, we would like to use information from several specifications that include all the fundamental variables and three policy variables, one for each area—institutions, physical infrastructure, and educational quality. Although Israel belongs to the sample of richer countries when it comes to general prosperity, we will take into account both the estimates based on the full sample and the estimates based only on countries with GDP per capita above $7,500 in 2000 (a total of 16 regressions described in Tables 4 and 7). This is because Israel is at the lower end of the distribution in some of the policy-affected variables (Figures 3-5), especially when it comes to the quality of institutions and the quality of education among some subgroups of the population. Our preference for taking into account the estimates derived from the full sample is also based on the proximity we mentioned in Section 5-b between the effect found for the quality of education in the specifications with the full sample, to other findings in the recent literature, such as Hanushek and Woessmann (2012). However, since the level of productivity in Israel is already high, we assume that the appropriate average global growth rate in TFP and the speed of convergence are those of the richer countries. Therefore, we based these parameters on estimates with the sample of rich countries only (equation 4 in Table 9).

Figure 8
The average gap between predicted and actual GDP, 2010
For countries with GDP per capita greater than $7,500



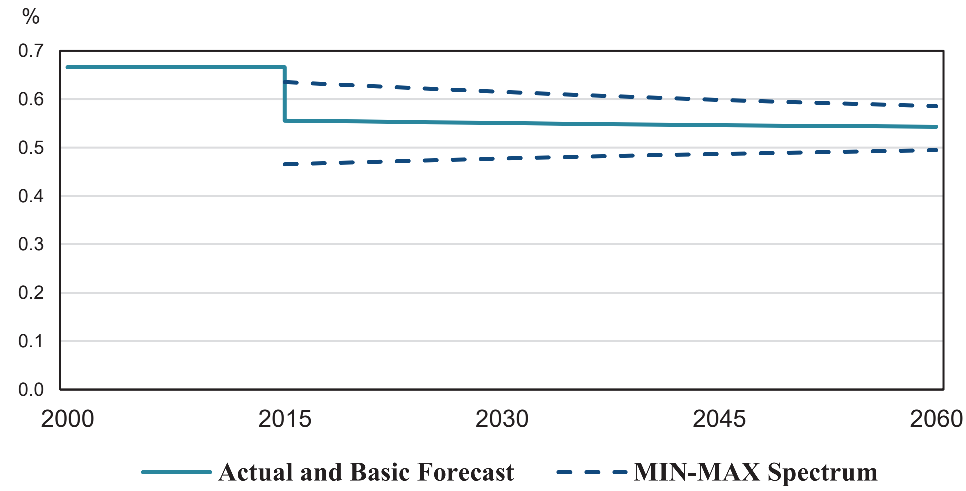
There are several options for weighting the predicted gaps resulting from the 16 level regressions. We decided to average the predicted gaps from the 16 specifications. Figure 8 presents the average gap for 2010 over the 16 regressions for each of the rich countries - also with a separation between the group of regressions based only on the rich countries and the group based on the full sample. Although there are a few cases (Tunisia, South Africa, Dominican Republic) where the regression groups yield different results, overall there is a high correlation of 0.69 between them. Countries like Bulgaria and Uruguay are the countries with the largest positive gap, indicating that these countries have higher growth potential compared to the average, leading to the conclusion that they are advancing towards the productivity level of richer countries. For countries on the left side of the graph, such as Panama and Cyprus, there is, according to our analysis, an actual labor productivity that is higher than that predicted based on the fundamental variables and policy variables we use. In any case, there does not seem to be a correlation between OECD membership and the gaps.

As for Israel, according to the average of all regressions, the gap between the predicted and actual productivity stands at 4%, with a relatively small range between what arises from the two regression groups. That is, Israel's potential for growth (given the current fundamental factors and policy environment) is slightly higher than that of the average of the rich countries. For comparison, the average gap of OECD countries, and the six comparison countries mentioned by Hazan and Tsur (2020), is -1%.

b. TFP Forecast for Israel

Using the calculation presented in equation (6), we create a long-term forecast for TFP growth. In the baseline scenario, TFP growth in the years 2020–60 (0.55%) is slightly lower than Israel's historical TFP growth rate (Figure 9): The endogenous forecast from the model begins in 2010, and the average growth rate in the decade preceding that year (1999-2010) was 0.67% as shown in Figure 9. Together with the following decade (2010-2019, without the Covid-19 crisis), in which productivity growth stood at 0.58%, the average growth rate of TFP in the years 1999-2019 stood at 0.62%. The growth rate in the forecast remains stable because it includes only a small component of positive convergence. The forecast mainly reflects the average global TFP growth for the years 1990-2010 in the sample of rich countries which stood at 0.53%. These years include mainly the period of the ICT productivity wave (1990-2005) as well as a short period of slow growth (2005-2010) associated with the global financial crisis. The choice of these reference periods assumes that global growth is not facing a long period of slow TFP growth, but it also assumes that the speed of growth during the ICT revolution will not persist at the rate of the years 1990-2005. The convergence component of the Israeli economy contributes 0.02 percentage points to the annual growth of TFP. Since the productivity gap for Israel in 2010 is 4% and the average gap for OECD countries stands at around -1%, Israeli productivity is expected to slowly close the gap (-13% in GDP per worker, and -24% in GDP per hour worked) vis-à-vis the average productivity of OECD countries. This finding is somewhat encouraging, although it is not driven by faster TFP growth in Israel compared to the past, but by slower growth in some OECD countries.

Figure 9
Annual growth rate of Total Factor Productivity (TFP)
Actual growth 2000–10 and additional standard deviation scenarios for 2010-2060



* The forecast range reflects the range created by the labor productivity gap at the starting point from 16 regression formulations that were examined.

The Minimum and Maximum lines in Figure 9 represent the lowest and highest TFP forecasts that were calculated based on the 16 specifications that produced the average TFP forecast. The spectrum of 16 forecasts is narrow and balanced, 0.48% - 0.60% (average 2020-2060). We conclude that the forecast is relatively robust to the choice of any of the individual specifications instead of using their average.

Figure 10 presents four additional scenarios for TFP growth. The first three scenarios are based on initial gaps that were calculated with better policy values - we added one standard deviation to each policy variable so that the long-term growth potential increases. The fourth scenario combines the three other improved scenarios. This graph essentially ranks the relative effect of the three policy variables, based on the 16 specifications that produced the average TFP forecast. The graph shows that an improvement of one standard deviation in infrastructure yields the largest relative effect, the effect of better institutions is ranked second, and the effect of education quality is ranked third. The simultaneous improvement of the three policy variables contributes about 0.4 percentage points to TFP growth at the beginning of the forecast horizon. The contribution of the better policy to growth gradually narrows, as the positive gap that opened decreases from period to period along the convergence process, but even until the end of the forecast horizon a higher level of growth is maintained.

Figure 10
Annual growth rate of Total Factor Productivity (TFP)
Actual growth 2000–10 and one-standard-deviation policy jump scenarios for 2010-2060

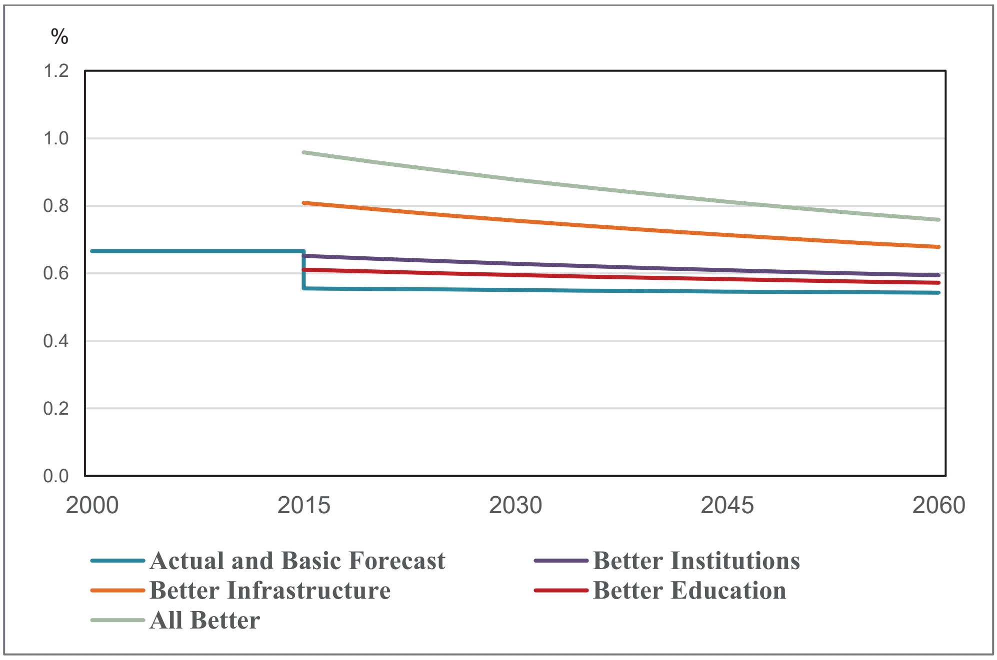


Figure 11 presents four additional scenarios for TFP growth. The first three scenarios are based on hypothetical initial gaps that were built under the assumption that Israel would achieve very good policy variable values; the value of each policy variable was set to the 95th percentile among the rich countries (with GDP per capita greater than $7,500). The fourth scenario combines these three policy scenarios. Unlike the scenarios presented in Figure 10, the scenarios presented in Figure 11 show the potential of the Israeli economy to improve by bringing its policy closer to best practices.

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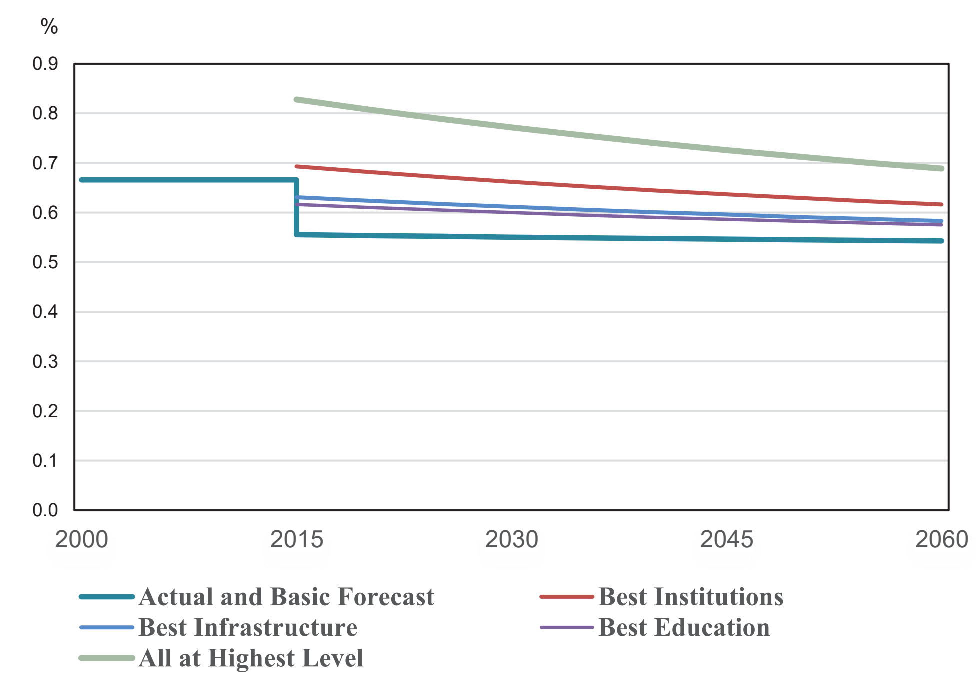
Figure 11
Annual Growth Rate of Total Factor Productivity (TFP)
Actual Growth 2000-2010 and Best Policy Jump Scenarios (95th Percentile) for 2010-2060



The effects of improving institutions in Israel up to the 95th percentile yield the largest jump in growth. The effects of improving infrastructure and improving the quality of education are slightly lower, and very similar to each other. This similarity reflects the strong impact coefficients estimated for infrastructure on the one hand, and the relative inferiority of the quality of education on the other hand. It should be noted that in this study we focus only on the quality of education, while in the paper of the broader model (Argov and Tsur, 2019) the focus is on the contribution of the quantity of schooling. A policy of better education and schooling is expected to increase both the quantity of schooling (the number of years of schooling and degrees acquired) and its quality. Therefore, the effect of a better education policy on the overall growth of productivity and output is higher, while the effect presented here is partial – only the one that passes through TFP. Also in the field of infrastructure, it should be emphasized that the effect presented is partial in terms of output and labor productivity. It relates only to the TFP growth channel, while in this case the growth of productivity and output will also be contributed by the increase in physical capital inputs.

The effects reported here should be treated with some caution: while the basic differences between the economies were well controlled for using the fundamental variables (deep roots of growth) and the panel formulations, the threat of reverse causality in the policy-dependent variables cannot be ignored. We cannot rule out, for example, the possibility that growth processes lead to better policy. The effects reported here can provide policymakers with a general direction, but a more accurate assessment of the potential contribution of a specific policy step should be based on more focused research.

7. SUMMARY

This study uses a framework of conditional convergence between countries to formulate and estimate a model for long-term forecasting of Israel's total factor productivity (TFP), and to examine how policy changes may affect it. Based on various specifications that include fundamental and policy-affected variables, we forecast that the annual growth of TFP will stand at 0.55% over the forecast horizon (2020-2060). This rate of TFP growth reflects the average global growth rate combined with a small positive convergence component, since the initial gap in Israel's GDP per worker was found to be small. The baseline scenario was obtained under the assumption that the current policy variables will remain unchanged. Indeed, it is still early to examine the accuracy of a 50-year forecast, but an indication can be obtained based on the actual developments between 2010 (the start date of the forecast from the model) and 2019 (the eve of the Covid-19 crisis). According to updated CBS data, the growth rate of output in the decade 2010-2019 stood at 4.0% and the growth rate of TFP at 0.58%, similar to the model's forecast.

Another goal of the study is to assess how various policy measures are expected to affect the long-term growth of TFP. We found that better physical infrastructures have the highest marginal contribution to the growth of TFP. However, considering the relatively extensive inferiority of Israeli institutions and the quality of education, the potential of the Israeli economy to grow by improving these policy factors is also large. Our broad project, and especially the TFP growth forecast, is not intended only to produce a good guess for future growth. The goal is to develop a well-organized tool that will help policymakers make more informed decisions about ways to close the productivity gaps between Israel and advanced economies.

REFERENCES

Acemoglu, Daron (2008). *Introduction to Modern Economic Growth*. Princeton University Press.

Acemoglu, Daron, Simon Johnson, and James A Robinson (2002). "Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution." *Quarterly Journal of Economics* 117(4): 1231-1294.

Acemoglu, Daron, Simon Johnson, and James A Robinson (2005). "Institutions as a fundamental cause of long-run growth." *Handbook of Economic Growth* 1:385-472.

Alesina, Alberto and Eliana La Ferrara (2005). "Ethnic Diversity and Economic Performance." *Journal of Economic Literature* 43(3): 762-800.

Angrist, Noam, Harry A Patrinos, and Martin Schlotter (2013). *An Expansion of a Global Data Set on Educational Quality: a Focus on Achievement in Developing Countries*. World Bank Policy Research Working Paper (6536).

Argov, Eyal and Shay Tsur (2019). *A Long Run Growth Model for Israel*. Bank of Israel Discussion Paper 2019.04.

Ashraf, Quamrul and Oded Galor (2013). "Genetic Diversity and the Origins of Cultural Fragmentation." *The American Economic Review* 103(3): 528-533.

Barro, Robert J. (1991). "Economic growth in a cross section of countries." *The Quarterly Journal of Economics* 106(2): 407-443.

Barro, Robert I. and Jong Wha Lee. (2013). "A New Data Set of Educational Attainment in the World, 1950 2010." *Journal of Development Economics* 104: 184-198.

Barro, Robert I. and Xavier Sala-i Martin (1992). "Convergence." *Journal of Political Economy* 100: 223-251.

Barro, Robert I, Xavier Sala-i Martin, Olivier Jean Blanchard, and Robert E Hall (1991). "Convergence across states and regions." *Brookings Papers on Economic Activity* 1991(1): 107— 182.

Battisti, Michele, Gianfranco Di Vaio, and Joseph Zeira (2022). "Convergence and divergence: a new approach, new data, and new results." *Macroeconomic Dynamics* 26(4): 945-978.

Becker, Sascha O and Ludger Woessmann (2009). "Was Weber wrong? A human capital theory of Protestant economic history." *The Quarterly Journal of Economics* 124(2): 631-596.

Botticini, Maristella and Zvi Eckstein (2007). "From farmers to merchants, conversions and diaspora: Human capital and Jewish history." *Journal of the European Economic Association* 5(5): 885-926

Braude, Kobe. (2013). *A Long Term Forecast*. Bank of Israel - internal memo (Hebrew).

Castelló, Amparo and Rafael Doménech (2002). "Human Capital Inequality and Economic Growth: Some New Evidence." *The Economic Journal* 112(478): 187-200.

Cette, Gilbert, Remy Lecat, and Carole Ly-Marin (2016). "Long-term growth and productivity projections in advanced countries." *OECD Journal: Economic Studies* 2016 (I).

Diamond, Jared. (1997). *Guns, Steel and Germs: The Fate of Human Societies*. New York.

Durlauf, Steven N. (2009). "The rise and fall of cross-country growth regressions." *History of Political Economy* 41(Suppl I): 316- 333.

Geva, Asaf (2013). "The Demographic Changes and their Consequences on Public Expenditure in the Years 2013-2059". *Bank of Israel Review* 87 (Hebrew):7-30.

Guillemette, Yvan, Alexandre Kopin, David Turner, and Andrea De Mauro (2017). *A Revised Approach to Productivity Convergence in Long-Term Scenarios*. OECD Economics Department Working Papers (1386).

Hanushek, Eric A. and Ludger Woessmann (2012). "Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation." *Journal of economic growth* 17(4): 267-321.

Hazan, Moshe and Shay Tsur (2021). "Why is Labor Productivity in Israel so Low?" In: Ben-Bassat A, Gronau R, Zussman A, eds. The Israeli Economy, 1995–2017: Light and Shadow in a Market Economy. Cambridge University Press; 329-361

Islam, Nazrul (1995). "Growth empirics: a panel data approach." *The Quarterly Journal of Economics* 110(4): 1127-1170.

Islam, Nazrul (2003). "What have we learnt from the convergence debate?" *Journal of Economic Surveys* 17(3): 309-362.

Jones, Benjamin F. and Benjamin A. Olken (2005). "Do leaders matter? National leadership and growth since World War II." *The Quarterly Journal of Economics* 120(3): 835-864.

North, Douglass C. and Robert Paul Thomas (1973). *The Rise of the Western World: A New Economic History*. Cambridge University Press.

Ramachandran, Sohini, Omkar Deshpande, Charles C. Roseman, Noah A. Rosenberg, Marcus W. Feldman and L. Luca Cavalli-Sforza (2005). "Support from the Relationship of Genetic and Geographic Distance in Human Populations for a Serial Founder Effect Originating in Africa." *Proceedings of the National Academy of Sciences* 102(44): 15942-15947.

Sala-i-Martin, Xavier (1997). "I just ran two million regressions." *The American Economic Review* 87(2): 178-183.

Solow, Robert M. (1956). "A contribution to the theory of economic growth." *The Quarterly Journal of Economics* 70(1): 65-94.

Thomas, Vinod, Yan Wang and Xibo Fan (2001). *Measuring education inequality: Gini coefficients of education*, (vol. 2526). World Bank Publications.

Ziesemer, Thomas (2016). "Gini Coefficients of Education for 146 Countries, 1950-2010." *Bulletin of Applied Economics* 3(2): 1-8.

APPENDIX

Description of the Variables Appearing in the Regression Tables

Name in Tables	**Full Name**	**Description**
Prod1980	Production 1980	Log GDP per worker in 1980
Neolithic	Years from Neolithic transition	The number of years (in thousands) that have passed since agriculture became the primary mode of subsistence in the country
Arable	Arable land	The share of total land areas that are arable, as reported by the World Bank's World Development Indicators
Tropical	Tropical zones	The percentage of the country's population in 1996 that lives in tropical area
Water	Distance from waterways	The average across a country's grid cells, in thousands of kilometers, from an ice-free coast or navigable river
Resources	Natural resources	Natural resource rents as a percentage of GDP (in the regression year). Includes rents from oil, natural gas, coal, minerals and forests
G.div /G.div sq	Genetic diversity / (Genetic diversity)^2	The heterozygosity (genetic diversity) in the country. To ensure exogeneity, it is calculated as the predicted value from a regression of the genetic diversity of each region on the migration distance of humans from East Africa to that region
Ethnic	Ethnic fractionalization	The probability that two randomly selected individuals from the same country will belong to different ethnic groups
Religion	Religion shares	Three variables: the shares of Muslims, Catholics and Protestants in the country's population
D.Business	Doing Business	The country's "Distance from the Frontier" (in reverse order) in the World Bank index that measures the ease of doing business in several areas
E.Freedom	Economic Freedom	Economic Freedom index which covers 12 areas, such as property rights and financial freedom

Roads	Road quality	Based on the first principal component of several indices on road quality, taken from the International Road Federation data
Phones	Telephone lines	Number of main telephone lines and mobile phones per thousand workers in the country
Scores	Test Scores	Scores from national tests for the years 1995-2010, standardized over time, across subjects (mathematics, reading and science), schooling levels and various international and regional assessments
E.Inequality	Education Gini	Gini coefficients for years of schooling within each country

Table 1
Global and Conditional Convergence in GDP per Worker
Dependent variable: Growth

	The Full Sample	The Full Sample	GDP PC>7500	GDP PC>7500
Prod1980	0.000932 (0.00104)	-0.00549*** (0.00171)	-0.00629*** (0.00145)	-0.00914*** (0.00155)
Neolithic		0.0111*** (0.00322)		0.00248 (0.00246)
Arable		-0.00225* (0.00123)		-0.00006 (0.000979)
Tropical		-0.00613* (0.00350)		-0.00504* (0.00283)
Water		-0.00369 (0.00431)		0.000190 (0.00346)
Resources		-0.000021 (0.000136)		0.000055 (0.000140)
G.div		1.531 (1.608)		5.980** (2.521)
G.div sq		-1.076 (1.137)		-4.158** (1.777)
Ethnic		-0.0101* (0.00547)		-0.00720* (0.00414)
Constant	0.00347 (0.0100)	-0.558 (0.566)	0.0816*** (0.0152)	-2.056** (0.887)
Observations	96	96	45	45
Adjusted R-squared	-0.002	0.200	0.289	0.578
Religion	No	Yes	No	Yes
Israel residuals[1]	-0.02069	0.381972	0.057367	0.076374

Note: 1. The predicted value minus the actual value (Gap) for Israel (in percentages).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 2
The Effect of Fundamental Variables on GDP per Worker
Dependent variable: Log GDP per worker in 2010

	(1)	(2)	(3)	(4)	(5)
Neolithic	1.085***		1.005***		1.198***
	(0.174)		(0.177)		(0.163)
Arable	-0.240***		-0.238***		-0.224***
	(0.0817)		(0.0825)		(0.0718)
Tropical	-1.108***		-1.077***		-0.923***
	(0.197)		(0.199)		(0.191)
Water	-1.286***		-1.057***		-0.927***
	(0.251)		(0.260)		(0.232)
Resources	-0.00583		-0.00238		0.00842
	(0.00908)		(0.00914)		(0.00808)
G.div		638.4***	307.3***		311.2***
		(141.0)	(104.2)		(91.57)
G.div sq		-457.1***	-218.3***		-219.4***
		(99.65)	(73.92)		(64.83)
Ethnic				-2.499***	-0.285
				(0.363)	(0.328)
Constant	2.302	-212.1***	-105.0***	10.79***	-109.2***
	(1.489)	(49.82)	(36.49)	(0.328)	(32.24)
Observations	96	96	96	96	96
Adjusted R-squared	0.618	0.201	0.645	0.367	0.746
Religion	No	No	No	Yes	Yes
Israel residuals[1]	19.58	-134.60	0.61	-124.89	-24.09

Note: 1. The predicted value minus the actual value (Gap) for Israel (in percentages).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3
The Effect of Fundamental and Policy Variables on GDP per Worker
Dependent variable: Log GDP per worker in 2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Neolithic	1.241***		0.690***	0.903***	0.937***	0.110	0.512***	0.970***
	(0.183)		(0.139)	(0.186)	(0.159)	(0.134)	(0.182)	(0.210)
Arable	-0.193**		-0.181***	-0.154*	-0.377***	0.0223	-0.227***	-0.181**
	(0.0861)		(0.0572)	(0.0775)	(0.0775)	(0.0483)	(0.0660)	(0.0827)
Tropical	-0.918***		-0.557***	-0.903***	-0.568***	0.00237	-0.627***	-0.704***
	(0.224)		(0.155)	(0.200)	(0.193)	(0.140)	(0.178)	(0.233)
Water	-1.000***		-0.605***	-0.907***	-0.0792	0.0717	-0.885***	-0.941***
	(0.278)		(0.191)	(0.249)	(0.282)	(0.170)	(0.213)	(0.268)
Resources	0.0126		0.00948	0.0188*	0.0220**	0.0298***	0.0299***	0.0126
	(0.0124)		(0.00827)	(0.0112)	(0.0102)	(0.00664)	(0.00988)	(0.0119)
G.div	308.5***		141.0**	292.9***	167.1**	111.8**	208.7***	265.4***
	(94.74)		(66.13)	(84.66)	(80.97)	(52.07)	(74.12)	(92.73)
G.div sq	-216.3***		-96.16**	-205.7***	-118.9**	-76.45**	-144.4***	-186.1***
	(67.44)		(47.11)	(60.26)	(57.44)	(37.06)	(52.79)	(65.96)
Ethnic	0.277		-0.0165	0.170	0.208	-0.00923	0.403	0.365
	(0.363)		(0.244)	(0.326)	(0.294)	(0.191)	(0.278)	(0.351)
D.Business		0.0177**	0.0481***					
		(0.00771)	-0.00579					
E.Freedom		0.0202		0.419***				
		(0.0962)		(0.109)				
Roads		0.0159			0.613***			
		(0.0649)			(0.113)			

Phones		0.429*** (0.0563)				0.563*** (0.0468)		
Scores		0.00453 (0.0100)					0.0616*** (0.00980)	
E.Inequality		0.133 (0.135)						-0.577** (0.243)
Constant	-109.3*** (33.23)	6.718*** (0.503)	-49.59** (23.23)	-103.7*** (29.69)	-55.73* (28.64)	-34.83* (18.41)	-71.25*** (26.10)	-92.59*** (32.65)
Observations	66	66	66	66	66	66	66	66
Adjusted R-squared	0.719	0.873	0.876	0.776	0.816	0.923	0.836	0.741
Religion	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Israel residuals[1]	4.88	12.49	0.47	-0.19	6.74	12.75	-15.32	-2.43

Note: 1. The predicted value minus the actual value (Gap) for Israel (in percentages).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4
The Effect of Fundamental and Policy Variables on GDP per Worker, Policy variables combinations
Dependent variable: Log GDP per worker in 2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Neolithic	0.0761 (0.120)	0.645*** (0.178)	0.509*** (0.172)	-0.0376 (0.118)	0.0104 (0.125)	0.517*** (0.144)	0.555*** (0.141)	0.147 (0.123)
Arable	-0.0490 (0.0439)	-0.303*** (0.0763)	-0.290*** (0.0716)	-0.00935 (0.0436)	0.0259 (0.0434)	-0.265*** (0.0600)	-0.267*** (0.0607)	-0.0289 (0.0449)
Tropical	-0.0802 (0.120)	-0.512** (0.191)	-0.559*** (0.171)	-0.0742 (0.120)	-0.0596 (0.128)	-0.446*** (0.144)	-0.381** (0.153)	-0.0671 (0.127)
Water	-0.0924 (0.150)	-0.207 (0.267)	-0.437 (0.261)	-0.0485 (0.149)	0.0347 (0.153)	-0.346 (0.222)	-0.229 (0.213)	-0.0328 (0.154)
Resources	0.0280*** (0.00610)	0.0235** (0.00958)	0.0304*** (0.00917)	0.0343*** (0.00574)	0.0318*** (0.00598)	0.0195** (0.00808)	0.0147* (0.00775)	0.0239*** (0.00610)
G.div	88.62* (44.66)	165.3** (76.58)	170.8** (71.28)	112.3** (44.27)	118.4** (46.77)	108.9* (61.15)	92.93 (62.03)	86.63* (46.87)
G.div sq	-59.37* (31.80)	-117.5** (54.31)	-119.6** (50.59)	-76.74** (31.52)	-81.41** (33.28)	-74.56* (43.44)	-63.95 (44.06)	-58.12* (33.36)
Ethnic	0.0122 (0.167)	0.215 (0.278)	0.279 (0.261)	0.0319 (0.166)	-0.0414 (0.173)	0.0905 (0.226)	0.0523 (0.226)	-0.0582 (0.173)
D.Business	0.0164*** (0.00560)					0.0329*** (0.00678)	0.0375*** (0.00613)	0.0214*** (0.00536)
E.Freedom		0.247** (0.0997)	0.162 (0.0974)	0.180*** (0.0600)	0.231*** (0.0591)			
Roads		0.468*** (0.116)	0.304** (0.123)			0.231** (0.105)	0.292*** (0.0980)	

Phones	0.390*** (0.0543)			0.462*** (0.0473)	0.516*** (0.0460)			0.414*** (0.0575)
Scores	0.0163** (0.00741)		0.0380*** (0.0116)	0.0173** (0.00724)		0.0196* (0.0107)		
E.Inequality		-0.350* (0.196)			-0.0180 (0.126)		-0.238 (0.159)	-0.0373 (0.126)
Constant	-27.26* (15.76)	-54.99** (27.15)	-57.10** (25.24)	-35.07** (15.66)	-37.47** (16.56)	-36.17* (21.59)	-30.41 (21.94)	-26.93 (16.55)
Observations	66	66	66	66	66	66	66	66
Adjusted R-squared	0.945	0.839	0.859	0.945	0.939	0.898	0.896	0.939
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Israel residuals[1]	3.47	-1.12	-8.64	3.47	9.08	-3.87	-0.68	8.23

Note: 1. The predicted value minus the actual value (Gap) for Israel (in percentages).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5
The Effect of Fundamental Variables on GDP per Worker
Countries with GDP per capita > $7,500
Dependent variable: Log GDP per worker in 2010

	(1)	(2)	(3)	(4)	(5)
Neolithic	0.315*		0.231		0.427**
	(0.163)		(0.163)		(0.171)
Arable	0.00215		0.0176		0.00666
	(0.0761)		(0.0774)		(0.0737)
Tropical	-0.774***		-0.807***		-0.675***
	(0.159)		(0.169)		(0.195)
Water	0.0194		-0.0553		-0.0435
	(0.249)		(0.240)		(0.259)
Narural	0.0112		0.0168*		0.0194*
	(0.00901)		(0.00966)		(0.00999)
G.div		282.6	437.9**		241.0
		(219.0)	(186.8)		(189.7)
G.div sq		-193.4	-307.3**		-168.5
		(154.0)	(131.7)		(133.7)
Ethnic				-0.659**	-0.110
				(0.297)	(0.308)
Constant	8.433***	-92.06	-146.7**	11.05***	-78.80
	(1.363)	(77.80)	(65.89)	(0.188)	(66.72)
Observations	45	45	45	45	45
Adjusted R-squared	0.401	0.098	0.455	0.175	0.512
Religion	No	No	No	Yes	Yes
Israel residuals[1]	9.49	-7.42	-8.07	-35.00	-11.67

Note: 1. The predicted value minus the actual value (Gap) for Israel (in percentages).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6
The Effect of Fundamental and Policy Variables on GDP per Worker, Countries with GDP per capita > $7,500
Dependent variable: Log GDP per worker in 2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Neolithic	0.445** (0.214)		0.479*** (0.168)	0.317 (0.190)	0.408*** (0.144)	-0.398** (0.153)	0.212 (0.198)	0.375 (0.226)
Arable	-0.0259 (0.0873)		-0.0977 (0.0702)	0.0111 (0.0764)	-0.206*** (0.0653)	0.0870* (0.0495)	-0.0744 (0.0769)	-0.0376 (0.0883)
Tropical	-0.805*** (0.228)		-0.367* (0.203)	-0.601*** (0.206)	-0.509*** (0.160)	0.0241 (0.158)	-0.476** (0.220)	-0.732*** (0.240)
Water	-0.109 (0.292)		-0.108 (0.228)	-0.0662 (0.253)	0.387* (0.211)	0.203 (0.163)	-0.169 (0.253)	-0.185 (0.302)
Resources	0.0150 (0.0119)		0.00987 (0.00941)	0.0211* (0.0105)	0.0209** (0.00805)	0.0328*** (0.00685)	0.0231** (0.0106)	0.0148 (0.0120)
G.div	356.4 (218.3)		-82.09 (196.8)	276.6 (190.5)	114.0 (151.3)	-102.8 (130.8)	77.79 (206.5)	318.4 (222.0)
G.div sq	-250.6 (154.3)		62.74 (139.5)	-193.3 (134.6)	-80.76 (106.8)	74.97 (92.47)	-51.49 (146.2)	-223.6 (156.9)
Ethnic	-0.0924 (0.340)		-0.207 (0.267)	-0.0890 (0.294)	0.0529 (0.229)	-0.0783 (0.185)	0.0395 (0.297)	0.00409 (0.355)
D.Business		0.0128* (0.00740)	0.0348*** (0.00777)					
E.Freedom		-0.0132 (0.122)		0.356*** (0.107)				
Roads		0.0113 (0.0697)			0.454*** (0.0736)			

Phones		0.474***				0.683***		
		(0.113)				(0.0806)		
Scores		-0.00338					0.0360***	
		(0.0120)					(0.0108)	
E.Inequality		0.0600						-0.201
		(0.146)						(0.208)
Constant	-119.3	7.316***	31.13	-93.24	-32.80	44.61	-21.70	-105.7
	(76.93)	(0.706)	(68.89)	(67.03)	(53.35)	(46.19)	(72.68)	(78.28)
Observations	42	42	42	42	42	42	42	42
Adjusted R-squared	0.497	0.642	0.692	0.623	0.775	0.850	0.624	0.496
Religion	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Israel residuals	-13.42	21.13	5.36	-14.76	-0.28	11.97	-10.50	-13.12

Note: 1. The predicted value minus the actual value (Gap) for Israel (in percentages).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7
The Effect of Fundamental and Policy Variables on GDP per Worker, Countries with GDP per capita > $7,500
Policy variables combinations
Dependent variable: Log GDP per worker in 2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Neolithic	-0.257 (0.162)	0.327** (0.152)	0.321** (0.156)	-0.361** (0.150)	-0.370** (0.152)	0.383** (0.149)	0.394** (0.144)	-0.260 (0.166)
Arable	0.0309 (0.0534)	-0.176** (0.0706)	-0.170** (0.0702)	0.0764 (0.0514)	0.0867* (0.0489)	-0.194*** (0.0623)	-0.203*** (0.0623)	0.0390 (0.0528)
Tropical	0.0652 (0.151)	-0.435** (0.166)	-0.428** (0.170)	0.0291 (0.154)	0.0263 (0.156)	-0.331* (0.171)	-0.337* (0.169)	0.0647 (0.154)
Water	0.130 (0.160)	0.291 (0.219)	0.287 (0.221)	0.165 (0.161)	0.172 (0.166)	0.223 (0.215)	0.228 (0.214)	0.136 (0.165)
Resources	0.0288*** (0.00697)	0.0221** (0.00805)	0.0235*** (0.00817)	0.0336*** (0.00664)	0.0332*** (0.00668)	0.0186** (0.00806)	0.0170** (0.00784)	0.0279*** (0.00697)
G.div	-210.0 (133.2)	96.42 (151.6)	72.96 (159.0)	-109.2 (130.7)	-90.98 (128.2)	-69.18 (164.5)	-51.48 (160.8)	-198.0 (133.5)
G.div sq	152.1 (94.38)	-67.73 (107.0)	-50.65 (112.5)	79.99 (92.51)	66.89 (90.61)	51.18 (116.7)	38.21 (114.0)	143.4 (94.59)
Ethnic	-0.0974 (0.180)	0.0916 (0.236)	0.0554 (0.228)	-0.0588 (0.181)	-0.0603 (0.188)	-0.0137 (0.223)	0.0185 (0.230)	-0.104 (0.187)
D.Business	0.0120* (0.00637)					0.0155* (0.00785)	0.0160** (0.00777)	0.0130** (0.00630)
E.Freedom		0.123 (0.0955)	0.111 (0.0978)	0.121 (0.0753)	0.135* (0.0726)			

Roads		0.393*** (0.0847)	0.363*** (0.0934)			0.315*** (0.0940)	0.346*** (0.0857)	
Phones	0.545*** (0.0990)			0.588*** (0.0934)	0.610*** (0.0874)			0.569*** (0.0944)
Scores	0.00636 (0.00765)		0.00835 (0.0102)	0.00555 (0.00796)		0.00792 (0.00961)		
E.Inequality		-0.119 (0.138)			-0.0381 (0.112)		-0.111 (0.133)	-0.0416 (0.110)
Constant	80.43* (46.72)	-27.36 (53.49)	-19.36 (56.03)	45.75 (46.17)	39.46 (45.31)	29.45 (57.54)	23.46 (56.28)	76.29 (46.86)
Observations	42	42	42	42	42	42	42	42
Adjusted R-squared	0.865	0.779	0.779	0.860	0.859	0.798	0.798	0.862
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Israel residuals[1]	13.81	-2.32	-2.65	8.44	8.79	4.74	5.42	14.82

Note: 1. The predicted value minus the actual value (Gap) for Israel (in percentages).
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8
The Effect of Policy Variables on GDP per Worker
A Panel Approach Using Fixed Effects; 1960–2010
Dependent variable: Log GDP per worker

	The Full Sample			
	(1)	(2)	(3)	(4)
E.Freedom	0.0793** (0.0340)			0.0615* (0.0360)
Roads		0.0597 (0.145)		0.0861 (0.124)
E.Inequality			-0.474** (0.196)	-0.164 (0.191)
Constant	9.645*** (0.239)	10.22*** (0.0584)	9.112*** (0.143)	9.719*** (0.348)
Observations	688	633	755	534
Adjusted R-squared	0.954	0.948	0.950	0.960
Year effect	Yes	Yes	Yes	Yes
Fixed effect	Yes	Yes	Yes	Yes
	Countries with GDP per capita > $7,500			
	(5)	(6)	(7)	(8)
E.Freedom	0.0563 (0.0356)			0.0655* (0.0343)
Roads		0.250*** (0.860)		0.214** (0.0819)
E.Inequality			-0.196 (0.145)	-0.0368 (0.107)
Constant	10.68*** (0.261)	10.86*** (0.0875)	10.76*** (0.227)	10.33*** (0.268)
Observations	367	339	351	321
Adjusted R-squared	0.925	0.920	0.911	0.941
Year effect	Yes	Yes	Yes	Yes
Fixed effect	Yes	Yes	Yes	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9
Estimation of the Convergence Rate for GDP per Worker (ρ) through Total Factor Productivity (TFP)
Dependent variable: 5-year growth rate (log-difference) in total factor productivity

	(1)	(2)	(3)	(4)	(5)	(6)
	The Full Sample	y>7500	The Full Sample	y>7500	The Full Sample	y>7500
	TFP 5 years growth	TFP 5 years growth	TFP 5 years growth	TFP 5 years growth	TFP 5 years growth	TFP 5 years growth
The lagged gap (Fundamentals based only)	0.0175** (0.00820)	0.0137 (0.0103)				
The lagged gap (Fundamentals and policy based)			0.0326*** (0.0123)	0.0370** (0.0164)	0.0308** (0.0130)	0.0360** (0.0173)
d1985	-0.0716*** (0.0172)	-0.0633*** (0.0184)	-0.0714*** (0.0171)	-0.0621*** (0.0183)	-0.0626*** (0.0178)	-0.0598*** (0.0173)
d1990	-0.0176 (0.0159)	-0.0159 (0.0128)	-0.0176 (0.0159)	-0.0153 (0.0128)	-0.0228 (0.0167)	-0.0155 (0.0130)
d1995	-0.0254 (0.0166)	-0.00701 (0.0141)	-0.0254 (0.0168)	-0.00743 (0.0144)	-0.0336* (0.0171)	-0.00440 (0.0134)
d2000	-0.0243 (0.0186)	-0.0118 (0.0148)	-0.0241 (0.0185)	-0.0114 (0.0146)	-0.0205 (0.0184)	-0.00333 (0.0140)
d2005	0.0198 (0.0160)	-0.00426 (0.0145)	0.0199 (0.0159)	-0.00353 (0.0143)	0.0424** (0.0171)	0.0140 (0.0160)
d2010	0.000862 (0.0185)	-0.0420** (0.0160)	0.000893 (0.0187)	-0.0414** (0.0162)	0.0223 (0.0199)	-0.0247 (0.0171)

Roads_d					0.0526 (0.0353)	0.0553** (0.0226)
E.Freedom diff					0.0488*** (0.0144)	0.0230** (0.00862)
E.Inequality diff					0.0684 (0.0529)	0.0676 (0.0474)
Constant	0.0269** (0.0123)	0.0408*** (0.0123)	0.0269** (0.0124)	0.0425*** (0.0126)	0.00400 (0.0161)	0.0272* (0.0139)
Observations	413	270	413	270	413	270
Adjusted R-squared	0.069	0.078	0.076	0.107	0.144	0.136

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10
Estimating the Convergence Rate in GDP per Worker (ρ) Using Physical Capital
Dependent Variable: 5-Year Growth Rate (log-difference) in Physical Capital Stock

	(1)	(2)	(3)	(4)
	The Full Sample	y>7500	The Full Sample	y>7500
	k 5 years growth	k 5 years growth	k 5 years growth	k 5 years growth
The lagged gap (Fundamentals based only)	0.00224 (0.0279)	-0.00925 (0.0182)		
The lagged gap (Fundamentals and policy based)			0.0219 (0.0301)	0.0225 (0.0273)
d1985	-0.0925*** (0.0199)	-0.0528*** (0.0187)	-0.0923*** (0.0199)	-0.0510*** (0.0185)
d1990	-0.130*** (0.0223)	-0.0843*** (0.0216)	-0.130*** (0.0223)	-0.0829*** (0.0212)
d1995	-0.0821*** (0.0230)	-0.0441** (0.0190)	-0.0821*** (0.0231)	-0.0433** (0.0191)
d2000	-0.0938*** (0.0223)	-0.0728*** (0.0209)	-0.0938*** (0.0222)	-0.0716*** (0.0199)
d2005	-0.106*** (0.0237)	-0.0871*** (0.0217)	-0.106*** (0.0236)	-0.0855*** (0.0206)
d2010	-0.0602** (0.0254)	-0.0721*** (0.0218)	-0.0603** (0.0253)	-0.0703*** (0.0208)
Constant	0.178*** (0.0200)	0.169*** (0.0150)	0.178*** (0.0199)	0.172*** (0.0157)
Observations	413	270	413	270
Adjusted R-squared	0.055	0.051	0.059	0.056

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11
Estimating the Convergence Rate in GDP per Worker (ρ) Using Human Capital
Dependent Variable: 5-Year Growth Rate (log-difference) in Human Capital Stock

	(1)	(2)	(3)	(4)
	The Full Sample	y>7500	The Full Sample	y>7500
	hc 5 years growth	hc 5 years growth	hc 5 years growth	hc 5 years growth
The lagged gap (Fundamentals based only)	0.000690 (0.00487)	-0.00696 (0.00671)		
The lagged gap (Fundamentals and policy based)			-0.0122* (0.00686)	-0.0288*** (0.00764)
d1985	0.0116** (0.00491)	0.0101 (0.00642)	0.0116** (0.00490)	0.00900 (0.00607)
d1990	0.00400 (0.00416)	0.00247 (0.00461)	0.00400 (0.00409)	0.00182 (0.00403)
d1995	0.00111 (0.00434)	-0.00491 (0.00449)	0.00111 (0.00431)	-0.00480 (0.00414)
d2000	-0.00614 (0.00416)	-0.00790* (0.00422)	-0.00614 (0.00418)	-0.00842** (0.00416)
d2005	-0.00951* (0.00516)	-0.0118** (0.00517)	-0.00951* (0.00515)	-0.0127** (0.00504)
d2010	-0.0151*** (0.00491)	-0.0122** (0.00496)	-0.0151*** (0.00475)	-0.0130** (0.00482)
Constant	0.0503*** (0.00353)	0.0446*** (0.00362)	0.0503*** (0.00349)	0.0428*** (0.00388)
Observations	453	270	453	270
Adjusted R-squared	0.056	0.056	0.078	0.180

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1