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Growth in Regions

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Abstract

We use a newly assembled sample of 1,503 regions from 82 countries to compare the speed of per capita income convergence within and across countries. Regional growth is shaped by similar factors as national growth, such as geography and human capital. Regional convergence is about 2.5% per year, not more than 1% per year faster than convergence between countries. Regional convergence is faster in richer countries, and countries with better capital markets. A calibration of a neoclassical growth model suggests that significant barriers to factor mobility within countries are needed to account for the evidence.

1. Introduction

Since the fundamental work of Barro (1991), the question of convergence of income levels between countries has received enormous attention (Barro, Mankiw, and Sala-i-Martin 1995, Caselli, Esquivel and Lefort 1996, Aghion, Howitt, and Mayer-Foulkes 2005, Barro 2012). Several papers also analyze convergence between regions of the same country, as in the case of Japanese prefectures, Canadian provinces, Australian regions, Russian regions, or U.S. states (Barro and Sala-i-Martin 1991, 1992, 1995, Blanchard and Katz 1992, Cashin 1995, Coulombe and Lee 1995, Sala-i-Martin 1996, Ganong and Shoag 2012, Guriev and Vakulenko 2012, Spilimbergo and Che 2012), but data availability has limited this kind of exercises. In this paper, we systematically study regional convergence by using a large sample of sub-national regions. To this end, we expand the dataset from Gennaioli et al. (2013) by collecting time-series data on regional GDP. We end up with data on 1,503 regions in 82 countries. We then analyze the patterns of convergence among regions and compare them to convergence across countries.

There is substantial inequality among regions of the same country that needs to be understood. In Brazil, which is typical in terms of regional inequality, the mean (median) region has per capita income in 2009 of about US $ 6,400 (US $5,000), and the standard deviation of regional GDP per capita is $3,000. In the average country in our dataset, the richest region is 5.2 times richer than the poorest one (roughly the difference between the US and the Dominican Republic), but sometimes differences are more extreme. For example, GDP per capita in the richest Mexican state, Campeche, is 16.4 times higher than that in the poorest, Chiapas, a difference that is roughly similar to that between US and Pakistan in 2010. If we avoid extremely poor regions, which typically have small populations, and extremely rich regions, which typically have natural resources, inequality within countries is lower but still substantial. Moreover, poor countries display greater dispersion of regional GDP levels than rich countries. The average standard deviation of (log) per capita income in the 20 poorest countries is 1.74 times larger than the average dispersion of per capita income in the 20 richest countries (40% vs 24%).

Because these income differences summarize past growth trajectories, understanding the speed of regional convergence can shed light on the persistence of regional inequality. Going back to the example of

Brazil, if a region one standard deviation below the median catches up at Barro's "iron law" rate of 2% per year, it will need almost half a century to catch up with the median. In the meantime, inequality will persist. So, what is the speed of regional convergence? How does it compare to the speed of convergence between countries? What factors determine it? Is it consistent with patterns of regional inequality? Our data allows us to systematically address these four questions.

The focus on regional convergence also allows us to better assess the explanatory power of the neoclassical growth model. The estimates of cross-country convergence rates are potentially subject to severe omitted variable problems, owing to large heterogeneity between countries. This problem may be less severe in the case of subnational regions, which are more homogeneous than countries in terms of productivity, institutions, and access to technology.

To organize the discussion, we present a neoclassical model of regional growth related to the earlier work of Barro, Mankiw, and Sala-i-Martin (1995), Braun (1993), and Ganong and Shoag (2012). To account for persistent disparities in regional incomes, we incorporate into the model a stylized process of mobility of human and physical capital from regions where it is abundant to regions where it is scarce subject to an exogenous mobility friction. This model generates a modified growth equation, which predicts that the speed of regional convergence decreases in the severity of that mobility friction. The model also predicts that a region's per capita income growth should rise with country-level income to an extent that increases in factor mobility. Indeed, a region can attract more capital, and thus grow faster, if it is integrated into a richer country. Both of these predictions of the model are new and empirically testable.

When we estimate the growth equation derived from the model, we find that doubling country-level income increases regional growth by about 1.5%. We estimate regional convergence to be about 2.5% per year, slightly higher than the "iron law" rate of 2% advocated by Barro (2012). This estimate is not substantially affected by country fixed effects. This finding is somewhat puzzling. Barriers to the mobility of human and physical capital are arguably important across countries (Lucas 1990), but their role would a priori seem to be smaller within countries. This would imply, contrary to what we find, a much faster convergence rate within than between countries. To better interpret our regional findings, we directly

estimate cross country convergence in our sample. We find that the speed of national GDP per capita convergence is slightly faster than 1%. On the one hand, this is significantly slower, by about 1.5 percentage points, than the regional convergence rate, consistent with the basic prediction that barriers to factor mobility are higher between than within countries. On the other hand, the difference is not that big.

To compare our findings to Barro's (2012) directly, we also estimate our equation for regional growth using instrumental variables, with lagged GDP serving as an instrument for current GDP, which might be measured with error. The estimated regional convergence rate falls to 1.7%, but due to decline in sample size, not the use of IV. Nor can the finding that regional convergence is broadly comparable to national convergence be due to the omitted variables problem, which is surely less severe at the regional than at the national level. Omitted variables should if anything cause a relative overstatement of regional convergence. Contrary to the view that factors are significantly more mobile within than across countries, this evidence suggests that mobility (and thus convergence) often limited in both cases. Indeed, when we map our estimated coefficients into the parameters of our model, they point to rather slow mobility of capital in response to within-country return differentials. The five-year elasticity of migration to regional return differentials implied by our model is about 2. With nearly perfect mobility, our model predicts a much higher elasticity.

Motivated by this evidence, we focus empirically on limited within country resource mobility and try to assess whether it can indeed account for regional growth patterns. To measure limited mobility, one would ideally look at regional differences in goods prices and factor returns. These differences would capture both the intrinsic non-tradeability of some factors or goods, such as land and housing, and the presence of man-made barriers to mobility.[2] Unfortunately, the scarcity of data on regional prices prevents us from looking at price differentials. A feasible alternative is to directly look at the barriers to regional mobility of resources caused by non-integrated markets at the national level. To implement this approach,

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[2] Different limits to mobility have important consequences for welfare. In the case of non-tradeability of certain locally produced goods, such as housing, perfect mobility of labor would suffice to equalize the living standards of workers across regions (as differences in price levels would offset nominal income differences). Barriers to mobility of labor would in contrast entail differences in the living standards of workers across regions. In our analysis, we try to directly measure potential regulatory barriers to mobility and look at migration of productive factors.

we run regional convergence regressions by interacting regional GDP with proxies for national market institutions as well as government transfers. This allows us to analyze country-level correlates of the speed of regional convergence. Regional convergence is faster in richer countries, consistent with the latter having lower regional inequality. Regional convergence is also faster in countries with better-regulated capital markets. However, even the statistically significant determinants of the speed of convergence do not move the convergence rate much beyond Barro's "iron law".

We also collect direct evidence – for a small subsample of countries – on the share of employees, as well as of skilled employees, that are recent migrants. We show that these shares are on average rather small, consistent with limited mobility of human capital. However, in-migration is also faster into richer regions and in countries with better-regulated capital markets, consistent with our model.

As a final robustness check, we consider fixed effects estimates of growth regressions. From cross country studies, it is well known that fixed effect estimation boosts the speed of convergence. In our sample of countries, the introduction of country fixed effects in cross-country regressions increases national convergence rates by roughly 2 percentage points. If we include regional fixed effects in our regional growth regressions, the speed of convergence rises substantially, by anywhere from 2 to 9 percentage points. These differences notwithstanding, it is still the case that substantial within-country mobility barriers are required to make sense of the data. We concur with Barro (2012) that fixed effects estimates likely lead to a large Hurwicz bias, particularly at the sub-national level, where the omitted variable problem is much less severe. We therefore rely on OLS estimates.

The paper is organized as follows. Section 2 lays out a model of regional convergence and migration. Section 3 describes the data. Section 4 estimates the model's equations governing regional convergence, and its dependence on country-level factors. Section 5 interprets the model in light of the empirical findings. Section 6 concludes.

2. The Model

We present a model of convergence across regions that explicitly takes into account barriers to factor mobility. Time is discrete $t = 0, 1, \dots$. A country consists of a measure one of regions, indexed by $i \in [0,1]$ and characterized by regional total factor productivity (TFP) A_i and an initial per capita capital endowment $\hat{h}_{i,0}$. Capital here is a broad construct, combining human and physical inputs (we do not have data on regional physical capital). We distinguish a region's time t capital endowment $\hat{h}_{i,t}$ from the amount of capital $h_{i,t}$ employed at time t in the same region. The two will tend to differ owing to capital mobility.

If at time t region i employs an amount $h_{i,t}$ of capital per-capita, its output per capita $y_{i,t}$ is determined by a diminishing returns Cobb-Douglas technology:

$$y_{i,t} = A_i h_{i,t}^\alpha, \qquad \alpha < 1. \tag{1}$$

Regions with higher A_i are more productive, owing for instance to better geography or institutions. The competitive remuneration of capital is then equal to $w_{i,t} = \alpha A_i h_{i,t}^{\alpha-1}$. Under perfect mobility, this remuneration is equalized across regions, which implies:

$$h_{i,t}^{free} = \hat{A}_i \cdot h_t, \tag{2}$$

where $\hat{A}_i = \dfrac{A_i^{\frac{1}{1-\alpha}}}{\int A_i^{\frac{1}{1-\alpha}} di}$ captures region i's relative TFP and $h_t = \int \hat{h}_{i,t} di$ is the aggregate human capital in the country. Intuitively, return equalization occurs when relatively more productive regions employ more capital than less productive ones. In general, however, capital mobility costs prevent return equalization.

2.1 Migration and Human Capital Accumulation

To close the model, we must specify how human capital evolves over time, both in the aggregate and across regions. To obtain closed form solutions, in our main specification we assume that human capital depreciates fully in one period and that population growth is zero. When we interpret our estimates, we also consider a model with capital depreciation and population growth, which we analyze in Appendix 2. In the spirit of the Solow model, we assume that at time t region i invests an exogenous share s of income in education. The human capital endowment of region i at time $t + 1$ is then equal to:

$$\hat{h}_{i,t+1} \equiv s y_{i,t} = s A_i h_{i,t}^{\alpha}. \tag{3}$$

The aggregate human capital endowment at time $t+1$ is then $\int \hat{h}_{i,t+1} di = h_{t+1} = s \int A_i h_{i,t}^{\alpha} di$.

The link between the initial capital endowment $\hat{h}_{i,t+1}$ and employment $h_{i,t+1}$ depends on migration. Migration occurs after new capital is created but before production. If mobility costs are infinite, each region employs its endowment, so that $h_{i,t+1} = \hat{h}_{i,t+1}$. If mobility is perfect, the remuneration of human capital is equalized across regions and, by Equation (2), $h_{i,t+1} = \hat{A}_i \cdot h_{t+1}$. To capture in a tractable way intermediate degrees of mobility, we assume that the human capital employed in region i at time $t+1$ is given by:

$$h_{i,t+1} = v_{t+1} \cdot \left(\hat{h}_{i,t+1}\right)^{\tau} \left(\hat{A}_i \cdot h_{t+1}\right)^{1-\tau}, \tag{4}$$

where $\tau \in [0,1]$ and $v_{t+1} \equiv \dfrac{h_{t+1}^{\tau}}{\int (\hat{h}_{i,t+1})^{\tau} (\hat{A}_i)^{1-\tau} di}$ is a normalization factor common to all regions.

In equation (4), parameter τ proxies for mobility costs [3]. At $\tau = 1$, these costs are so high that there is no mobility at all. At $\tau = 0$, these costs are absent and the allocation of capital adjusts so that its remuneration is equalized across regions. In less extreme cases, there is an intermediate degree of mobility (and thus of convergence in returns). Equation (4) is admittedly ad-hoc, but it allows us to tractably account for the costs of capital mobility in the regressions.

2.2 Steady State and Growth Regressions

We can now explore the dynamics of our economy to derive the implications for growth regressions. Equation (1) implies that the growth rate of region i between times t and $t+1$ is given by $y_{i,t+1}/y_{i,t} = (h_{i,t+1}/h_{i,t})^{\alpha}$. Per capita income growth is pinned down by per capita human capital employment growth (i.e., post migration). From Equations (3) and (4), we can derive per capita capital growth:

$$\frac{h_{i,t+1}}{h_{i,t}} = v_{t+1} \cdot h_{i,t}^{\alpha\tau - 1} \cdot (s A_i)^{\tau} \left(\hat{A}_i \cdot s \cdot \int A_j h_{j,t}^{\alpha} dj\right)^{1-\tau}. \tag{5}$$

The growth rate of capital employment in region i increases in: i) the savings rate s, ii) the region's TFP, iii) aggregate investment $s \cdot \int A_j h_{j,t}^{\alpha} dj$. This growth rate decreases, due to diminishing returns, in the initial

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[3] In this one-good model, there is no trade in goods across regions, but in a multi-goods model of Hecksher-Ohlin type, imperfect capital mobility would be isomorphic to imperfect trade in goods.

capital stock $h_{i,t}$. The dynamics of the economy are identified by the evolution of the regions' capital endowment and migration patterns. These in turn determine the evolution of the aggregate human capital endowment h_t and output $y_t = \int A_i h_{i,t}^{\alpha} di$. The appendix proves the following result:

Proposition 1 *There is a unique steady state characterized by (non-zero) regional per capita incomes $(y_i^*)_i$ and aggregate per capita income $y^* = \int y_i^* di$. In this steady state, there is no migration. Starting from non-zero income, each region converges to this steady state according to the difference equation:*

$$\frac{y_{i,t+1}}{y_{i,t}} = s^{\alpha} \cdot v_{t+1}^{\alpha} \cdot A_i \cdot \hat{A}_i^{\alpha(1-\tau)} \cdot y_{i,t}^{\alpha\tau-1} \cdot y_t^{\alpha(1-\tau)}. \tag{6}$$

According to Proposition 1, per-capita income growth is temporary because diminishing returns cause regional incomes to eventually converge to their steady state values. In Appendix 2, we extend Equation (6) to the case of positive population growth and finite depreciation, which reduces per capita growth as in the standard Solow model.

By taking logs and relabeling terms, we can rewrite (6) as:

$$ln\left(\frac{y_{i,t+1}}{y_{i,t}}\right) = a_{t+1} + b_i - (1-\alpha\tau)ln y_{i,t} + \alpha(1-\tau)ln y_t + \epsilon_{i,t+1}, \tag{7}$$

where $\epsilon_{i,t+1}$ is a random shock hitting region i at time $t+1$.[4] This is our main estimating equation.

The constant b_i in Equation (7) captures region specific productivity: more productive regions should ceteris paribus grow faster. Indeed, according to the model, $b_i = [1 + \alpha(1-\alpha)(1-\tau)]ln(A_i)$, which increases in the region's TFP. This implies that, unless all determinants of productivity are controlled for, OLS estimation of (7) is subject to an omitted variables problem that creates a downward bias in the estimated convergence rate. This problem is severe in the context of cross country growth regressions, owing to large cross country differences in institutions, culture, etc. To overcome this difficulty, researchers have tried to use fixed effects estimates. It is however well known that this strategy creates a potentially severe opposite Hurwicz (1950) bias (especially in short time series), overstating the rate of convergence. Because of this bias, Barro (2012) and others prefer estimating cross country growth regression without

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[4] We view this random shock as stemming from a transitory (multiplicative) shock to regional productivity A_i.

country fixed effects. In the sub-national context, the case for not using regional fixed effects is much stronger than in cross country regressions (after country fixed effects are controlled for). Indeed, differences in institutions or culture are arguably small within countries and in any event much smaller than between countries. Accordingly, the bias from using fixed effects is much larger at the regional level. As a consequence, our preferred estimates for Equation (7) use OLS with country fixed effects. We however show how the results change when we use regional fixed effects.

According to equation (7), holding regional productivity constant, economic growth decreases in the initial level of income (recall that $\alpha\tau < 1$). This is the standard convergence result of neoclassical models, due to diminishing returns. The novel twist is that the speed of convergence $(1 - \alpha\tau)$ decreases with mobility costs (i.e. decreases in τ). Mobility of capital to poorer regions accelerates convergence. Finally, holding regional income constant, regional growth increases in aggregate per capita income y_t. This is also an implication of mobility: higher national income increases investment and thus the amount of capital available for employment in the region. The strength $\alpha(1 - \tau)$ of this effect falls in τ. In Section 5, we discuss how the interpretation of coefficients changes with conventional population growth and depreciation rates.

These effects are absent in conventional cross country studies because mobility costs are assumed to be prohibitive ($\tau = 1$). Of course, the quantitative relevance of capital mobility costs in a regional context is an empirical question, and the estimation of Equation (7) can shed light on these barriers to capital mobility.

The mobility parameter τ may vary across countries, owing to differences in factor market development and government transfers. We thus estimate Equation (7) by also allowing τ to vary across countries $c = 1,…,C$ according to the formula $\tau_c = 1 - \beta \cdot d_c$, where d_c is a proxy capturing the extent of factor market development or government transfers in country c and $\beta > 0$ is a parameter linking that proxy to the effective mobility cost. This leads to the interactive equation:

$$ln\left(\frac{y_{i,t+1}}{y_{i,t}}\right) = a_{t+1} + b_i - (1 - \alpha)lny_{i,t} - \alpha \cdot \beta \cdot d_c \cdot lny_{i,t} + \alpha \cdot \beta \cdot d_c \cdot lny_t + \epsilon_{i,t+1}. \qquad (8)$$

To assess the role of market development or government transfers in affecting regional convergence, we pick several empirical proxies d_c for each of these factors and then estimate Equation (8)

to back out parameters α and β. We can then link the speed of convergence to the inequality of regions within a country. By equation (8), and assuming that all regions (in all countries) are subject to the same variance σ of the random shock and that productivity differences induce a variance of region-specific constants equal to z, we can calculate that long run inequality across regions within a country c obeys:

$$Var(lny_{i,t}) = \frac{z + \sigma}{1 - \alpha^2} \frac{1}{(1 - \beta \cdot d_c)^2}. \tag{9}$$

Regional inequality is lower in countries with lower barriers to regional factor mobility (i.e. with higher d_c).

Finally, we conclude the theoretical analysis by mapping our mobility parameter τ into the elasticity of migration to return differentials. To do so, suppose that the economy is in a steady state with return w and region i experiences a drop in its wage level to $w_i < w$. This situation represents a developed economy that has already converged but faces an adverse shock in one region. Starting from an initial factor endowment $h_{i,0}$, out migration adjusts the actual resources stock to h_i, to satisfy:

$$ln\left(\frac{h_i}{h_{i,0}}\right) = -\frac{1 - \tau}{1 - \alpha} \cdot ln\left(\frac{w}{w_{i,0}}\right) = -\frac{\beta \cdot d_c}{1 - \alpha} \cdot ln\left(\frac{w}{w_{i,0}}\right). \tag{10}$$

Equation (10) characterizes the percentage outmigration flow from region i as a function of the return differential. The coefficient $\frac{1-\tau}{1-\alpha}$ has the intuitive interpretation of "elasticity of outmigration" to the return difference $w/w_{i,0}$. For given τ, elasticity increases in α: when returns are less diminishing, under perfect mobility capital is allocated more unequally. This boosts mobility in Equation (4) and thus the elasticity of migration in Equation (10). Our regional regressions provide values for the parameters α and τ that can be used to obtain a reference value for the elasticity in (10). This reference value can be compared to direct estimates obtained from developed economies to evaluate whether our regressions are consistent with higher mobility frictions in developing countries.

3. Data

Our analysis is based on measures of regional GDP, years of schooling, and geography in up to 1,503 regions in 82 countries for which we found regional GDP data. We begin by gathering GDP data at the most disaggregated administrative division available (typically states or provinces), or, when such data does not

exist, at the most disaggregated statistical division level (e.g. the Eurostat NUTS in Europe) for which such data is available. During our sample period (see below), the number of regions with GDP data increased in 35 of the countries in our sample. For example, GDP data for the three Northwest Territories of Canada (i.e. Nova Scotia, Nunavut, and Yukon) was reported as an aggregate before 1998 and broken down for each of the 3 territories after that. To make the data comparable across time, we compute all of our statistics for the regions that existed during the period when GDP first became available (see the online Appendix 1 for a list of the regions in our dataset and how they map into existing administrative and statistical divisions). Figure 1 shows that our sample coverage is extensive outside of Africa.

We collect as much yearly data on regional GDP as possible. Table 1 lists the years for which we have been able to find regional GDP data and shows that typically there are gaps in the data. For example, regional GDP for Brazilian states is available for 1950-1966, 1970, 1975, 1980, and 1985-2009. The average country in our sample has regional GDP data for 19.2 time points spanning 32.3 years. We first convert all regional GDP data into (current purchasing power) USD values by multiplying national GDP in PPP terms by the share of each region in national GDP and then use regional population to compute per capita GDP in each region. Regional price deflators are generally unavailable. We then follow the standard practice and compute the 5-year growth rate of per capita GDP for each region (e.g., Barro 2012).

Next we gather data on the highest educational attainment of the population 15 years and older, primarily from population censuses (see online Appendix 2 for a list of sources). We estimate the number of years of schooling associated with each level of educational attainment. Specifically, we use UNESCO data on the duration of primary and secondary school in each country and assume: (a) zero years of school for the pre-primary level, (b) 4 additional years of school for tertiary education, and (c) zero additional years of school for post-graduate degrees. We do not use data on incomplete levels because it is only available for about half of the countries in the sample. For example, we assume zero years of additional school for the lower secondary level. For each region, we compute average years of schooling as the weighted sum of the years of school required to achieve each educational level, where the weights are the fraction of the population aged 15 and older that has completed each level of education.

Table 1 lists the years for which we have data on educational attainment. Data on years of schooling is typically available at ten year intervals. In some cases, data on educational attainment starts after regional GDP data. For example, data on regional educational attainment for Argentinian provinces starts in 1970 while regional GDP data is available for 1953. In our empirical work, we use interpolated data on years of schooling matching 80% (25,383/31,705) of the region-year observations with regional GDP.

Finally we collect data on geography, natural resources, and the disease environment as proxies for unobserved differences in productivity. The Appendix describes the variables in detail, here we summarize them briefly. We use three measures of geography computed directly from GIS maps. They include the area of each region, the latitude for the centroid of each region, and the (inverse) average distance between cells in a region and the nearest coastline. We use data from the USGS World Petroleum Assessment Data to estimate per capita cumulative oil and gas production. We measure the disease environment using GIS data on the dominant vector species of mosquitoes from Kisezewski et al. (2004) to capture the component of malaria variation that is exogenous to human intervention. Lastly, we keep track of the region of the country's capital city.

Table 2 presents a full list of the 82 countries in the sample, with the most recent year for which we have regional data. The countries are listed in the order from poorest to richest. Table 2 also reports per capita regional income in the poorest, 25th percentile, 50th percentile, 75th percentile, and the richest region in each country, as well as the ratio of richest to poorest, and 75th to 25th percentile regions. Several points come out in the data. First, if we look across countries, inequality is immense. The 2010 GDP per capita of Norway, the richest country in our sample, is 55 times higher than that of Mozambique, the poorest. Even in the middle of the distribution there is substantial inequality among countries. The 2010 GDP per capita in Spain, at the 75th percentile, is 6.3 times higher than that of Paraguay, at the 25th percentile. Second, inequality is smaller but still substantial within countries. At the extreme, in Venezuela, the 1990 GDP per capita in Falcón is 46 times higher than that in Trujillo ($21,422 vs $466). To put this difference in perspective, Trujillo is not much richer than Liberia, the poorest African country at that time, and Falcón is similar to Mississippi, the poorest US state. Similar patterns of inequality show up in Russia, Mexico, and

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other countries with extremely wealthy mining and exploration regions. Using the Theil index to measure inequality, it is possible to compare the extent of regional inequality to country-level inequality. The Theil population-weighted index of inequality of GDP per capita is .54, of which .45 can be attributed to between country inequality, and .09 to within-country regional inequality. Put differently, within-country regional inequality explains roughly 10% of total world income inequality. Although country-level inequality takes the lion's share, regional inequality is substantial even from the vantage point of world income inequality.

Third, inequality within countries is much lower if we compare 75th and 25th percentile regions. In Venezuela, the ratio of incomes in 75th and 25th percentile regions is only 2.8; it is 1.7 in Russia and 1.6 in Mexico. Clearly, enormous within-country inequality is driven to a substantial extent by natural resources. Fourth, even ignoring the extremes, regional inequality within countries is substantial and appears to decline with development. The ratio of incomes of 75th to 25th percentile regions is 1.68 in the poorest countries, but declines to 1.44 in the richest ones. The standard deviation of (log) GDP per capita is 39% in the poorest 20 countries, but declines to 23% in the richest 20 countries.

To understand these patterns of inequality within countries, we try to see how they evolve over time. To this end, we use our model to assess the speed of convergence and its determinants.

4. Estimation Results

We now present our basic empirical results across both regions and countries. The estimation of Equation (7) with OLS implicitly assumes that regional income $y_{i,t}$ is uncorrelated with the error term. The problem is that regional productivity differences, in this case absorbed by the error term, would create a positive correlation between regional income and growth, giving the misleading impression of little (or no) convergence. Various studies have dealt with this problem in a variety of ways, none perfect, ranging from including many controls for productivity differences to fixed effects estimation. Following the recommendation of Barro (2012), our basic results do not include country fixed effects in cross-country regressions and region fixed effects in cross-region regressions. As we show in the robustness section, such fixed effects estimates lead to much faster convergence rates, but probably for spurious econometric

reasons (Hurwicz 1950, Nickell 1981).   Barro (2012) also uses lagged per capita GDP as an instrument for current per capita GDP to address an errors-in-variables concern.   For comparability purposes, we also present results using instrumental variables, which make little difference for parameter estimates but sharply cut sample size.

To begin, Table 3 presents the basic regional regressions, using all the data we have. Following Barro (2012), we estimate panel regressions with 5-year growth rates of real per capita regional GDP as dependent variables. To get at convergence, we control for beginning of period levels of per capita income. To get at spillovers from national income, which are implied by our model, we also control for national per capita GDP at the beginning of the period. To take into account the fact that different regions might have different steady states, we use the usual geographic controls, such as latitude, inverse distance to coast, malaria ecology, log of the cumulative oil and gas production, log of population density, and a dummy for whether the national capital is in the region. In some specifications, we also control for the beginning of each 5-year period years of education in the region.

In the first three columns of Table 3, we present results with no fixed effects at all. In the next three columns, we control for country fixed effects. Because it is customary to insert in growth equations time controls accounting for variation of growth rates over time (again, see Barro 2012), in column (7) we also include year fixed effects. Finally, we present the IV specification in column (9), and the OLS specification for the same (smaller) sample in column (8).

The results on control variables in Table 3 confirm some well-known findings. Without country fixed effects, latitude, inverse distance to coast, natural resource endowments, and population density all influence regional growth rates in expected ways. The economic significance of these four variables on per capita GDP growth ranges from .5 percentage points for a one-standard deviation increase in latitude to .15 percentage points for a one-standard deviation increase in oil. These results are much weaker, or disappear, when country fixed effects are controlled for. There is also a strong result, even with country fixed effects, that regions that include a national capital have grown about .8% faster during this period.

The main result of OLS specifications in Table 3 is the confirmation of the "iron law" convergence rate of about 2.5% - 3% per year in this regional sample. Without country fixed effect, we also find that doubling the country's per capita income raises the region's growth rate by about 1.7%, consistent with our model. Interestingly, the inclusion of country fixed effects leaves the convergence coefficient almost unaffected, while rendering regional controls such as geography insignificant. This suggests that the regional information contained in the controls is accounted for by country fixed effects, but the latter in turn contain little additional information relative to the controls themselves. Consistent with our priors, the omitted variable bias does not appear to be very large at the regional level once country effects are controlled for.

Years of education also enter significantly in the regional growth regressions, with the usual sign. Increasing average education by 5 years (a big change) raises the annual growth rate by between 1% (without country fixed effects) and 3% (with country fixed effects), depending on the specification. This effect of education on regional growth is consistent with the standard findings in a cross-section of countries (Barro 1991, Mankiw, Romer, and Weil 1992), but also with the cross-sectional evidence that differences in education explain by far the largest share of differences in per capita incomes across regions within countries (Gennaioli et al. 2013).

Column (8) presents the OLS results with country and year fixed effects on the smaller sample for which we can instrument GDP with lagged GDP. The estimated convergence rate drops to 1.8% per year for this smaller sample. Column (9) presents an IV regression similar to Barro (2012), but for regions. The use of instrumental variables for regional data does not materially affect the convergence rate, now estimated at 1.9%. Since IV has a minor impact on convergence, we emphasize the OLS estimates for a larger sample.

The estimates of the average convergence rate hide substantial heterogeneity among countries. Some of the most rapidly growing countries in the sample, such as India, China, and Chile, actually exhibit regional divergence. Later in the paper, we investigate national determinants of convergence rates.

The results obtained from the estimation of Equation (7) are quite surprising. Even a regional convergence rate of 3% is not much higher than the cross country convergence rate documented by Barro (2012). In principle, one might think that mobility of human and physical capital should be much higher

within than across countries, leading to much faster convergence across region than across countries. To see whether this finding is not an artifact of our sample, and thus to better compare regional and national convergence, Table 4 presents the basic cross-country results for the 89 countries in our sample that have per capita GDP data going back to at least the year 1965. Columns (1)-(4) include no fixed effects, whereas in column (5) we include year fixed effects. Column (6) shows the results where income is instrumented with past income. We take data from the standard period over which these results are usually considered, 1960-2010. We use 5-year economic growth rates as independent variables. We use beginning-of-the-period national income to get at convergence. We use the same geographic controls as in Table 3 and, consistent with the earlier literature, find several statistically significant effects, especially for inverse distance to coast. In the context of national growth, we cannot identify the spillover effect predicted by Equation (7), and so we exclude world income in specifications with year fixed effects.

In specifications including only geographic controls, the estimated convergence rate between countries is only .3% to .4%. However, as we add additional controls, especially life expectancy, investment-to-GDP, and fertility (which of course are correlated with initial per capita income), we can raise estimated convergence rates to about 1.7% per year in OLS specifications. An instrumental variable specification in column (6) yields a very similar 1.7%, showing that, again, IV does not matter. These are somewhat slower than regional convergence rates, but comparable to Barro's estimated "iron law" rate of 2%. We also find that greater human capital is associated with faster growth when we control for geography but not when we add additional controls such as life expectancy, investment-to-GDP, and fertility.

We draw two tentative conclusions from these specifications. First, a comparison of estimated convergence rates in Tables 3 and 4 points to higher estimates within countries than between countries, by about 1% per year, in OLS specifications. This result is supportive of the model because: i) resources such as human and physical capital are more mobile within than between countries, and ii) productivity differences between regions of a country are likely to be smaller than those between countries, which implies that the downward bias of the estimated convergence rate is likely smaller in within-country estimates. Both considerations imply that convergence should be faster at the regional than at the national level. The

second message emerging from our estimates is that, although higher, the rate of convergence between regions is puzzlingly close to that estimated between countries. In this sense, the OLS difference in these convergence rates of about 1% can be viewed as an upper bound on the role of regional mobility.[5]

To evaluate the role of mobility more precisely, we can use the results of Table 3 to infer the structural parameters of the model, and in particular assess the mobility frictions entailed by our estimates. Recall that this table uses both cross-regional variation in initial incomes, and some residual cross-country variation, to estimate convergence. The (negative of the) coefficient on beginning-of-period income is an estimate of the "convergence" rate $(1 - \alpha\tau)$ in Equation (7), while the coefficient on national income is an estimate of "aggregate externality" $\alpha(1 - \tau)$ in Equation (7). In effect, we have two equations with two unknowns. These estimates suggest, roughly, that α = .99 and τ = .98. In other words, the data suggests a model in which broadly defined human and physical capital captures the lion's share of national income and there are significant barriers to capital mobility. The high value of α is in the ballpark of standard estimates for the income share remunerating physical and human capital. The most puzzling finding is instead the high within-country mobility cost implied by τ = .98. We later come back to these parameter values to discuss their implications for the elasticity of migration in Equation (10). For now, we just note that, even within countries, the approximate model in which every sub-national region converges at its own speed seems to be a good approximation. In Section 5, we show that these results are robust to accounting for population growth and depreciation of capital.

In light of these puzzling findings, several questions arise. First, can we directly measure the limits to within- country mobility? Second, can these limits shed light on the slow regional convergence documented in Table 3? Third, is the directly measured factor mobility within countries slow and particularly so in countries with high measured barriers to mobility? In the remainder of our empirical analysis, we address these questions.

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[5] A 1% difference in convergence rates has a substantial impact on the length of time to converge. For example, per capita GDP in the poorest region in the median country in our sample is 40% below the country mean. Closing that gap would take 25 years at a 2% convergence rate but only 17 years at a 3% convergence rate.

Theoretically, there are two broad sources of limited factor mobility (and thus of slow convergence among regions). One is the presence of non-tradable sectors, such as housing and services. Another is the presence of artificial barriers to factor mobility across regions. Because in both cases there is a departure from the law of one price, one could use regional differences in goods or factor prices to measure limits to mobility. However, since we do not have data on regional prices, we cannot measure mobility barriers in this way. Of course, price differences across regions also imply that real income differences between regions are smaller than what we measure without using regional price deflators.[6]

An alternative strategy to measure limits to mobility is to try to find direct proxies for legal and regulatory barriers to factor mobility across regions. At first sight, this seems counterintuitive, since we typically think of human and physical capital as being highly mobile within countries. Lucas (1990) has famously asked why physical capital does not move across international borders. Reasons include the lack of proper institutions and of complementary factors of production, such as human capital, in poor countries. In the regional context, the latter explanation itself relies on lack of mobility of human capital. Although institutional differences are minimal within countries (and do not explain differences in regional development, Gennaioli et al. 2013), limited mobility may be the consequence of a country's overall market infrastructure, such as the extent of regulation of financial, labor and goods markets. Inappropriate country-wide regulations can create barriers to factor mobility and can be measured directly.

To get at this issue, we proxy for the barriers to factor mobility using the following measures of a country's market infrastructure: an index of the regulation of domestic financial markets from Abiad, Detragiache and Tressel (2008), an index of international trade tariffs from Spilimbergo and Che (2012), an index of labor regulations from Aleksynska and Schindler (2011). We also use a dummy equal to 1 if the country's laws are of English Legal Origin. According to La Porta et al. (2008), English Legal Origin is a broad indicator of a market-supporting regulatory stance. To assess whether the public sector has a direct effect on regional convergence, we also proxy for determinants of mobility using two measures of redistribution: a

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[6]In particular, if labor and capital are perfectly mobile, their real remuneration would be equalized across regions. Although accounting for regional price differences is crucial to assess living standards, it is less important for our main goal, which is to analyze productivity differences across regions.

measure of government transfers and subsidies as a fraction of total government spending, and the ratio of government spending to GDP. Finally, we check Lucas's hypothesis by investigating the role of regional human capital in affecting mobility and thus the region's speed of convergence.

To evaluate the role of different mobility barriers in shaping the speed of regional convergence, we estimate Equation (8) by interacting the (log) level of regional GDP by using the previously described institutional variables as proxies for d_c in Equation (8). Lucas' hypothesis is tested by replacing d_c with a region specific interactive variable: the region's human capital as proxied by its average level of schooling. As first step, we check how the rate of regional convergence depends on the (log) level of GDP in the country (formally, this is akin to setting $d_c = y_c$). All regressions include country fixed effects to capture time-invariant determinants of productivity.[7]

The results of this exercise are reported in Table 5. All regressions include our standard geography controls, regional per capita GDP, country fixed effects, and proxies for d_c entered separately. In Panel A, the regressions also include the interaction between each proxy and regional GDP per capita. In Panel B, we add to the previous specification the level of GDP per capita as well as the interaction between regional and national GDP per capita. The regressions omit the interaction between national GDP per capita and proxies for d_c, because national and regional GDP per capita are highly correlated.[8]

Begin with Panel A. We find that higher (log) GDP per capita is associated with faster regional convergence (see Column 1, Panel A). To interpret the economic magnitude of the coefficients, consider a region with GDP per capita of $800 in a country with a GDP per capita of $1,000 (roughly the level of Tanzania). Our estimates suggest that boosting national GDP per capita by 20% while keeping regional per capita GDP constant at $800 adds .53 percentage points to the hypothetical region's growth rate. Columns 2 to 8 in Panel A introduce one at the time the interactions with proxies for national market infrastructure and

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[7] We also tried: (1) an index of the regulation of capital flows from Abiad, et al. (2008), (2) an index of the regulation of the banking from Abiad, et al. (2008), (3) an index of capital controls from Schindler (2009), and (4) the number of months of severance payments for a worker with 9 years of tenure on the job from Aleksynska et al. (2011).

[8] Formally, the regressions in Panel A of Table 5 do not include the term $\alpha \cdot \beta \cdot d_c \cdot ln y_t$ appearing in Equation (8). The reason is that national and regional incomes are strongly correlated. As a result, having a set of interactions between national income and country-level determinants of the speed of convergence creates multicolinearity problems. Nevertheless, the results on interactions are qualitatively similar if we add national income as a control (Table 5B).

government transfers. These regressions indicate that more liberalized financial markets, lower international trade tariff rates, and higher government transfers all increase the speed of convergence. To quantify these effects, consider again a hypothetical region with GDP per capita of $800. Our estimates then suggest that this hypothetical region grows 3.02 percentage points faster when the domestic finance (de)regulation index is two standard deviations higher than the sample average, 2.66 percentage points faster when tariffs are two standard deviations below their sample average, and 5.76 percentage points faster when government transfers are two standard deviations higher than the sample average.[9] The results generally support the model's prediction that frictions slow the convergence rate. The exception is the effect of common law since it implies that – despite having more favorable market infrastructure --- the convergence rate is 1.31 percentage points *lower* in common law countries than in civil law ones.

Because the interaction term is typically negative, the economic magnitudes of these effects tend to decline sharply with GDP per capita (the effect of English Legal Origin is the exception). For example, a region with per capita GDP of $8,000 grows .91 (vs 3.02) percentage points faster when the domestic finance (de)regulation index is two standard deviations higher than the sample average, .76 (vs 2.66) percentage points faster when tariffs are two standard deviations below their sample average, and 1.44 (vs 5.76) percentage points faster when government transfers are two standard deviations higher than the sample average. In contrast, there is no evidence that the speed of convergence is associated with labor regulation or government expenditure. Although the effect of English Legal Origin remains puzzling, these results suggest that economic and financial development, international trade, and government transfers may, ceteris paribus, reduce regional inequality.

Because the quality of market infrastructure and government redistribution may be products of economic development, in Panel B we include these proxies while controlling for the interaction between regional and national per capita GDP as well as the level of (log) per capita GDP. Neither trade tariffs nor government transfers play a role here. The coefficient of the interaction between regional GDP and both

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[9] Results are qualitatively similar for the index of capital controls (i.e. 9.13 percentage points faster growth when the index of capital controls is two standard deviations above its average) and the index of banking regulation (i.e. 12.67 percentage point faster growth when the index of banking regulation is two standard deviations above its average).

the domestic financial regulation index and English Legal Origin are roughly unchanged and remain statistically significant, while the interactions between regional GDP and both trade and government transfers lose statistical significance. Financial market infrastructure emerges as a robust predictor of faster regional convergence.

Next, we investigate the role of regional human capital in promoting regional convergence. We find no evidence that the rate of convergence (as opposed to regional growth rate per se) varies with regional education. The results in the last column of Panel A show that while regional education has a large impact on the growth rate of GDP per capita, the interaction term between regional education and GDP per capita is insignificant (and remains insignificant in Panel B).

Having documented that proxies for mobility barriers are indeed correlated with slower regional convergence, we now directly look at the role factor movements: is regional factor mobility particularly slow in countries having stronger market barriers? To get a rough estimate of the magnitude of human capital mobility between regions, we use census data for 26 countries. These data enable us to calculate the share of each region's population over the age of 15 that has arrived in the previous 5 years from a different region. They also enable us to calculate the share of college-educated workers who have recently arrived in the total number of college-educated.

Table 6 presents these results. Panel 6A reports the raw data, showing that, in an average region in this sample, only 3.8% of the adults are recent migrants, although in Mongolia in particular, this share is much higher. The average share of recent college-educated migrants is a much higher but still modest 8.1%, and high not only in Mongolia but also in Spain, South Africa, and France.

Panel 6B presents the simple regressions of the determinants of in-migration into each region. In-migration is lower into densely populated regions, which might reflect housing costs. Total in-migration in a region also increases with the region's relative income, although not for the subset of college educated workers. Critically, though, the responsiveness of total in-migration to relative per capita GDP is fairly muted: in-migration adds 1.2 percentage points to the population of a region that doubles its per capita GDP relative to the national level. In Panel 6C we run a finer test, considering how total in-migration is

related to the previously used measures of a country's market infrastructure. In-migration is higher in countries having less regulated financial and goods markets, consistent with the idea that better market infrastructure fosters human capital mobility. Consistent with Lucas's hypothesis, in-migration increases with the level of education of the region. These preliminary results are consistent with our finding of slow convergence: human capital at least does not move too fast. Of course, we have no data on the movement of physical capital, which might be faster.

In sum, the results in this section indicate – quite surprisingly -- that the speed of regional convergence is not substantially faster than that of national convergence. In part, this seemingly puzzling phenomenon may be due to differences in standards of living across regions, which we cannot measure in our dataset. Our analysis, however, points to a complementary possibility, namely the presence of sub-national barriers to the mobility of human and physical capital across regions. In particular, the data point to the importance of poorly developed financial markets as one of the factors slowing down mobility.

Before interpreting these findings in light of our model, we briefly discuss their robustness with respect to the inclusion of regional fixed effects. In a regional context, this is akin to introducing a region-specific constants b_i, consistent with Equation (7). Barro (2012) urges against the use of such estimates because of the strong bias toward faster estimated convergence in short panels (see Nickell 1981). As previously noted, we agree with Barro, but show the results for completeness.

Table 7 presents the results. The estimated regional convergence rates jump to the neighborhood of 11% (see columns 2-4 in Table 7A) while the estimated national convergence rates now range from 3% to 4.6% (see columns 2-4 in Table 7B). Our regional convergence results are of the same order of magnitude as the 10% annual cross-country convergence rate estimated by Caselli et al. (1996) for growth using instrumental variables, but in all likelihood overestimate the speed of convergence. The coefficient on national income also rises sharply (see Panel A), indicating large spillovers from national income to regional growth. Interestingly, even these much higher, and likely biased, parameter estimates imply relatively low rates of mobility of full capital. The estimates suggested by column (2) of Panel A, for example, imply $\alpha = .98$ and $\tau = .91$. At the substantive level, even with no bias for omitted productivity differences

between regions, the data suggest relatively low factor mobility at least with respect to the frictionless benchmark of $\tau = 0$ – a result substantially at odds with the proposition that broad capital is freely mobile within countries.

Although the finding of low factor mobility within countries is surprising, the convergence rates suggested by fixed effects regressions are implausibly high, and inconsistent with the evidence of persistent regional inequality. At 11% annual convergence rates, the regional disparities that we observe in the data would quickly become small (assuming of course, that productivity differences across regions are modest). In the next section, we summarize the implications of our findings for the parameters of the model and patterns of regional inequality.

5. Taking Stock

Our estimation results – summarized by the estimates in Table 3 – imply values for the structural parameters α and τ that point to significant limits to regional mobility. While the value of α is reasonable, placed in a narrow range between 0.95 (in columns 6 and 7) and 0.99 (columns 2 and 3), the values of τ are puzzlingly large, located in a narrow range between 0.98 (in columns 2 and 3) and 1.02 (columns 6 and 7). We now investigate the implication of these findings for: i) the elasticity of migration to return differentials, ii) the country-level variation in mobility frictions, and thus iii) country-level variation in regional inequality.

Equation (10) provides a direct way to map α and τ into an estimate for the elasticity of migration to return differentials. The latter is in fact given (1-τ)/(1-α). Given the value of α = 0.99, if $\tau = 0.98$ the elasticity of capital migration (or, equivalently, employment) equals 2. Because in our regressions we measure growth over five year intervals, the value 2 should be interpreted as the elasticity of migration over a five-year period of persistent return differentials. Across countries, Ortega and Peri (2009) find an elasticity of migration of roughly 0.3 to one-year changes in destination country income, while Barro and Sala-i-Martin (1991) surprisingly find a number close to zero within the United States. Braun (1993) extends Barro/Sala-i-Martin results to a sample regions within 6 wealthy countries, and finds an even lower elasticity of migration than in the US in five of them, and comparable in one (Japan). Our results on migration in Table

6 are indicative of a low elasticity. If barriers to mobility are higher across than within countries, 0.3 should be viewed as a lower bound on the one-year elasticity for regional mobility of workers. Perhaps more fundamentally, because our notion of capital includes both human and physical capital, we should expect the empirical counterpart of Equation (10) to be quite high, reflecting the relatively high mobility of physical capital. The elasticity of factor mobility implies by Equation (10) is very sensitive to the value of τ. If τ drops from 0.98 to 0.95 elasticity more than doubles from 2 to 5. Given the scant evidence on the elasticity of migration of different forms of capital, these numbers should be viewed as very preliminary.

On the other hand, our estimates allow us to examine the country-level determinants of mobility frictions τ. As we just discussed, τ affects the elasticity of factor mobility and thus the speed of convergence. With all the usual caveats attached to cross-country regressions, in Table 5 finance emerges as a key factor that explains differences in factor mobility costs. The estimate of the role of finance in Panel A is again consistent with the value $\alpha=0.99$ but it further implies that β, the parameter shaping the gradient of mobility costs with respect to our financial market indicator, is roughly equal to 0.02 (indeed, parameter estimates for the finance-income interaction imply $\alpha\beta = 0.016$). This implies that the elasticity of capital mobility to return differentials should be equal to 0 in a country with fully repressed financial markets ($d_c = 0$) and to 2 in a country financial markets are fully liberalized ($d_c = 1$).

What do these values imply for the impact of financial frictions on the speed of regional convergence and on the steady state level of regional inequality? Our estimates indicate that fully liberalizing financial markets increases the convergence rate by 1.6 percentage points. This suggests that financial development can play an important role in the process of regional convergence. At the same time, it indicates that financial development alone cannot break the shackles of the iron law: the maximum convergence rate equals 2.8% (=0.0127+0.0157), and has a modest impact on the number of years that it takes for the per capita GDP of a poor region to catch up to the national average. In sum, the mobility attained with fully liberalized financial markets is still far from ensuring fast regional convergence.

Can finance account for cross country patterns of regional income disparities? For $\alpha = 0.99$ and $\beta = 0.02$, Equation (9) implies the variance of log regional GDP in a country with repressed financial markets ($d_c=$

0) is 2.95 times larger than in a country with fully liberalized financial markets ($d_c = 1$). Unlike in the case of the speed of convergence, variation in financial liberalization exerts a large impact on the dispersion of regional GDP. In our data, the average variance of log GDP per capita is 19% among the 20 poorest countries and 8% among the 20 richest ones. The average d_c for the poorest 20 countries in our sample is .34; that for the richest 20 is .70, implying the dispersion of regional GDP pc in the former 1.4 times larger than that in the latter. The model can thus explain roughly 60% of the 2.4 fold difference in measures of regional income dispersion.

Finally, we examine how the mapping between the structural parameters and the estimated coefficients changes when we relax the assumptions that capital depreciates fully in one period ($\delta=1$) and that population growth is zero ($n=0$). As we show in Appendix 2, in the more general case with the population growth rate n and depreciation rate δ, the speed of convergence equals $(\delta + n) \cdot (1 - \alpha\tau)$ and the coefficient on national per capita GDP is $(\delta + n) \cdot \alpha \cdot (1 - \tau)$. In this case, backing out α and τ from estimated coefficients requires making an explicit assumption on $\delta + n$. Note that our main estimating equation (7) holds exactly when $\delta+n$ equals 1. In the more general case, the convergence coefficients are based on a log-linear approximation around the steady state. We assume that the *annual* growth rate of population is 2% (i.e., roughly equal to the average growth rate of the world population during the period 1960-2010) and that the *annual* depreciation rate is 6% in line with the depreciation of physical capital (e.g. see Caselli 2005). Next, we combine the assumption that $\delta+n$ equals 40% over a five-year period (=5x(2%+6%)) with the coefficients from estimating the empirical analogue of our preferred specification (i.e. column 3 of Table 3) for 5-year growth rates of regional GDP per capita. The results suggest that $\alpha = 0.89$ and $\tau = 0.95$.[10] These estimates for τ imply that relaxing the assumption that $\delta + n = 1$ does not lead to regional convergence rates that are meaningfully faster than at the national level (i.e. regional convergence rates for τ equal to 0.8 are still about one percent faster than under the benchmark suggested by $\tau = 1$). Accordingly, our finding of substantial limits to within country factor mobility is robust to allowing for conventional value of population growth and the depreciation rate of the capital stock.

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[10] Alternatively, setting δ+n equal to 8% per year, the estimated coefficients from our basic specification for the *annual* growth rate of regional per capita GDP as the dependent variable implies that α equals 0.98 and τ is 0.78.

6. Conclusion

Our analysis of growth and convergence in 1,503 regions of 82 countries allows for some tentative conclusions. First, regional growth is shaped by some of the same key factors as national growth, namely geography and human capital. Second, our estimated annual rate of regional convergence of 2.5% per year is similar to Barro's "iron law" of 2%. These regional convergence estimates are about 1% per year higher than what we estimate for countries, but still raise a key puzzle of why the flow of capital between regions of a country is so slow. Third, regional growth and convergence are faster in richer countries, consistent with the prediction of our neoclassical model that the national supply of capital benefits regional investment and growth. Fourth, among the national factors correlated with the speed of regional convergence is capital market regulation: countries with better regulation exhibit faster convergence. This finding is again consistent with the notion that frictions within countries limit capital flows and convergence. The facts on persistent regional inequality and slow convergence thus line up with each other, but they do leave open the puzzle of why resource flows within countries are typically so slow.

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Appendix 1.

Proof of Proposition 1.

At time t+1, the employment of capital in region i is equal to $h_{i,t+1} = v_{t+1} \cdot (\hat{h}_{i,t+1})^\tau (\hat{A}_i \cdot h_{t+1})^{1-\tau}$.

By replacing in this expression the capital endowment $\hat{h}_{i,t+1} \equiv sy_{i,t} = sA_i h_{i,t}^\alpha$, and the aggregate capital

shock $h_{t+1} = s \int A_i h_{i,t}^\alpha di$, we obtain that the growth of employed capital in region i is equal to:

$$\frac{h_{i,t+1}}{h_{i,t}} = v_{t+1} \cdot h_{i,t}^{\alpha\tau-1} \cdot (sA_i)^\tau \left(\hat{A}_i \cdot s \cdot \int A_i h_{i,t}^\alpha di \right)^{1-\tau},$$

which is Equation (5) in the text.

A steady state in the economy is a configuration of regional employment $(h_i^*)_i$ and an entailed

aggregate capital employment $h^* = s \int A_i (h_i^*)^\alpha di$ such that the steady state capital h_r^* in any region r is:

$$1 = v^* \cdot (h_r^*)^{\alpha\tau-1} \cdot (sA_r)^\tau \left(\hat{A}_r \cdot s \cdot \int A_i (h_i^*)^\alpha di \right)^{1-\tau},$$

where v^* is the normalization factor in the steady state. This can be rewritten as:

$$(h_r^*)^{1-\alpha\tau} = A_r^{\tau-(1-\alpha)(1-\tau)} \cdot v^* \cdot s \cdot \left(\frac{\int A_i (h_i^*)^\alpha di}{\int A_i^{1-\alpha} di} \right)^{1-\tau}. \tag{A.1}$$

There is always an equilibrium in which $h_i^* = 0$ for all regions i. Once we rule out this possibility, the

equilibrium is interior and unique. In fact, Equation (A.1) can be written as $h_r^* = A_r^{\frac{\tau-(1-\alpha)(1-\tau)}{1-\alpha\tau}} \cdot C$, where C is

a positive constant which takes the same value for all regions, where such value depends on the entire

profile of regional capital employment levels. Because the capital employed in a region does not affect (has

a negligible impact on) the aggregate constant C, there is a unique value of h_r^* fulfilling the condition. By

plugging the value of h_r^* into the expressions for v^* and $\int A_i (h_i^*)^\alpha di$, one can find that for $\alpha < 1$ and $\tau < 1$,

there is a unique value of C that is consistent with equilibrium.

Finally, given the fact that $y_{i,t+1}/y_{i,t} = (h_{i,t+1}/h_{i,t})^\alpha$, the economy approaches the interior steady

state according to Equation (5) in the text.

Appendix 2. Convergence coefficients for generic values of depreciation and population growth.

Our main analysis assumes a zero rate of population growth ($n = 0$) and full depreciation ($\delta = 1$). Focusing on this case allowed us to obtain an exact closed form for our main estimating equation. We now perform a log-linear approximation to derive convergence coefficients when n and δ are generic.

In region i, the growth of per capita GDP between periods t and $t + 1$ is equal to $ln(y_{i,t+1}/y_{i,t})$ which, by the assumed production function, is equal to $\alpha ln\left(\frac{h_{i,t+1}}{h_{i,t}}\right) \cong \alpha\left(\frac{h_{i,t+1}}{h_{i,t}} - 1\right)$. There is a direct link between a region's income growth and the growth of the region's per capita capital employment.

Let us therefore find the law of motion for $h_{i,t}$ for generic values of n and δ. Denote by $\widehat{H}_{i,t}$ the capital endowment of region i at time t, and by $H_{i,t}$ the same region's employment of capital. The law of motion for $\widehat{H}_{i,t}$ then fulfills:

$$\widehat{H}_{i,t+1} = sA_iH_{i,t}^\alpha L_{i,t}^{1-\alpha} + (1 - \delta) \cdot \widehat{H}_{i,t}.$$

The capital stock next period is equal to undepreciated capital $(1 - \delta) \cdot \widehat{H}_{i,t}$ plus this period's savings $sA_iH_{i,t}^\alpha L_{i,t}^{1-\alpha}$. To express the equation in per capita terms, we can devide both sides of the above equation by the region's population $L_{i,t}$ at time t and obtain:

$$\frac{\widehat{H}_{i,t+1}}{L_{i,t}} \equiv \frac{\widehat{H}_{i,t+1}}{L_{i,t+1}} \cdot \frac{L_{i,t+1}}{L_{i,t}} \equiv \hat{h}_{i,t+1}(1 + n) =$$

$$sAh_{i,t}^\alpha + (1 - \delta) \cdot \hat{h}_{i,t}.$$

The law of motion of the region's per capita capital endowment can be approximated as:

$$\hat{h}_{i,t+1} \cong sA_ih_{i,t}^\alpha + (1 - \delta - n)\hat{h}_{i,t}. \qquad (A.2)$$

To solve for regional GDP growth, we need to transform the above equation into a law of motion for regional capital employment $h_{i,t}$. To do so, we can exploit our migration equation (4) to write:

$$\hat{h}_{i,t} = \left(h_{i,t}\right)^{\frac{1}{\tau}} \cdot \left(\hat{A}_i \cdot h_t\right)^{-\frac{1-\tau}{\tau}} \cdot (v_t)^{-\frac{1}{\tau}}.$$

By plugging the above equation into $(A.2)$ we then obtain, after some algebra, the following equation:

$$\frac{h_{i,t+1}}{h_{i,t}} - 1 \cong \left[sA_ih_{i,t}^{\frac{\alpha\tau-1}{\tau}} \cdot (v_t)^{\frac{1}{\tau}} \cdot \left(\hat{A}_i \cdot h_t\right)^{\frac{1-\tau}{\tau}} + (1 - \delta - n)\right]^\tau \cdot \left[\frac{h_{t+1}}{h_t}\right]^{1-\tau} \cdot \left[\frac{v_t}{v_{t+1}}\right] - 1.$$

By noting that the aggregate capital stock grows at the rate $(h_{t+1}/h_t) = s(y_t/h_t) + (1 - n - \delta)$, we can rewrite the above law of motion as:

$$\frac{h_{i,t+1}}{h_{i,t}} - 1 \cong \left[sA_i h_{i,t}^{\frac{\alpha\tau-1}{\tau}} \cdot (v_t)^{\frac{1}{\tau}} \cdot \left(\hat{A}_i \cdot h_t\right)^{\frac{1-\tau}{\tau}} + (1 - \delta - n) \right]^{\tau} \cdot [s(y_t/h_t) + (1 - n - \delta)]^{1-\tau} \cdot \left[\frac{v_t}{v_{t+1}}\right] - 1.$$

A steady state is identified by the condition $h_{i,t+1} = h_{i,t} = h_{i,SS}$ and thus $h_{t+1} = h_t = h_{SS}$. Because in the steady state there is no migration, and the human capital endowment of a region is also equal to its ideal employment level, we also have that $v_{t+1} = v_t = 1$. As a result, the steady state is identified by the following conditions:

$$sA_i h_{i,SS}^{\frac{\alpha\tau-1}{\tau}} \cdot \left(\hat{A}_i \cdot h_{SS}\right)^{\frac{1-\tau}{\tau}} = (\delta + n),$$

$$s(y_{SS}/h_{SS}) \equiv s\left(\int A_i h_{i,SS}^{\alpha} / h_{SS}\right) = (n + \delta).$$

If we log-linearize with respect to regional employment $h_{i,t}$ and national output y_t the right hand side of the law of motion of $h_{i,t}$ around the steady state above, we find that for any $\tau > 0$ we can write the following approximation:

$$\frac{h_{i,t+1}}{h_{i,t}} - 1 \cong -(\delta + n) \cdot (1 - \alpha\tau) \cdot \ln\left(\frac{h_{i,t}}{h_{i,SS}}\right) + (\delta + n) \cdot (1 - \tau) \cdot \ln\left(\frac{y_t}{y_{SS}}\right).$$

By exploiting the fact that $ln\left(\frac{y_{i,t+1}}{y_{i,t}}\right) \cong \left(\frac{y_{i,t+1}}{y_{i,t}} - 1\right) \cong \alpha \cdot \left(\frac{h_{i,t+1}}{h_{i,t}} - 1\right)$, we can then write:

$$\frac{y_{i,t+1} - y_{i,t}}{y_{i,t}} \cong -(\delta + n) \cdot (1 - \alpha\tau) \cdot \ln\left(\frac{y_{i,t}}{y_{i,SS}}\right) + (\delta + n) \cdot \alpha \cdot (1 - \tau) \cdot \ln\left(\frac{y_t}{y_{SS}}\right).$$

As a result, the speed of convergence is equal to $(\delta + n) \cdot (1 - \alpha\tau)$ and regional growth increases in country level income with coefficient $(\delta + n) \cdot \alpha \cdot (1 - \tau)$. These coefficient boil down to those obtained under the exact formulas of our model when $(\delta + n) = 1$ (and thus when, as assumed in the model, $\delta = 1$ and $n = 0$). When, on the other hand, $(\delta + n) \neq 1$, the mapping between our estimates and the economy's "deep" parameters will be different, entailing different values for α and τ.
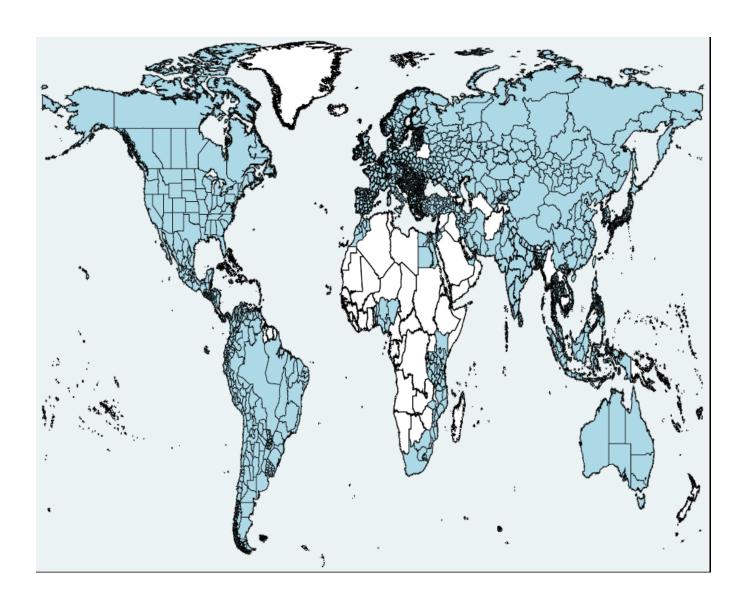
Figure I: Sample Coverage

Table 1: Sample Coverage for GDP and Years of schooling

Country	Data on GDP Sample Period	Data on Years of Schooling Sample Period
Albania	1990,2001,2009	1989, 2001
Argentina	1953,1970,1980,1993-2005	1970, 1980, 1991, 2001, 2010
Australia	1953,1976,1989-2008	1966, 2006
Austria	1961-1992,1995-2008,2010	1964, 1971, 1981, 1991, 2001, 2009
Bangladesh	1982,1993,1995,1999,2005	1981, 2001
Belgium	1960-1968,1995-2010	1961, 2001
Benin	1992,1998,2004	1992, 2002
Bolivia	1980-1986,1988-2010	1976, 1992, 2001
Bosnia and Herzegovina	1963,2010	1961, 1991
Brazil	1950-1966,1970,1975,1980,1985-2009	1950, 1960, 1970, 1980, 1991, 2000, 2010
Bulgaria	1990,1995-2010	1965, 1992, 2011
Canada	1956,1961-2011	1961, 1971, 1981, 1991, 2001, 2006
Chile	1960-2001,2008-2010	1960, 1970, 1982, 1992, 2002
China	1952-1978,1982,1985,2006-2010	1982, 1990, 2000, 2010
Colombia	1950,1960-2010	1964, 1973, 1985, 1993, 2005
Croatia	1963,2000-2009	1961, 2001
Czech Republic	1993,1995-2010	1993, 2011
Denmark	1970-1991,1993-2010	1970, 2006
Ecuador	1993,1996,1999,2001-2007	1962, 1974, 1982, 1990, 2001, 2010
Egypt, Arab Rep.	1992,1998,2007	1986, 1996, 2006
El Salvador	1996,1999,2002,2010	1992, 2007
Estonia	1996-2009	1997, 2009
Finland	1960,1970,1983-1992,1995-2010	1960, 1980, 1985, 2010
France	1950,1960,1962-1969,1977-2010	1962, 1968, 1975, 1982, 1990, 1999, 2006
Germany, East	1991-2010	1970, 1971, 1981, 1987, 2009
Germany, West	1950,1960,1970-2010	1970, 1971, 1981, 1987, 2009
Greece	1970,1974,1977-2008,2010	1971, 1981, 1991, 2001
Guatemala	1995,2004,2005,2006,2007,2008	1994, 2002
Honduras	1988-2003	1988, 2001
Hungary	1975,1994-2002,2007-2010	1970, 2005
India	1980-1993,1999-2010	1971, 2001
Indonesia	1971,1983,1996,2004-2010	1971, 1976, 1980, 1985, 1990, 1995, 2000, 2005, 2010
Ireland	1960,1979,1991-2010	1966, 1971, 1979, 1981, 1986, 1991, 1996, 2002, 2006
Italy	1950,1977,1978-1996,2001,2007,2010	1951, 1961, 1971, 1981, 1991, 2001
Japan	1955-1965,1975-2003,2006-2009	1960, 2000, 2010
Jordan	1997,2002,2010	1994, 2004
Kazakhstan	1990-2010	1989, 2009
Kenya	1962,2005	1962, 1989, 1999, 2009
Korea, Rep.	1985-2010	1970, 1975, 1980, 1985, 1990, 1995, 2000, 2005, 2010
Kyrgyz Republic	1996-2000,2002-2007	1989, 1999, 2009
Latvia	1995-2006	1989, 2001
Lesotho	1986,1996,2000	1976, 2006
Lithuania	1995-2010	1989, 2001
Macedonia	1963,1990,2000-2009	1989, 2001
Malaysia	1970,1975,1980,1990,1995,2000,2005-2010	1970, 1980, 1991, 2000
Mexico	1950,1960,1970,1975,1980,1993-2010	1950, 1960, 1970, 1990, 1995, 2000, 2005, 2010
Mongolia	1989,1990-2004,2006-2007,2010	1989, 2000
Morocco	1990, 2000-2010	2004
Mozambique	2000-2009	1997, 2007
Nepal	1999,2006	2001
Netherlands	1960,1965,1995-2010	2001
Nicaragua	1974,2000,2005	2001
Nigeria	1992,2008	1991, 2006
Norway	1973,1976,1980,1995,1997-2005,2009-2010	1960, 2010
Pakistan	1970-2004	1973, 1981, 1998
Panama	1996-2007	1960, 1970, 1980, 1990, 2000, 2010
Paraguay	1992,2002,2008	1992, 2002
Peru	1970-1995,2001-2010	1961, 1993, 2007
Philippines	1975,1980,1986-1987,1992,1997,2006-2009	1970, 1990, 1995, 2000, 2007
Poland	1990,1995-2010	1970, 2002
Portugal	1977-2008,2010	1960, 1981, 1991, 2001, 2011
Romania	1995-2008	1977, 1992, 2002
Russian Federation	1995-2009	1994, 2010
Serbia	1963,2002	1961, 2002
Slovak Republic	1995-2010	1991, 2001, 2011
Slovenia	1963,1995-2010	1961, 2002, 2011
South Africa	1970,1975,1980-1989,1995-2010	1970, 1996, 2001, 2007
Spain	1981-2008,2010	1981, 1991, 2001
Sri Lanka	1990,1991,1993,1995,1997,1999,2001,2003,2005,2009-2010	1981, 2001
Sweden	1985-2008,2010	1985, 2010
Switzerland	1965,1970,1975,1978,1980-1995,1998-2005	1970, 1980, 1990, 2000, 2010
Tanzania	1980,1985,1990,1994,2000-2010	1978, 1988, 2002
Thailand	1981-2009	1970, 1980, 1990, 2000
Turkey	1975-2001	1965, 1985, 1990, 2000
Ukraine	1990,2004-2010	1989, 2001
United Arab Emirates	1981-1982,1988-1991,2001-2009	1980, 2005
United Kingdom	1950,1960,1970,2010	1951, 1991, 2001
United States	1950-2010	1960, 1970, 1980, 1990, 2000, 2005
Uruguay	1961,1991-2002	1963, 1975, 1985, 1996, 2006
Uzbekistan	1995-2005	1989
Venezuela	1950,1961,1971,1981,1990	1971, 1981, 1990, 2001
Vietnam	1990,1995,2000,2006,2008	1989, 1999, 2009

Table 2: Dispersion of Regional GDP per capita

Country	Year	Minimum	25th pctl	Mean	75th pctl	Maximum	75th pctl / 25th pctl	Max/Min	Ctry GDP / World
Mozambique	2009	$423	$475	$768	$860	$2,033	1.8	4.8	0.06
Nepal	2006	$647	$754	$917	$993	$1,258	1.3	1.9	0.08
Bangladesh	2005	$760	$819	$995	$1,037	$1,830	1.3	2.4	0.10
Tanzania	2010	$727	$780	$1,125	$1,311	$2,615	1.7	3.6	0.10
Lesotho	2000	$675	$766	$923	$1,178	$1,228	1.5	1.8	0.10
Kenya	2005	$669	$703	$1,765	$1,798	$4,472	2.6	6.7	0.11
Benin	2004	$600	$798	$1,171	$1,529	$1,542	1.9	2.6	0.12
Kyrgyz Republic	2007	$967	$1,123	$2,154	$2,533	$4,870	2.3	5.0	0.15
Nigeria	2008	$1,149	$1,461	$1,929	$2,398	$2,736	1.6	2.4	0.15
Uzbekistan	2005	$1,178	$1,398	$1,917	$2,321	$3,203	1.7	2.7	0.17
Pakistan	2004	$1,585	$1,606	$1,836	$2,067	$2,261	1.3	1.4	0.17
Vietnam	2008	$1,249	$1,588	$2,120	$2,619	$4,504	1.6	3.6	0.20
India	2010	$1,453	$2,853	$4,713	$5,611	$12,831	2.0	8.8	0.24
Nicaragua	2005	$1,410	$1,700	$1,908	$1,888	$3,023	1.1	2.1	0.25
Philippines	2009	$1,484	$1,552	$3,101	$2,936	$9,631	1.9	6.5	0.27
Honduras	2003	$1,733	$1,991	$2,733	$3,340	$3,984	1.7	2.3	0.27
Mongolia	2010	$867	$1,177	$2,154	$2,309	$8,044	2.0	9.3	0.28
Indonesia	2010	$934	$2,447	$4,103	$3,704	$16,115	1.5	17.2	0.30
Morocco	2010	$2,399	$2,834	$3,357	$3,889	$4,871	1.4	2.0	0.33
Paraguay	2008	$2,361	$2,982	$3,748	$4,307	$7,443	1.4	3.2	0.34
Guatemala	2008	$1,756	$2,510	$4,591	$6,049	$14,331	2.4	8.2	0.34
Bolivia	2010	$2,863	$3,153	$4,097	$4,619	$7,716	1.5	2.7	0.34
Sri Lanka	2010	$2,411	$2,847	$3,434	$3,378	$6,451	1.2	2.7	0.36
Egypt, Arab Rep.	2007	$3,463	$4,118	$4,381	$4,606	$5,417	1.1	1.6	0.39
Jordan	2010	$3,178	$3,723	$4,133	$4,425	$5,717	1.2	1.8	0.41
El Salvador	2010	$3,890	$4,465	$5,229	$5,754	$8,401	1.3	2.2	0.47
Ukraine	2010	$2,646	$3,520	$5,084	$6,048	$17,454	1.7	6.6	0.47
Ecuador	2007	$3,095	$3,892	$5,585	$5,738	$20,777	1.5	6.7	0.53
China	2010	$3,127	$5,249	$8,012	$9,974	$17,622	1.9	5.6	0.53
Thailand	2009	$1,982	$2,817	$7,215	$6,269	$52,001	2.2	26.2	0.58
Bosnia and Herzegovina	2010	$3,760	$4,571	$5,829	$6,184	$12,575	1.4	3.3	0.58
Albania	2009	$4,932	$5,578	$6,338	$6,617	$10,846	1.2	2.2	0.60
Serbia	2002	$1,612	$4,517	$5,466	$6,318	$9,439	1.4	5.9	0.66
Colombia	2010	$3,125	$4,147	$6,311	$7,019	$14,876	1.7	4.8	0.66
Peru	2010	$2,382	$3,511	$6,008	$6,965	$16,401	2.0	6.9	0.67
Macedonia	2009	$3,542	$4,618	$6,713	$7,798	$11,762	1.7	3.3	0.73
South Africa	2010	$5,836	$6,279	$7,048	$7,817	$8,659	1.2	1.5	0.74
Brazil	2009	$2,909	$3,848	$6,426	$8,978	$12,113	2.3	4.2	0.76
Uruguay	2002	$3,640	$5,142	$6,156	$6,917	$10,745	1.3	3.0	0.78
Turkey	2001	$1,989	$4,598	$6,215	$7,467	$14,759	1.6	7.4	0.85
Kazakhstan	2010	$3,489	$7,237	$12,986	$13,681	$43,931	1.9	12.6	0.85
Bulgaria	2010	$5,600	$6,403	$8,028	$8,355	$23,397	1.3	4.2	0.90
Panama	2008	$2,737	$3,857	$6,797	$5,335	$17,713	1.4	6.5	0.90
Argentina	2005	$3,704	$4,651	$10,179	$12,652	$28,358	2.7	7.7	0.91
Romania	2008	$4,911	$6,684	$8,772	$10,260	$26,242	1.5	5.3	0.91
Mexico	2010	$5,130	$8,033	$13,442	$12,823	$84,158	1.6	16.4	0.98
Venezuela	1990	$466	$3,790	$7,677	$10,741	$21,422	2.8	46.0	1.05
Malaysia	2010	$4,098	$7,451	$11,086	$13,515	$20,500	1.8	5.0	1.07
Russian Federation	2009	$2,528	$7,770	$12,995	$13,017	$64,254	1.7	25.4	1.09
Chile	2010	$4,878	$8,324	$13,189	$14,874	$42,174	1.8	8.6	1.14
Latvia	2006	$3,048	$5,550	$8,030	$9,082	$21,320	1.6	7.0	1.18
Lithuania	2010	$6,243	$9,098	$11,555	$13,473	$21,935	1.5	3.5	1.22
Croatia	2009	$8,207	$10,597	$12,694	$12,933	$26,079	1.2	3.2	1.29
Estonia	2009	$7,272	$8,264	$10,744	$11,120	$25,738	1.3	3.5	1.30
Hungary	2010	$7,552	$10,737	$13,548	$14,964	$35,690	1.4	4.7	1.33
Poland	2010	$11,220	$12,370	$15,196	$17,380	$26,612	1.4	2.4	1.36
Slovak Republic	2010	$10,558	$15,024	$20,018	$20,665	$45,815	1.4	4.3	1.57
Portugal	2010	$15,903	$17,040	$19,974	$20,423	$27,260	1.2	1.7	1.69
Czech Republic	2010	$16,586	$18,431	$21,581	$21,383	$49,908	1.2	3.0	1.85
Greece	2010	$17,072	$18,537	$21,459	$22,887	$32,612	1.2	1.9	1.88
Slovenia	2010	$16,155	$18,857	$21,866	$23,494	$35,628	1.2	2.2	1.96
Korea, Rep.	2010	$16,738	$21,924	$25,703	$30,724	$34,461	1.4	2.1	2.09
Spain	2010	$12,173	$21,554	$25,677	$29,765	$39,849	1.4	3.3	2.10
Italy	2010	$18,167	$21,283	$27,252	$32,654	$36,672	1.5	2.0	2.12
France	2010	$24,439	$25,312	$27,901	$28,074	$48,123	1.1	2.0	2.31
Japan	2009	$19,510	$25,290	$27,581	$29,208	$52,074	1.2	2.7	2.38
Finland	2010	$24,781	$28,561	$32,086	$37,851	$39,964	1.3	1.6	2.45
Denmark	2010	$19,873	$23,268	$36,691	$53,383	$61,723	2.3	3.1	2.53
United Kingdom	2010	$25,515	$27,239	$31,067	$32,761	$46,666	1.2	1.8	2.57
Belgium	2010	$23,055	$24,405	$31,586	$33,740	$49,930	1.4	2.2	2.57
Germany, West	2008	$26,532	$28,755	$34,692	$38,602	$52,740	1.3	2.0	2.63
Germany, East	2010	$26,631	$27,256	$27,290	$27,304	$27,983	1.0	1.1	2.63
Sweden	2010	$28,711	$30,328	$32,718	$33,526	$48,285	1.1	1.7	2.67
Australia	2010	$32,602	$37,430	$43,708	$53,063	$56,915	1.4	1.7	2.68
Canada	2011	$27,987	$29,726	$37,224	$39,928	$55,356	1.3	2.0	2.70
Austria	2010	$25,457	$33,379	$37,438	$40,304	$50,553	1.2	2.0	2.76
Ireland	2010	$22,393	$23,793	$30,186	$43,553	$44,459	1.8	2.0	2.82
Netherlands	2010	$29,929	$31,916	$36,799	$41,398	$47,625	1.3	1.6	2.89
Switzerland	2005	$26,290	$30,636	$37,728	$40,397	$78,885	1.3	3.0	3.10
United States	2010	$32,190	$35,999	$41,080	$44,123	$73,257	1.2	2.3	3.29
United Arab Emirates	2009	$13,253	$17,188	$37,176	$53,496	$112,294	3.1	8.5	3.63
Norway	2010	$37,442	$40,568	$45,860	$47,061	$89,007	1.2	2.4	3.67

Table 3: Determinants of Regional Growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ln(GDP pc Region)	-0.0104[a]	-0.0244[a]	-0.0262[a]	-0.0207[a]	-0.0254[a]	-0.0305[a]	-0.0299[a]	-0.0181[a]	-0.0199[a]
	(0.0022)	(0.0064)	(0.0066)	(0.0048)	(0.0070)	(0.0070)	(0.0072)	(0.0046)	(0.0062)
Ln(GDP pc Country)		0.0169[a]	0.0163[a]		0.0097	-0.0072	-0.0180	0.0044	0.0062
		(0.0061)	(0.0061)		(0.0103)	(0.0117)	(0.0168)	(0.0047)	(0.0052)
Latitude	0.0004[a]	0.0003[a]	0.0002[c]	0.0002	0.0003	0.0002	0.0002	0.0004[b]	0.0004[b]
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0002)
Inverse Distance to Coast	0.0361[c]	0.0412[b]	0.0537[a]	0.0116	0.0192	0.0272[c]	0.0259[b]	0.0363	0.0374
	(0.0189)	(0.0194)	(0.0168)	(0.0136)	(0.0168)	(0.0140)	(0.0125)	(0.0218)	(0.0225)
Malaria Ecology	0.0003	0.0006	0.0007	0.0010	0.0012	0.0014	0.0014	0.0009	0.0009
	(0.0007)	(0.0007)	(0.0009)	(0.0009)	(0.0010)	(0.0011)	(0.0011)	(0.0011)	(0.0011)
Ln(Cum Oil & Gas Prod)	0.1879[c]	0.2370[b]	0.1862[c]	0.1117	0.1145	0.0571	0.0488	0.0153	0.0250
	(0.1000)	(0.1158)	(0.1019)	(0.0879)	(0.0967)	(0.0909)	(0.0916)	(0.0691)	(0.0777)
Ln(Population density)	0.0019[b]	0.0020[b]	0.0010	0.0005	0.0005	-0.0013	-0.0015[c]	0.0004	0.0004
	(0.0008)	(0.0008)	(0.0007)	(0.0005)	(0.0006)	(0.0010)	(0.0009)	(0.0010)	(0.0010)
Capital is in Region	0.0008	0.0087[b]	0.0090[b]	0.0122[a]	0.0150[a]	0.0124[a]	0.0120[a]	0.0046	0.0054
	(0.0030)	(0.0038)	(0.0038)	(0.0034)	(0.0045)	(0.0046)	(0.0036)	(0.0043)	(0.0042)
Years of Education			0.0018[b]			0.0064[a]	0.0067[a]	0.0025[b]	0.0026[b]
			(0.0008)			(0.0020)	(0.0022)	(0.0011)	(0.0011)
Constant	0.0959[a]	0.0673[a]	0.0833[a]	0.1954[a]	0.1459[b]	0.3119[a]	0.3496[a]	0.1116[a]	0.1113[a]
	(0.0157)	(0.0127)	(0.0197)	(0.0392)	(0.0665)	(0.0864)	(0.1066)	(0.0294)	(0.0291)
Observations	7,772	7,772	6,651	7,772	7,772	6,651	6,651	4,136	4,136
Adjusted R^2	6%	8%	9%	7%	8%	10%	17%	9%	9%
Number of countries	82	82	82	82	82	80	80		
Within R^2				7%	8%	10%	17%		
Between R^2				7%	8%	6%	7%		
Fixed Effects	None	None	None	Country	Country	Country	Ctry, Year	None	None
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV
Instrument	NA	NA	NA	NA	NA	NA	NA	NA	Lagged GDP

Table 4: Determinants of National GDP Growth
(Countries that have initial GDP data no later than 1965)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(GDP pc Ctry)	-0.0043[a]	-0.0029[c]	-0.0050[b]	-0.0177[a]	-0.0165[a]	-0.0169[a]	-0.0173[a]	-0.0160[a]
	(0.0015)	(0.0015)	(0.0021)	(0.0021)	(0.0020)	(0.0021)	(0.0023)	(0.0022)
Ln(GDP pc World)		-0.0160[a]	-0.0233[a]	-0.0400[a]			-0.0381[a]	0.0000
		(0.0052)	(0.0062)	(0.0066)			(0.0081)	(0.0000)
Latitude	0.0003[a]	0.0002[a]	0.0002[b]	-0.0000	-0.0000	-0.0000	0.0001	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Inverse Distance to Coast	0.1389[a]	0.1281[a]	0.1222[a]	0.0251	0.0279	0.0280	0.0285	0.0387
	(0.0320)	(0.0315)	(0.0340)	(0.0235)	(0.0234)	(0.0235)	(0.0551)	(0.0545)
Ln(Cum Oil & Gas Prod)	-0.0003	-0.0015	-0.0017	0.0019	0.0014	0.0017	0.0029	0.0030
	(0.0025)	(0.0025)	(0.0025)	(0.0037)	(0.0035)	(0.0036)	(0.0034)	(0.0035)
Malaria Environment	-0.0009[a]	-0.0008[a]	-0.0007[a]	-0.0006[b]	-0.0004	-0.0004	-0.0016[b]	-0.0013[c]
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0007)	(0.0006)
Years Education			0.0016[b]	-0.0004	-0.0007	-0.0006	-0.0000	-0.0002
			(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0009)	(0.0009)
1/(life expectancy at birth)				-1.9446[a]	-2.2905[a]	-2.3255[a]	-0.6167	-1.1106
				(0.6455)	(0.6296)	(0.6319)	(0.9993)	(0.9462)
Fertility				-0.0264[a]	-0.0258[a]	-0.0261[a]	-0.0306[a]	-0.0304[a]
				(0.0046)	(0.0046)	(0.0047)	(0.0064)	(0.0062)
Law and Order				0.0137[c]	0.0126	0.0127[c]	0.0107	0.0080
				(0.0073)	(0.0076)	(0.0077)	(0.0074)	(0.0075)
Investment-to-GDP ratio				0.0723[a]	0.0730[a]	0.0732[a]	0.0556[a]	0.0563[a]
				(0.0125)	(0.0130)	(0.0131)	(0.0169)	(0.0173)
Government-consumption-to-GDP ratio				-0.0577[b]	-0.0445[c]	-0.0451[c]	-0.0659	-0.0551
				(0.0276)	(0.0267)	(0.0268)	(0.0434)	(0.0422)
Openess				0.0061[b]	0.0050[c]	0.0051[c]	0.0093[b]	0.0080[b]
				(0.0027)	(0.0028)	(0.0028)	(0.0038)	(0.0037)
(Change in terms of trade) x Openess				0.0231	0.0187	0.0191	-0.0020	-0.0074
				(0.0152)	(0.0153)	(0.0154)	(0.0229)	(0.0218)
Democracy				0.0124[b]	0.0085[c]	0.0088[c]	0.0280	0.0155
				(0.0051)	(0.0048)	(0.0048)	(0.0305)	(0.0283)
Democracy Squared				-0.0010[a]	-0.0007[b]	-0.0007[b]	-0.0265	-0.0191
				(0.0003)	(0.0003)	(0.0003)	(0.0268)	(0.0254)
Inflation				-0.0042[a]	-0.0037[a]	-0.0037[a]	-0.0020	-0.0013
				(0.0012)	(0.0013)	(0.0013)	(0.0018)	(0.0016)
Constant	0.0485[a]	0.1731[a]	0.2439[a]	0.5476[a]	0.2268[a]	0.2306[a]	0.5148[a]	0.2158[a]
	(0.0122)	(0.0404)	(0.0524)	(0.0664)	(0.0216)	(0.0219)	(0.0822)	(0.0298)
Observations	868	868	868	868	868	868	536	536
Adjusted R^2	7%	8%	9%	27%	27%	31%	22%	28%
Number of countries	89	89	89	89	89	89	54	54
Fixed Effects	No	No	No	No	Year	Year	Year	Year
Instrumental Variables	None	None	None	None	None	Lagged GDP	None	None

Table 5: Country-level determinants of the speed of convergence

Panel A: Basic Specification

	Ln(GDP pc)	English Legal Origin	Financial Regulation	Trade	Labor	Transf / Gov	Gov / GDP	Yrs Educ (Regional)
Ln(GDP pc Region)	0.0413[b]	-0.0237[a]	-0.0127[a]	-0.0127	-0.0068	-0.0027	-0.0138	-0.0256[a]
	(0.0207)	(0.0056)	(0.0038)	(0.0091)	(0.0121)	(0.0163)	(0.0090)	(0.0082)
Interaction Var	0.0818[a]		0.1574[a]	0.1583[b]	0.1379	0.4302[b]	0.1343	0.0154[b]
	(0.0296)		(0.0340)	(0.0625)	(0.1806)	(0.2119)	(0.1922)	(0.0066)
Ln(GDP pc Region) x Interaction Var	-0.0078[a]	0.0131[b]	-0.0157[a]	-0.0159[b]	-0.0196	-0.0439[b]	-0.0197	-0.0011
	(0.0026)	(0.0065)	(0.0034)	(0.0074)	(0.0209)	(0.0216)	(0.0202)	(0.0007)
Latitude	0.0004	0.0003	0.0001	0.0002	0.0003	0.0003	0.0002	0.0003
	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0005)	(0.0002)	(0.0002)
Inverse Distance to Coast	0.0164	0.0073	0.0158	0.0182	0.0209	0.0082	0.0146	0.0281[b]
	(0.0165)	(0.0122)	(0.0152)	(0.0175)	(0.0125)	(0.0261)	(0.0149)	(0.0138)
Malaria Ecology	0.0011	0.0007	0.0011	0.0012	0.0013	-0.0010	0.0011	0.0015
	(0.0010)	(0.0007)	(0.0010)	(0.0010)	(0.0009)	(0.0012)	(0.0009)	(0.0011)
Ln(Cum Oil & Gas Prod)	0.1340	0.0961	0.1054	0.1320	0.1662	0.0545	0.1197	0.0803
	(0.1039)	(0.0954)	(0.1009)	(0.0831)	(0.2042)	(0.1380)	(0.0842)	(0.1036)
Ln(Population density)	0.0003	0.0005	0.0001	0.0003	-0.0007	-0.0003	0.0003	-0.0013
	(0.0007)	(0.0005)	(0.0008)	(0.0007)	(0.0007)	(0.0011)	(0.0006)	(0.0010)
Capital is in Region	0.0160[a]	0.0122[a]	0.0146[a]	0.0144[a]	0.0160[a]	0.0251[a]	0.0138[a]	0.0147[a]
	(0.0048)	(0.0033)	(0.0039)	(0.0040)	(0.0052)	(0.0051)	(0.0035)	(0.0035)
Constant	-0.4644[b]	0.1932[a]	0.1219[a]	0.1174	0.0952	0.0246	0.1524[c]	0.2085[a]
	(0.2227)	(0.0361)	(0.0308)	(0.0716)	(0.1023)	(0.1489)	(0.0790)	(0.0657)
Observations	7,772	7,772	5,492	6,180	2,697	2,158	7,040	6,651
Adjusted R[2]	18%	16%	17%	17%	19%	26%	16%	20%
Fixed Effect	Country	Country	Country	Country	Country	Country	Country	Country

Table 5: Determinants of the speed of convergence (continued)

Panel B: Control for both level and interactions of GDP per capita

	Ln(GDP Country)	English Legal Origin	Financial Regulation	Trade	Labor	Transf / Gov	Gov / GDP	Yrs Educ (Regional)
Ln(GDP pc Region)	0.0413[b]	0.0397[c]	0.0037	-0.0024	-0.0288	0.0836[c]	0.0606[a]	0.0687[c]
	(0.0207)	(0.0201)	(0.0273)	(0.0208)	(0.0429)	(0.0496)	(0.0227)	(0.0357)
Ln(GDP pc Country)	0.0818[a]	0.0841[a]	-0.0173	0.0035	-0.0442	0.0712	0.1032[a]	0.1037[b]
	(0.0296)	(0.0300)	(0.0293)	(0.0360)	(0.0541)	(0.0604)	(0.0374)	(0.0521)
ln(GDP pc Region) x Ln(GDP pc Country)	-0.0078[a]	-0.0080[a]	-0.0017	-0.0013	0.0028	-0.0106[c]	-0.0101[a]	-0.0128[b]
	(0.0026)	(0.0026)	(0.0032)	(0.0035)	(0.0046)	(0.0058)	(0.0033)	(0.0053)
Interaction Var			0.1375[a]	0.1184	0.1713	0.2834	-0.0889	-0.0094
			(0.0388)	(0.1051)	(0.1609)	(0.2213)	(0.1552)	(0.0116)
Ln(GDP pc Region) x Interaction Var		0.0146[b]	-0.0109[b]	-0.0106	-0.0218	-0.0273	0.0063	0.0020
		(0.0058)	(0.0045)	(0.0123)	(0.0195)	(0.0228)	(0.0170)	(0.0014)
Latitude	0.0004	0.0004	0.0001	0.0002	0.0002	0.0004	0.0003	0.0002
	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0004)	(0.0002)	(0.0003)
Inverse Distance to Coast	0.0164	0.0117	0.0087	0.0148	0.0206	0.0080	0.0185	0.0238[c]
	(0.0165)	(0.0156)	(0.0143)	(0.0177)	(0.0130)	(0.0265)	(0.0168)	(0.0129)
Malaria Ecology	0.0011	0.0007	0.0009	0.0011	0.0013	-0.0011	0.0012	0.0012
	(0.0010)	(0.0008)	(0.0009)	(0.0009)	(0.0009)	(0.0011)	(0.0010)	(0.0011)
Ln(Cum Oil & Gas Prod)	0.1340	0.1172	0.0923	0.1277	0.1584	0.0693	0.1449	0.0426
	(0.1039)	(0.1147)	(0.0925)	(0.0807)	(0.2033)	(0.1404)	(0.0987)	(0.0877)
Ln(Population density)	0.0003	0.0003	0.0001	0.0003	-0.0007	-0.0003	0.0002	-0.0016
	(0.0007)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0011)	(0.0007)	(0.0010)
Capital is in Region	0.0160[a]	0.0162[a]	0.0124[a]	0.0130[a]	0.0151[b]	0.0253[a]	0.0171[a]	0.0112[b]
	(0.0048)	(0.0044)	(0.0041)	(0.0047)	(0.0058)	(0.0051)	(0.0045)	(0.0044)
Constant	-0.4644[b]	-0.4853[b]	0.2601	0.0987	0.4545	-0.5231	-0.6256[b]	-0.5432
	(0.2227)	(0.2302)	(0.2446)	(0.2268)	(0.4920)	(0.5103)	(0.2677)	(0.3634)
Observations	7,772	7,772	5,492	6,180	2,697	2,158	7,040	6,651
Adjusted R^2	18%	18%	18%	17%	19%	28%	19%	22%
Fxd Effect	Country	Country	Country	Country	Country	Country	Country	Country

Table 6: Migration between regions

Panel A: Raw Data

Country	Years with census data	Migration / Population	Migration College Educated / College Educated
Argentina	1970;1980;1991;2001	2.1%	4.4%
Bolivia	1976;1992;2001	3.7%	5.9%
Brazil	1991;2000	1.9%	3.3%
Canada	1971;1981;1991;2001	1.9%	3.2%
Chile	1970;1982;1992;2002	3.3%	6.1%
China	1990	2.0%	8.5%
Colombia	1985;1993;2005	2.3%	2.7%
Ecuador	1990;2001	4.5%	7.4%
France	2006	6.8%	13.4%
Greece	1971;1981;1991;2001	1.4%	4.2%
Indonesia	980;1985;1990;1995;2000;200	0.4%	1.3%
Malaysia	1991;2000	3.2%	10.6%
Mexico	1990;1995;2000;2005;2010	0.9%	1.6%
Mongolia	2000	27.8%	55.1%
Morocco	2004	4.0%	9.6%
Nepal	2001	1.6%	9.7%
Nicaragua	1971;1995;2005	1.8%	3.2%
Peru	2007	7.2%	12.5%
Philippines	2000	3.0%	3.8%
Portugal	1991;2001	1.2%	5.0%
South Africa	2001	4.6%	11.0%
Spain	1991	5.8%	13.5%
Switzerland	1970;1980;1990;2000	2.0%	3.6%
United States	1960;1970;1980;1990;2000	2.4%	3.6%
Uruguay	1975;1985;1996;2006	1.8%	5.0%
Vietnam	1989;1999;2009	1.1%	2.3%
All		3.8%	8.1%

Panel B: OLS Regressions
Dependent Variable:

	Migration / Population	Migration College Educated / College Educated
ln(density)	-0.0009	-0.0038[b]
	(0.0014)	(0.0014)
Temperature	0.0001	0.0005
	(0.0003)	(0.0005)
ln(Reg GDP pc / Ctry GDP pc	0.0124[b]	0.0062
	(0.0046)	(0.0038)
Constant	0.0291[a]	0.0568[a]
	(0.0061)	(0.0090)
Number of Observations	1,380	1,369
Adjusted R^2	62%	68%
Fixed Effect	Ctry	Ctry

Table 6: Migration between regions (continued)

Panel C: Regressions with country-fixed-effects

	None	Ln(GDP pc)	Financial Regulation	Trade	Labor	Transf / Gov	Gov / GDP	Yrs Educ (Regional)
				Control Variable:				
ln(density)	-0.0009	-0.0011	-0.0022[a]	-0.0020[a]	-0.0031[a]	0.0021	0.0018	-0.0021[c]
	(0.0009)	(0.0010)	(0.0004)	(0.0004)	(0.0005)	(0.0041)	(0.0031)	(0.0011)
Temperature	0.0001	0.0001	-0.0001	-0.0001	-0.0003	0.0004	0.0004	0.0004
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0012)	(0.0008)	(0.0002)
ln(Reg GDP pc / Ctry GDP pc)	0.0124[a]	0.0127[a]	0.0106[a]	0.0114[a]	0.0133[a]	0.0148[b]	0.0135[a]	0.0112[a]
	(0.0020)	(0.0020)	(0.0015)	(0.0015)	(0.0019)	(0.0062)	(0.0047)	(0.0030)
Control Variable		0.0125[a]	0.0106[a]	0.0094[a]	0.0218	0.0018	0.0133	0.0043[a]
		(0.0016)	(0.0019)	(0.0028)	(0.0143)	(0.0071)	(0.0233)	(0.0005)
Constant	0.0291[a]	-0.0834[a]	0.0253[a]	0.0233[a]	0.0299[a]	0.0289	0.0183	-0.0004
	(0.0040)	(0.0138)	(0.0038)	(0.0033)	(0.0102)	(0.0247)	(0.0200)	(0.0064)
Number of Observations	1,380	1,380	1,085	1,213	630	322	425	1,234
Adjusted R^2	62%	62%	51%	47%	52%	62%	63%	62%
Fixed Effect	Ctry	Ctry	Ctry	Ctry	Ctry	Ctry	Ctry	Ctry

Table7: Robustness

Panel A: Regional fixed effects; Driscoll standard errors

	(1)	(2)	(3)	(4)
Ln(GDP pc Region)	-0.0423[a]	-0.1066[a]	-0.1141[a]	-0.1136[a]
	(0.0066)	(0.0078)	(0.0097)	(0.0102)
Ln(GDP pc Country)		0.0861[a]	0.0768[a]	0.0528[a]
		(0.0079)	(0.0113)	(0.0162)
Ln(Population density)	0.0302[a]	0.0119[a]	0.0059	-0.0085
	(0.0042)	(0.0041)	(0.0088)	(0.0090)
Years of Education			0.0049[c]	0.0022
			(0.0029)	(0.0031)
Constant	0.2770[a]	0.1441[a]	0.2849[a]	0.4970[a]
	(0.0455)	(0.0310)	(0.0712)	(0.1425)
Observations	7,776	7,776	6,655	6,655
Number Regions	1,503	1,503	1,482	1,482
Within R^2	15%	27%	28%	35%
Fixed Effects	Region	Region	Region	Region & Year

	(1)	(2)	(3)	(4)
Panel B: National GDP; Country fixed effects				
Ln(GDP pc Ctry)	-0.0293[a]	-0.0301[a]	-0.0456[a]	-0.0432[a]
	(0.0053)	(0.0052)	(0.0049)	(0.0050)
Ln(GDP pc World)	0.0134[b]	0.0064	-0.0141	
	(0.0065)	(0.0108)	(0.0100)	
Years Education		0.0013	-0.0016	-0.0037[c]
		(0.0016)	(0.0018)	(0.0020)
1/(life expectancy at birth)			-0.8026	-1.0569
			(1.2028)	(1.2522)
Fertility			-0.0341[a]	-0.0337[a]
			(0.0084)	(0.0083)
Law and Order			0.0161[c]	0.0141
			(0.0095)	(0.0107)
Investment-to-GDP ratio			0.0815[a]	0.0838[a]
			(0.0192)	(0.0199)
Government-consumption-to-GDP ratio			-0.1627[a]	-0.1355[a]
			(0.0451)	(0.0463)
Openess			0.0267[a]	0.0228[a]
			(0.0060)	(0.0063)
(Change in terms of trade) x Opene			0.0343	0.0270
			(0.0258)	(0.0253)
Democracy			0.0116[b]	0.0072
			(0.0056)	(0.0051)
Democracy Squared			-0.0009[b]	-0.0006[c]
			(0.0004)	(0.0003)
Inflation			-0.0035[a]	-0.0032[a]
			(0.0007)	(0.0007)
Constant	0.1536[a]	0.2112[a]	0.5535[a]	0.4334[a]
	(0.0424)	(0.0756)	(0.0917)	(0.0431)
Observations	868	868	868	868
Adjusted R^2	12%	12%	28%	32%
Countries	89	89	89	89
Within R2	12%	12%	29%	33%
Between R2	14%	13%	1%	2%
Fixed effects	Country	Country	Country	Country & Yr