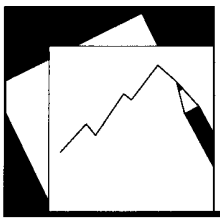
WP/12/106



IMF Working Paper

Structural Reforms and Regional Convergence

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INTERNATIONAL MONETARY FUND

 WP/12/106

IMF Working Paper

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Structural Reforms and Regional Convergence

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Authorized for distribution by Mohammed El Qorchi

April 2012

Abstract

Which structural reforms affect the speed the regional convergence within a country? We found that domestic financial development, trade/current account openness, better institutional infrastructure, and selected labor market reforms facilitate regional convergence. However, these reforms have mixed effects on the growth of regions closer to the country's development frontier. We also document that regional income disparity and average income are inversely correlated across countries so that speeding up regional convergence increases national income. We also present a theoretical model to discuss these results.

JEL Classification Numbers: O11, O18, O33, O25, J68

Keywords: Structural reforms; regional convergence; economic growth; income inequality

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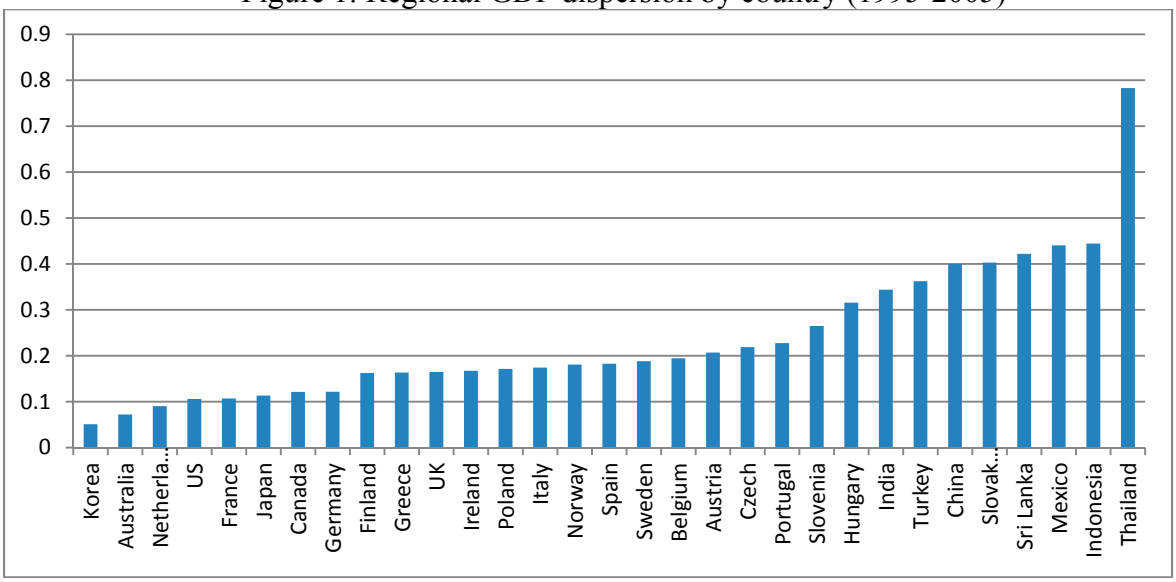
I. INTRODUCTION

Although the majority of the empirical studies on growth and convergence focus on the differences in GDP level across countries, the output disparity within a country across different regions is by no means less dramatic. Figure 1 compares the average regional GDP dispersion in 32 countries over the period of 1995-2005, where the regional dispersion is calculated as the sum of the absolute gap between regions' GDP per capita and the country's GDP per capita, weighted by regions' population shares. Among the advanced economies, most continental European countries, such as Italy and Spain, have higher regional GDP dispersion than the United States. The emerging economies such as China and India have still higher regional dispersions.

Figure 1: Regional GDP dispersion by country (1995-2005)



* The regional GDP dispersion for each country is calculated as the sum of the absolute gap between regions' GDP per capita and the country's GDP per capita, weighted by regions' population shares. The y axis is the average GDP dispersion over the 1995-2005 period. The GDP per capita used is PPP adjusted and deflated using 2005 as the base year.

Figure 1 also shows that there is a distinctive relationship between a country's overall development level and the regional output disparity within the country. Figure 2 articulates this pattern. Here we plot a country's average real GDP per capita over the 1995-2005 period against the country's regional GDP dispersion of the same period. The graph indicates a clear negative correlation between the two.

If the poorer regions in the countries that have high regional dispersions can catch up with the richer regions faster so that the regional income disparities could be reduced to a relatively low level, how much change would it bring to these countries' overall economic performance? The answer is: a lot. Table 1 calculates each country's hypothetical GDP per capita assuming that the income of the poorest regions could be increased so that the ratio of GDP per capita between the rich part and the poor part of the country is equal to that of the United States, and compares the

hypothetical GDP with the actual GDP.[1] The increase from actual to hypothetical GDP ranges from 1.15% for Japan to 48% for Thailand. For most of the European countries the increase is considerable, ranging from 5% to over 10%.

Figure 2: Correlation between regional GDP dispersion and country GDP level

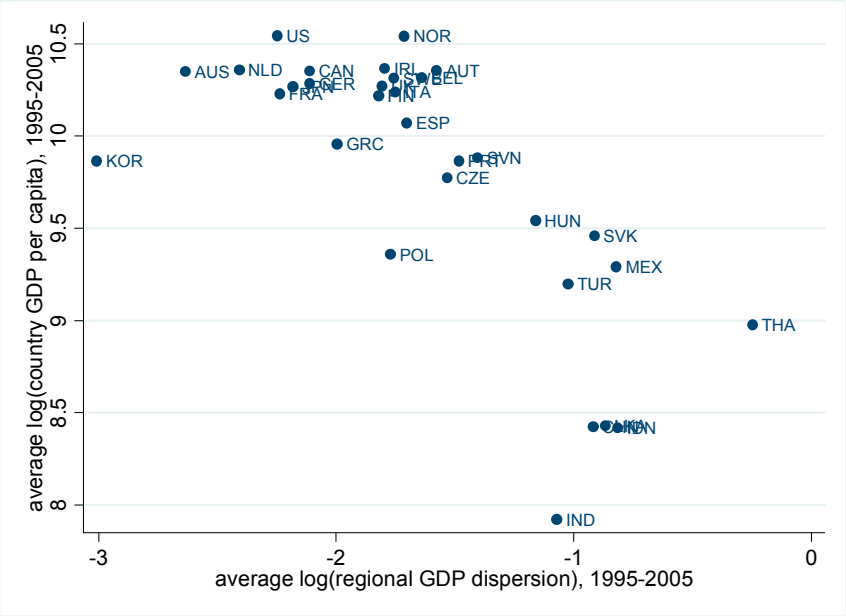


Table 1: Comparison between hypothetical and actual GDP (1995-2005)[2]

Country	Hypothetical GDP per capita	Actual GDP per capita	Percentage change from actual to hypothetical GDP
Japan	29723	29385	1.15
Canada	31812	31383	1.36
Germany	30925	29392	5.08
Finland	29175	27726	5.10
Ireland	34079	32268	5.46
Belgium	32247	30353	6.05
Sweden	30943	29083	6.20
Greece	23135	21724	6.29
Slovenia	24721	23136	6.63
United Kingdom	31245	29172	6.86
Norway	41114	38203	7.35
Poland	12642	11626	8.37
Czech Republic	19155	17614	8.38
Austria	31371	28694	8.92
Spain	26323	23834	9.93

[1] A country's actual GDP per capita is calculated as population-share weighted average of GDP per capita of all regions within the country whose data is available.

[2] the hypothetical GDP is calculated assuming that the GDP of the poor part of a country (the poorer regions that consist 2/3 of the population) increase so that the ratio of GDP per capita between the rich part of the country (the richer regions that consist 1/3 of the population) and the poor part is equal to the ratio of the US. Both the hypothetical and actual GDP numbers are averages over the period of 1995-2005.

Italy	30957	27728	11.02
Portugal	20931	18721	11.16
Slovak Republic	10754	9566	11.71
Hungary	17633	14069	22.58
India	2585	2041	23.65
Indonesia	5435	4250	24.59
Turkey	8599	6660	25.55
Sri Lanka	5482	4126	28.42
China	6434	4666	32.12
Mexico	12500	8968	33.21
Thailand	12953	7979	48.45

The above empirical observations naturally bring about the following question: what kind of policy and institutional reforms will encourage faster convergence between a country's rich and poor regions? By looking at the relationship between structural reforms and regional convergence, we uncover an important channel through which various types of structural reforms, such as financial sector development, trade/current account liberalization and changes in labor market regulations, affect the economic performance of a country. A rough look at the relationship between certain structural reforms and the dispersion of regional development level indicates that the two are indeed related. This is demonstrated in Figure 3, which plotted several structural reform indices against the regional GDP dispersion of countries.

There are several reasons why certain structural reforms can affect the speed of regional convergence. For example, a more developed financial system can facilitate the cross-region mobility of capital resources to the regions where capitals have the highest marginal returns, thus increases the speed of catch up. Trade and financial openness may serve a similar function—increasing the mobility of innovative ideas and encouraging efficient allocation of production resources by introducing more market competition into the economic system. Labor market reforms that reduce the cost of hiring and firing may make the regional allocation of labor more efficient.[3] The quality of a country's institutional infrastructure, such as the rule of law and the quality of bureaucracy, also promote regional convergence, if just by making the above-mentioned structural reforms more effectively implemented.

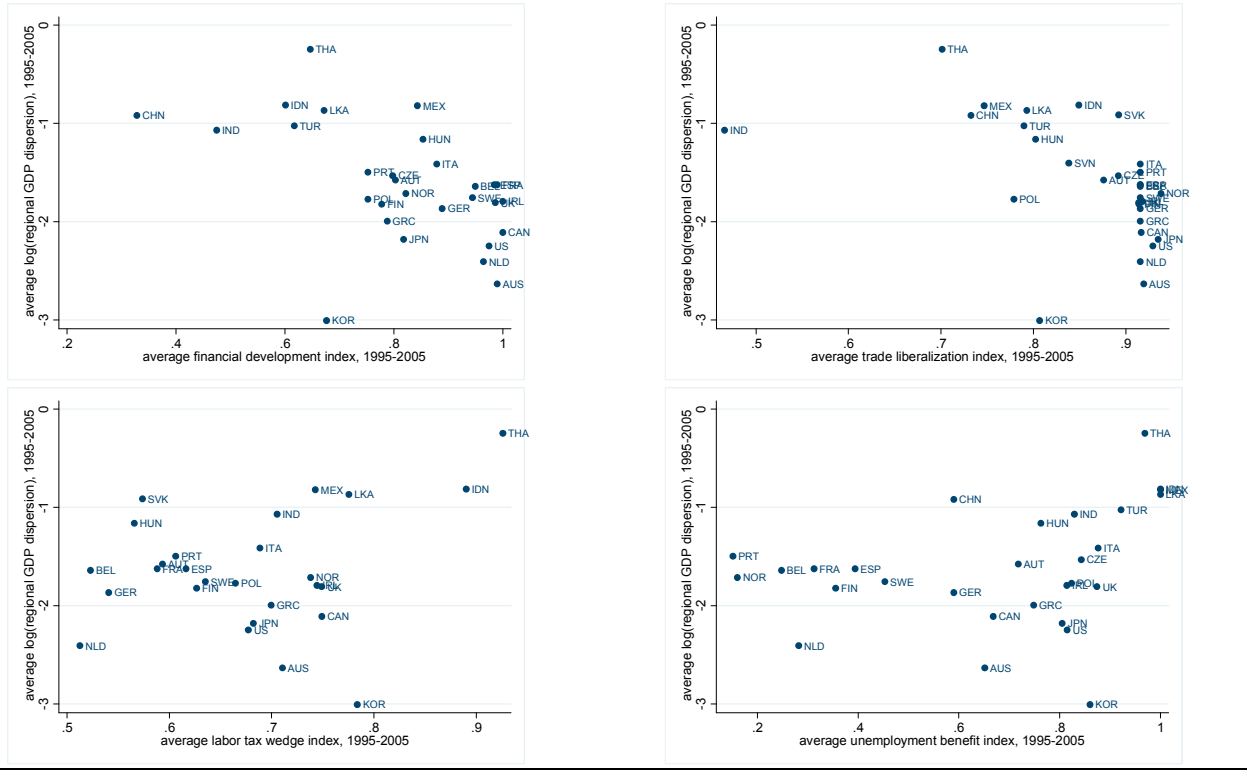
The current literature on the impact of structural reforms on convergence is mainly at the country level. For example, Aghion et al. (2005), with data of 71 countries from 1960 to 1995, interacted financial development variable with country's initial GDP in their growth regression, and found that domestic financial development speeds up convergence. Fung (2009) used data from 57 countries over the 1967-2001period and reached similar conclusions. He also found that human capital is more important to growth for countries that are less developed. Abiad et al. (2007), using data of EU countries from 1975 to 2004, found that for EU countries, current account deficit (capital inflow) is associated with higher GDP growth, and more so for countries with lower per capita income, indicating that capital inflow contributes to speeding up the cross-country convergence in Europe. Similar patterns hold for FDI inflows. However, the relationship does not hold in their global sample of 135 countries. In contrast, they found the

[3] Sometimes, the impact of certain structural reforms can be ambiguous. For instance, lower unemployment benefits may encourage job-seeking efforts and facilitate reallocation decisions of workers, but at the same time may prevent workers from severing unproductive job matches due to increased risk of doing so.

domestic financial development enhances growth and convergence in the global sample, but not in the sample of European countries. Ben-David (1993, 2000) found that trade liberalization that reduce barriers on trade among major trade partners (EU countries, US, and Canada) facilitated income convergence among these trade-liberalizing countries. Unlike the present paper, these studies take country as their basic unit of observation and do not consider the impact of structural reforms on different regions within a country.

The paper is also related to a vast number of studies documenting the existence of unconditional

Figure 3: Structural reforms and regional GDP dispersion



or conditional beta convergence at regional level. For example, Sala-i-Martin (1996) found the existence of unconditional convergence across U.S. states, Japanese prefectures, and several European countries (Germany, UK, France, Italy and Spain) and conditional convergence across a group of European regions. Similar exercise has been carried out for regions in different countries; e.g. Holtz-Eakin (1993) for US regions, Cashin (1995) for Australian regions, Coulombe and Lee (1993) for Canadian regions, and Neven & Gouyette (1995) for European regions. For European regions, there is a consensus that the speed of regional convergence has changed a lot over time: conditional beta-convergence was strong up to the end of the 1970s, stagnated during the 1980s, and then re-emerged at a slow pace (See Magrini, 2004, for a comprehensive review). Although this literature uses a similar concept of regional convergence as in the present paper, its main interest is to provide evidence to the existence of convergence, instead of identifying specific factors that facilitate convergence at the regional level.

We focus in particular on Euro area countries for two reasons. First, these countries include a relatively homogenous set of economies with relative macroeconomic stability. Second, the euro

area debt crisis has at its root the fact that the less rich countries were unable to catch up as rapidly as hoped for with the most advanced regions.

The paper is organized as follows. Section 2 describes the empirical data used and major patterns in the data. Section 3 presents our basic empirical models and discusses baseline estimation results. Section 4 extends the baseline model and conducts robustness checks. Section 5 concludes.

II. Data

We collected data at state/province level for 32 countries. Regional GDP and population data are from several sources. For the United States, we use data from the Bureau of Economic Analysis. For other OECD countries, we use data mainly from OECD Statistics, supplemented by the regional data from EUROSTAT for a few European countries before 1995. The data for five Asian countries are collected from the national statistics agency of each country. The regional GDP variable is deflated (2005 is the base year) and PPP adjusted using the data on purchasing power parity from the Penn World Table. Column 1-6 of Table 2 list the countries/years covered, number of regions in each country, the average regional population, and real GDP per capita for each country.

Consistent with previous literature on regional convergence, we found evidence to "beta convergence" at the regional level. Specifically, we regress, country by country, regions' annual GDP per capita growth on regions' initial GDP per capita at t-1 and some control variables at the country level:

$$\Delta \ln GDP_{j,i,t} = a_0 - \beta_i \ln GDP_{j,i,t-1} + a_1 \text{controls}_{i,t} + \text{e}_{j,i,t} \qquad (1)$$

where the control variables include output gap and terms of trade. A positive β indicates convergence, i.e., a negative correlation between regions' growth rates and their initial GDP levels.

Columns 7-9 of Table 2 reports the estimated β for each sample country, its t-statistics, and the R^2 of the regression. In 19 out of the 32 countries, β is positive and significant at 10% level. β is negative for 7 countries, but only one of them (Czech Republic) is significant. The cross-country average of β is equal to 0.04, which is a bit higher than in some previous studies such as Sala-i-Martin (1996). Notice that even among the countries with positive β, the speed of convergence still vary considerably across country, the value of β ranging from 0.001 for India to 0.36 for Sweden. The coefficient of variation for the estimates of β is 0.6.

Table 2: Summary Statistics and Regional Beta Convergence by Country

Country code	Country name	Sample period	Number of regions	Average regional population (thousands)	Average regional real GDP per capita (USD)	Beta	T value	R2
AUS	Australia	1990 - 2008	8	2,380	29,861	-0.004	-0.289	0.19
AUT	Austria	1988 - 2007	9	889	26,530	0.018	2.667	0.26

BEL	Belgium	1977 - 2007	3	3,363	29,394	0.003	0.167	0.01
CAN	Canada	1990 - 2008	12	2,536	30,636	0.019	1.696	0.13
CHN	China	1978 - 2007	31	39,230	3,502	0.006	1.937	0.14
CZE	Czech Rep.	1995 - 2007	8	1,284	18,446	-0.024	-2.937	0.42
DNK	Denmark	2004 - 2007	5	1,091	32,982	0.012	0.825	0.98
ESP	Spain	1980 - 2007	19	2,096	22,517	0.070	6.275	0.34
FIN	Finland	1988 - 2007	5	1,027	26,191	0.180	4.873	0.39
FRA	France	1977 - 2007	22	2,212	20,879	0.046	8.280	0.17
GER[4]	Germany	1978 - 2007	16	5,283	25,660	0.088	10.011	0.23
GRC	Greece	1977 - 2007	4	2,598	36,419	0.079	3.653	0.48
HUN	Hungary	1995 - 2007	7	1,455	13,207	-0.017	-1.490	0.17
IDN	Indonesia	1993 - 2007	26	7,931	4,725	0.008	0.976	0.12
IND	India	1980 - 2007	32	30,079	2,053	0.001	0.092	0.03
IRL	Ireland	1996 - 2007	2	1,968	30,305	-0.017	-0.787	0.46
ITA	Italy	1977 - 2007	21	2,349	26,993	0.032	3.589	0.09
JPN	Japan	1990 - 2005	10	12,614	27,196	0.031	2.770	0.16
KOR	Korea	1990 - 2007	7	6,595	16,838	0.147	4.102	0.48
LKA	Sri Lanka	1996 - 2007	9	2,127	3,612	0.065	1.817	0.06
MEX	Mexico	1993 - 2006	32	3,045	8,741	0.004	0.794	0.23
NLD	Netherlands	1977 - 2007	4	3,793	24,633	0.049	1.847	0.04
NOR	Norway	1995 - 2007	7	647	38,384	0.099	2.693	0.13
POL	Poland	1995 - 2007	16	2,401	11,207	-0.008	-0.831	0.20
PRT	Portugal	1980 - 2007	7	1,664	18,086	0.111	4.665	0.35
SVK	Slovak Rep.	1995 - 2007	4	1,346	12,442	-0.005	-0.322	0.58
SVN	Slovenia	1995 - 2007	2	997	23,725	0.001	0.035	0.49
SWE	Sweden	1985 - 2007	8	1,095	19,007	0.357	4.976	0.30
THA	Thailand	1981 - 2007	7	8,247	7,866	-0.002	-0.279	0.14
TUR	Turkey	1990 - 2006	26	2,468	5,672	0.020	2.922	0.49
UK	UK	1977 - 2007	12	5,081	27,706	0.045	3.014	0.09
US	US	1969 - 2008	51	4,902	31,053	0.009	2.785	0.10

The primary focus of our paper is to examine the impact of structural reforms on the speed of regional convergence. The primary measurement of structural reforms we use is the structural reform indices compiled by the International Monetary Fund (2009). These indices evaluate countries' performances in domestic financial development, trade and financial openness, and various categories of labor market policies. We are also interested in other "softer" institutional qualities of a country and their influences on regional convergence. Therefore, we include three such indices—law and order, corruption, and quality of bureaucracy— constructed by the International Country Risk Guide (ICRG) in our study. In addition, we also look at the impact of inflation on the speed of catching up. Table 3 gives the summary statistics of all the structural reform variables under study. More detailed descriptions of the variables are included in the appendix.

Table 3: Summary Statistics of the Structural Reform and Institutional Variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Domestic finance	588	0.69	0.27	0	1
Trade liberalization	611	0.82	0.19	0	0.97
Unemployment benefit	550	0.65	0.28	0.02	1

[4] 11 regions before 1991.

Labor tax wedge	426	0.66	0.12	0.23	0.94
Minimum wage	571	0.69	0.24	0.05	1
Severance payment	563	0.89	0.23	0.14	1
Current account liberalization	636	0.82	0.23	0	1
Law and order	574	4.96	1.15	1	6
Quality of Bureaucracy	574	3.36	0.72	1	4
Corruption	574	4.09	1.33	1	6
Inflation rate	642	0.01	0.01	-0.76	0.40

* The structural reform indices from the IMF's structural reform database are in the rage of 0 to 1. For financial development and trade/current account liberalization indices, a higher score indicates higher development/more openness. For labor market policy indices, a higher score indicates a lower value of the original variable, e.g. a higher minimum wage score means a lower minimum wage level. The three institutional quality indices from ICRG are in the rage of 1 to 6, higher scores indicating higher institutional quality.

As will be discussed in the next section, in our baseline estimations we are mostly interested in how fast the backward regions of a country catch up with the "frontier region" within the country. The frontier region is defined as the region that has the highest GDP per capita among all regions within a country in any given year. Consequently, the "distance to frontier" of Region j in Country i is defined as

$$\text{distance}_{j,i,t} = \ln Y_{frontier,i,t} - \ln Y_{j,i,t} \quad (2)$$

where $Y_{frontier}$ and Y_j are the real GDP per capita of the frontier region and region j respectively. Table 4 reports summary statistics of several regional variables, including regional GDP growth, distance to frontier, and GDP growth of the frontier regions.

Table 4: Summary statistics of regional variables

Variable	Observations	Mean	Std. Dev.	Min	Max
Distance to country frontier	8,898	0.84	0.53	0.001	2.91
Non-frontier regions' growth in GDP per capita	8,898	0.03	0.08	-1.16	2.52
Frontier regions' growth in GDP per capita	645	0.03	0.13	-0.86	2.52

III. ESTIMATION MODEL AND RESULTS

A. Theoretical Model

Our theoretical framework follows Aghion et al. (2005). In this section we provide a sketch of the theoretical model and show how it can be linked to our empirical model. For more modeling details please refer to the appendix.

There are m regions in a country that share the same institutional structure and government policies. Technologies and ideas can be spread and copied across regions, while labor is not mobile. We assume that there is a final good being competitively produced in each region, using labor and an intermediate good:

$$Z_t = A_t^{1-\alpha} x_t^{\alpha};\ 0<\alpha<1$$

where x_t is the quantity of the intermediate good used in the period, and A_t is the productivity of the region.

In each period, there is an entrepreneur in the region who tries to increase productivity by investing in innovation and/or adoption of frontier technologies. Thus the region's productivity A_t evolves according to

$$A_t = \mu_t \overline{A}_t + (1-\mu_t) A_{t-1}$$

where $\overline{A}_t = (1+g_i)\overline{A}_{t-1}$, is the potential productivity of the country in period t. g_i is the potential growth rate of all regions in the country and can differ across countries. μ is a parameter indicating the extent of technological progress of a region. It also indicates the catching up effect. If μ is 0, there is no catching up and each region's productivity stays constant.

Let $a_t = A_t / \overline{A}_t$ denote the gap between actual and potential productivity in period t. Dividing the expression above by $\overline{A}_t$ we have:

$$a_{t+1} = \mu(a_t, SR_t) + \frac{1-\mu(a_t, SR_t)}{1+g(SR_t)} a_t \qquad (3)$$

Crucially μ is function of the current productivity gap, a_t, and the structural reform, SR_t.[5] g is only function of the structural reform SR_t. The intuition is that structural reforms may improve the speed of catching up as well as improving potential growth of the country.
Therefore, region *j* 's productivity growth rate can be written as

$$1+G_{j,i,t} = \frac{A_{t+1}}{A_t} = \frac{a_{t+1}}{a_t}(1+g_i(SR)) \qquad (4)$$

Combining equation (3) and (4), we have

$$G_{j,i,t} = G(a_t, SR) = \mu(a_t, SR)\left(\frac{1+g_i(SR)}{a_t} - 1\right) \qquad (4b)$$

where SR_1, a_1 are the current level of SR in the country and the highest level of a achievable by a region.

[5] The detailed model, including the derivation of function μ, is in the appendix.

B. Empirical Model

A version of the log-differentiation of equation (4b) produces

$$
\begin{aligned}
G(a,SR) \cong g_i &+ \left[\mu'_{SR}(a_1,SR_1)\left(\frac{1+g_i(SR_1)}{a_1}-1\right)+\frac{\mu(a_1,SR_1)}{a_1}g'_i(SR_1)\right](SR-SR_1) \\
&+\left[\frac{\mu(a_1,SR_1)(1+g_i(SR_1))}{a_1}-\mu'_a(a_1,SR_1)\left(1+g_i(SR_1)-a_1\right)\right](\ln a_1-\ln a) \\
&+\left[\begin{array}{l} +\mu'_{SR}(a_1,SR_1)\left(\frac{1+g_i(SR_1)}{a_1}\right)+\frac{\mu(a_1,SR_1)}{a_1}g'_i(SR_1) \\ -\mu''_{a,SR}(a_1,SR_1)\left(1+g_i(SR_1)-a_1\right)-\mu'_a(a_1,SR_1)g'_i(SR_1)\end{array}\right](SR-SR_1)(\ln a_1-\ln a)
\end{aligned}
\tag{5}
$$

which can be modified into our testable equation:[6]

$$
\Delta Y_{j,i,t} = \alpha_0 + \alpha_1 \text{distance}_{j,i,t-1} + \alpha_2 \text{distance}_{j,i,t-1} \times SR_{i,t-1} + \alpha_3 SR_{i,t-1} + \alpha_5 \Delta Y_{frontier,i,t} + e_{j,i,t} \tag{6}
$$

where $\Delta Y_{j,i,t}$ is the real GDP per capita growth of Region j in Country i. "distance" is defined as in Equation (2). "SR_i" is the structural reform variable under study. $\Delta Y_{frontier,i,t}$ is the real GDP per capita growth of Country i's most developed region, dubbed as the "frontier region".

There are a few differences between equation (5) and (6). First, equation (6) uses output growth instead of productivity growth. Secondly, since there is no data on regions' "potential" growth rate and output level, the growth rate and production level of the frontier region (i.e. the region with highest income per capita) is used to approximate the former. And since $\Delta Y_{frontier,i,t}$ is not exactly g_i, we allow its coefficient to be different than 1, and the coefficient is expected to be positive.

α_1, the coefficient for the variable "distance", corresponds to

$$
\left[\frac{\mu(a_1,SR_1)(1+g_i(SR_1))}{a_1}-\mu'_a(a_1,SR_1)\left(1+g_i(SR_1)-a_1\right)\right]
$$

in the derivative of equation (5), which is positive given the fact that μ'_a is equal to zero at a_1. Intuitively, a positive relationship between distance-to-frontier and regional GDP growth indicates that convergence exists within a country.

The coefficient we are mainly interested in is α_2, the coefficient of the interaction between distance-to-frontier and the structural reform factor, which corresponds to

[6] See appendix 3B for derivations.

$$\begin{bmatrix} +\mu'_{SR}(a_1, SR_1)\left(\frac{1+g_i(SR_1)}{a_1}\right)+\frac{\mu(a_1, SR_1)}{a_1}g'_i(SR_1) \\ -\mu''_{a,SR}(a_1, SR_1)\left(1+g_i(SR_1)-a_1\right)-\mu'_a(a_1, SR_1)g'_i(SR_1) \end{bmatrix} \quad (7)$$

in equation (5). α_2 will be positive if $\mu'_{SR}(a_1, SR_1) \geq 0$ and $g'_i(SR_1) \geq 0$. In other words, increasing SR from its current level will increase both the current probability of productivity gain and the long-run potential productivity growth. On the other hand, if α_2 turns out to be negative, it implies that at least one of the two effects is negative. Empirically, a positive α_2 would indicate that the higher a country's score is for a particular SR factor, the faster is its regional convergence. And a negative α_2 shows that a higher SR score is associated with slower catching-up across regions.

It is also worth noticing that α_3, the coefficient for the SR variable, approximates the term

$$\left[\mu'_{SR}(a_1, SR_1)\left(\frac{1+g_i(SR_1)}{a_1}-1\right)+\frac{\mu(a_1, SR_1)}{a_1}g'_i(SR_1)\right] \quad (8)$$

in equation (5). Again, this expression says that α_3 consists of two effects: (1) the effect of SR on the productivity advance for regions close to the frontier; (2) the effect of SR on the country's potential productivity growth. When α_3 is positive, it suggests that the underlining structural reform, besides its effect on backward regions, also has an overall positive effect on the growth of regions very close to the frontier. And the opposite is true when α_3 is negative.

An interesting case emerges when α_2 and α_3 have different signs. Comparing expression (7) and (8), it is easy to see that according to the model's framework, we have

Proposition 1:

- $\alpha_2 > 0$ *and* $\alpha_3 \leq 0$ *suggest that at least one of* $\mu'_{SR}(a_1, SR_1)$ *and* $g'_i(SR_1)$ *must be* ≤ 0 *;*
- $\alpha_2 < 0$ *and* $\alpha_3 \geq 0$ *suggest that* $\mu'_{SR}(a_1, SR_1) \leq 0$ *but* $g'_i(SR_1) \geq 0$.

We assume that

$$e_{j,i,t} = u_i + v_{j,i,t}.$$

In other words, the error term in Equation (6) is composed of a country fixed-effect, which sums up unobserved country-specific factors that may co-vary with other RHS variable, and an observation-specific error. We do not include region-level fixed effects because the speed of convergence when the regional fixed effects are present is the speed that each region converges to its own steady-state, instead of converging to the frontier region of the country.

Note that if a similar convergence regression is estimated at the country level, i.e. if we regress country GDP growth on its initial GDP and the SR factors, the SR variable is very likely to be endogenous, thus renders the OLS estimate of the SR variable biased, and so is the interaction between initial GDP and SR. This is either because of reverse causality—changes in SRs can be prompt by higher growth of a country, or because of omitted variables—other common factors not captured in the model can affect both a country's growth and its SRs. These endogeneity issues are mostly bypassed in our model specification. First of all, instead of using initial regional GDP as a regressor, we use distance-to-country-frontier to capture regions' relative development level, which is mostly independent to the country's GDP level or country growth. Second, we include the GDP growth of a country's frontier region on the RHS of Equation (6), thus control for the country's overall growth performance and potentially the omitted factors that exert mutual influence on country growth and SR factors. In addition, it is not likely that the regional growth rate, conditional on a country's frontier growth, will reverse-cause changes in SR variables at the country level.

Since Equation (6) aims to capture the long-run regional convergence patterns, in the baseline estimations we define the time unit of observations to be five years. Therefore, the observation X_t is the average of the values of X over a five-year span. This specification also helps to diffuse the impact of business cycle volatilities on the regression results. We choose the overlapping years of our sample data on regional GDP and on structural reforms from 1971 to 2005, which means we have 7 periods in total for the baseline estimation.[7] The panel is, however, unbalanced, as the starting period differs for each country.

C. Baseline Estimation Results

We consider 11 structural reform variables in total: domestic financial development, trade openness, current account openness, inflation rate,[8] four variables of labor market reforms (unemployment benefit, labor tax wedge, minimum wage, and severance payment), and three variables of long-run institutional quality (corruption, quality of bureaucracy, and rule of law). Tables 5-9 report the baseline regression results of Equation (6) for each SR variable. Heteroscedasticity and serial-correlation robust standard errors are reported in the parentheses.

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[7] A well-known econometric issue related to panel estimation with a large panel dimension and a small time dimension is that when the lagged dependent variable is included as a regressor, the fixed-effect estimate is inconsistent due to the correlation between the lagged dependent variable and the error term (Nickell, 1981). At the first glance, Equation (6) falls into this category of model. To see this, rewrite Equation (6) as follows: $\text{distance}_{j,i,t} = -\alpha_0 + (1-\alpha_1)\text{distance}_{j,i,t-1} + (1-\alpha_6)\Delta Y_{frontier,i,t} + e_{j,i,t}$. Here for simplicity, we omitted the SR variable and its interaction with distance. However, since we estimate the equation with only country-level fixed effects, the typical bias in dynamic panels is much less of an issue here. Let N be the number of regions in a country, and T the total time dimension. The inconsistency is to the order of $1/(T \times N)$, instead of being $O(1/T)$ as in usual dynamic models.

[8] The role of higher inflation on regional growth can be similar to that of lowering minimum wage. In the presence of positive minimum wage requirement, higher inflation makes the minimum wage rate less binding, thus may potentially increase the allocation efficiency of the labor market.

We estimated Equation (6) both the entire sample of countries and for EU15 countries.[9] The results are reported in Column (3) and (4) respectively under each SR variable heading. We also regressed regional growth on the lagged distance-to-frontier and the SR variable only, to confirm each SR's impact on the overall growth of a country. Those results are reported in Column (1) and (2) under each SR variable heading for the whole sample and the EU sample respectively.

First let's look at the impact of financial development and trade openness. In table 5, the first two columns under each SR heading show that the lagged distance-to-frontier variable is positive and mostly significant, indicating convergence in regional GDP for both the whole sample and the EU sample. The coefficients for lagged SRs show that overall both financial development and trade openness are positively correlated with regions' growth. Turning to Column 3 and 4 under each SR heading, the interaction between financial development index and distance-to-frontier is positive and significant in both samples, indicating that a developed financial system facilitates regional convergence. And the effect is bigger in the EU sample than in the whole sample. The interaction between trade openness index and distance-to-frontier is positive and significant for the whole sample. But trade liberalization does not seem to have a significant effect on the convergence pattern of EU regions.[10]

Coefficient α_3 is negative and significant in the EU sample for financial development and in the whole sample for trade liberalization, which indicates that these two SR factors have somewhat negative effect on the growth of developed regions that are close to the frontier. One explanation is that by increasing the economy's potential productivity growth, these SR factors push the frontier further away from where the regions are and make the cost of innovation/adoption higher. And this effect has a disproportionally large impact on regions that are more developed.

Table 5: Baseline regression results—financial development & trade liberalization

	Financial Development				Trade Liberalization			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU
L.distance	0.028**	0.183***	-0.010	-0.108	0.041***	0.217***	-0.030	0.698*
	(0.01)	(0.05)	(0.02)	(0.08)	(0.01)	(0.06)	(0.02)	(0.42)
L.distance*SR			0.113***	0.436***			0.134***	-0.551
			(0.04)	(0.14)			(0.04)	(0.46)
L.SR	0.144***	0.205***	-0.016	-0.189***	0.081***	0.782***	-0.174***	0.268
	(0.02)	(0.03)	(0.03)	(0.07)	(0.02)	(0.17)	(0.05)	(0.20)
frontier GDP growth			0.552***	0.770***			0.558***	0.731***
			(0.04)	(0.07)			(0.04)	(0.06)
N	1,810	613	1,810	613	1,821	613	1,821	613

[9] The EU15 countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. We dropped Luxembourg as no economically meaningful regions can be defined due to the small size of the country.

[10] The interactions between SR factors and distance to frontier are insignificant in the EU sample for several SRs. One possible explanation is that identification is more difficult for the EU sample as the sample size is smaller and the SR variables are more homogeneous across EU countries.

r2	.43	.35	.62	.75	.41	.32	.61	.74

Note: Dependent variable is regional GDP growth. OLS panel regressions. Standard errors are in parentheses. ***, ** and * denote statistical significance at 1, 5 and 10 percent respectively.

In Table 6, when regional growth rate is regressed on lagged current account openness index without the interaction, the results show that more current account liberalization is associated with higher regional growth in general. In contrast, the coefficient of inflation rate is negative and significant in the EU sample. The interaction terms in Column 3 and 4 under each SR heading show that current account openness increases the speed of regional convergence in both samples, and the impact is stronger for the EU sample. On the other hand, higher inflation is significantly related to faster convergence, but only when the whole sample is used. The coefficient α_3 for lagged inflation shows up as negative and significant for the whole sample, indicating that inflation has mostly negative growth effect on regions that are more advanced.

Turning to the labor market reforms, in

Table 7, the coefficients of lagged SR in the first two columns show that lower unemployment benefit is associated with lower regional growth in general,[11] while there is no significant direct relationship between the level of labor tax wedge and regional growth. The interaction terms between distance-to-frontier and SR variables indicate that lower unemployment benefit and lower labor tax wedge have basically negative effects on regional convergence. However, α_3 for both unemployment benefit and tax wedge is positive and mostly significant, suggesting that a lower level of both is beneficial to regions close to the frontier.

Table 6: Baseline regression results— Current account liberalization and inflation

	Current Account Liberalization				Inflation			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU
L.distance	0.029**	0.198***	-0.016	-0.201	0.027**	0.205***	0.054***	0.209***
	(0.01)	(0.05)	(0.02)	(0.15)	(0.01)	(0.05)	(0.01)	(0.04)
L.distance*SR			0.111***	0.458**			0.222***	-0.089
			(0.03)	(0.19)			(0.07)	(0.24)
L.SR	0.351***	0.405***	0.032	-0.147	0.044	-0.132*	-0.218***	-0.017
	(0.03)	(0.04)	(0.04)	(0.09)	(0.04)	(0.07)	(0.05)	(0.08)
frontier GDP growth			0.521***	0.735***			0.510***	0.693***
			(0.04)	(0.07)			(0.04)	(0.06)
N	1848	613	1848	613	1681	564	1681	564
r2	0.44	0.39	0.62	0.74	0.44	0.36	0.61	0.74

Note: Dependent variable is regional GDP growth. OLS panel regressions. Standard errors are in parentheses. ***, ** and * denote statistical significance at 1, 5 and 10 percent respectively.

[11] This seems to be consistent with the argument by Acemoglu & Shimer (2000), that higher unemployment benefit can increase the quality of labor matching, thus increasing productivity.

Table 7: Baseline regression results—Unemployment Benefit and labor tax wedge

	Unemployment Benefit				Labor Tax Wedge			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU
L.distance	0.043***	0.211***	0.165***	0.408***	0.062***	0.233***	0.402***	0.705***
	(0.02)	(0.06)	(0.06)	(0.08)	(0.02)	(0.06)	(0.10)	(0.10)
L.distance*SR			-0.128**	-0.337***			-0.452***	-0.755***
			(0.06)	(0.09)			(0.12)	(0.16)
L.SR	-0.256***	-0.271***	0.154*	0.096	-0.015	-0.070	0.510***	0.317***
	(0.04)	(0.10)	(0.08)	(0.07)	(0.10)	(0.15)	(0.13)	(0.11)
frontier GDP growth			0.532***	0.746***			0.622***	0.749***
			(0.04)	(0.06)			(0.06)	(0.07)
N	1729	582	1729	582	1311	537	1311	537
r2	0.41	0.32	0.59	0.74	0.26	0.30	0.53	0.73

Note: Dependent variable is regional GDP growth. OLS panel regressions. Standard errors are in parentheses. ***, ** and * denote statistical significance at 1, 5 and 10 percent respectively.

The results in Table 8 show that lower severance payment is generally associated with higher regional growth, while the effect of lower minimum wage on growth is mixed, negative in the whole sample and positive in the EU sample. Regarding the interaction terms, the results show that lower minimum wage and lower severance payment are both related to higher GDP growth of the more backward regions, i.e. they both facilitate regional convergence, but the effect is significant only in the whole sample. The results also indicate that lower minimum wage and severance payment is associated with higher growth for more advanced regions, in the EU sample and the whole sample respectively.

Table 8: Baseline regression results— Minimum wage and severance payment

	Minimum Wage				Severance Payment			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU
L.distance	0.040***	0.227***	0.004	0.062	0.038***	0.231***	-0.061**	-0.002
	(0.01)	(0.05)	(0.02)	(0.07)	(0.01)	(0.05)	(0.02)	(0.20)
L.distance*SR			0.080**	0.188			0.140***	0.217
			(0.04)	(0.12)			(0.03)	(0.22)
L.SR	-0.083***	0.127*	-0.052	0.132***	1.813***	1.277*	1.131**	-0.318
	(0.02)	(0.07)	(0.04)	(0.04)	(0.58)	(0.75)	(0.53)	(0.24)
frontier GDP growth			0.567***	0.735***			0.551***	0.738***
			(0.04)	(0.06)			(0.04)	(0.06)
N	1790	613	1790	613	1790	613	1790	613
r2	0.41	0.30	0.61	0.74	0.40	0.30	0.61	0.74

Note: Dependent variable is regional GDP growth. OLS panel regressions. Standard errors are in parentheses. ***, ** and * denote statistical significance at 1, 5 and 10 percent respectively.

Finally, Table 9 report results for the three long-run institutional factors. The coefficients of the lagged SRs in the first two columns under each SR heading show that less corruption, higher bureaucracy quality, and more rule of law are all positively correlated with overall regional growth. Moreover, the interaction terms for all the three factors are positive and significant in both samples, indicating that regional convergence is faster when a country has higher qualities

of institutions. The estimates of α_3 show that all of the three institutional factors are negatively related to the growth of the close-to-frontier regions.

It is worth noting that in the regression specification involving the interaction terms between distance and SR factors, the distance variable itself sometimes becomes insignificant or even negative. One explanation to this is that when the level of the SR factor is low, there is no regional convergence, or even regional divergence within a country. In other words, regional convergence only appears when the underlining SR is above the threshold level.

Table 9: Baseline regression results— Long term institutional factors

	Law and order				Corruption				Bureaucracy Quality			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU
L.distance	0.043***	0.250***	-0.100***	-0.777**	0.046***	0.303***	-0.079***	-0.496***	0.043***	0.275***	-0.182***	-0.502**
	(0.02)	(0.06)	(0.03)	(0.34)	(0.02)	(0.07)	(0.02)	(0.16)	(0.02)	(0.06)	(0.05)	(0.21)
L.distance*SR			0.039***	0.193***			0.041***	0.156***			0.085***	0.203***
			(0.01)	(0.07)			(0.01)	(0.04)			(0.02)	(0.06)
L.SR	0.015***	0.057***	-0.043***	-0.108***	0.014***	0.061***	-0.032***	-0.058***	0.103***	0.177***	-0.037*	-0.058*
	(0.00)	(0.01)	(0.01)	(0.03)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)
frontier GDP growth			0.594***	0.773***			0.593***	0.704***			0.568***	0.724***
			(0.05)	(0.08)			(0.05)	(0.07)			(0.05)	(0.08)
N	1599	517	1599	517	1599	517	1599	517	1599	517	1599	517
r2	0.415	0.329	0.614	0.748	0.416	0.351	0.620	0.760	0.434	0.378	0.619	0.734

Note: Dependent variable is regional GDP growth. OLS panel regressions. Standard errors are in parentheses. ***, ** and * denote statistical significance at 1, 5 and 10 percent respectively.

It is interesting to compare the magnitudes of various structural reforms' impacts on regional convergence. Table 10 presents one way to evaluate such magnitudes. Here using the estimated coefficients of the interactions between structural reforms and distance to frontier in the whole sample, we calculate how much the GDP growth rate would change for a region whose distance-to-country-frontier is at the medium level of the sample (equal to 0.46), if the underlining structural reform index increases from the lowest to highest possible value (except for inflation rate, for which we assume the increase is 50 percentage points). The results are reported in Column 4 of Table 10. For the structural reforms that facilitate regional convergence, the effect of increasing SR variables from the lowest to highest level on medium-distance regions' annual growth rate ranges from 0.7% for minimum wage to 2.3% for bureaucracy quality. For the two SR indices that are negatively correlated with the speed of regional convergence, the effect of decreasing the index from the highest to lowest level on the medium-distance regions' annual growth is 1% for unemployment benefit and 4% for labor tax wedge.

Table 10: Magnitudes of SR impact on regional growth

SR variable	coefficient of interaction (in the whole sample)	SR increase from/by	Increase in the GDP growth rate (5-year) for regions whose distance-to-frontier =0.46
Domestic finance	0.113	0 to 1	0.052
Trade openness	0.134	0 to 1	0.062
Unemployment benefit	-0.128	0 to 1	-0.059
Labor tax wedge	-0.452	0 to 1	-0.208

Minimum wage	0.08	0 to 1	0.037
Severance payment	0.14	0 to 1	0.064
Current account	0.111	0 to 1	0.051
Inflation	0.222	50 percentage points	0.051
Law and order	0.039	1 to 6	0.090
Corruption	0.041	1 to 6	0.094
Bureaucracy quality	0.085	1 to 4	0.117

IV. EXTENSIONS AND ROBUSTNESS CHECKS

A. Annual Estimation

Table 11 report estimation results for Equation (6) using annual regional GDP growth as dependent variable and 1-year lagged distance-to-frontier, structural reform factors, and their interactions as regressors. The signs and significance level of most interaction terms are similar to the baseline estimations, except for the interaction of inflation rate and distance-to-frontier, which is now insignificant in either whole sample or EU sample. Moreover, most of the significant interaction terms have a larger magnitude than the 5-year averages of the baseline estimates. Overall, Table 11 suggests that our empirical results are not significantly affected by the choice of time unit.

Table 11: SR and regional convergence -- annual estimation

	Domestic finance		Trade openness		Unemployment benefit		Labor tax wedge		Minimum wage		Severance payment	
	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU
L.distance	0.003	0.001	-0.000	0.326*	0.049***	0.108***	0.146***	0.305***	0.005	0.034*	-0.005	0.086
	(0.00)	(0.02)	(0.01)	(0.17)	(0.02)	(0.02)	(0.03)	(0.05)	(0.01)	(0.02)	(0.01)	(0.07)
L.distance*SR	0.031***	0.086**	0.031***	-0.296	-0.031*	-0.076***	-0.152***	-0.368***	0.025**	0.041	0.032***	-0.021
	(0.01)	(0.04)	(0.01)	(0.19)	(0.02)	(0.02)	(0.04)	(0.08)	(0.01)	(0.04)	(0.01)	(0.08)
L.SR	-0.008	-0.050***	-0.037**	0.127*	0.032*	0.010	0.129***	0.155***	-0.020	0.010	-0.213**	-0.081
	(0.01)	(0.02)	(0.02)	(0.07)	(0.02)	(0.01)	(0.04)	(0.04)	(0.01)	(0.01)	(0.10)	(0.06)
Frontier GDP growth	0.585***	0.796***	0.586***	0.784***	0.611***	0.789***	0.684***	0.800***	0.615***	0.792***	0.615***	0.791***
	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)
N	8170	2870	8381	2870	7403	2661	5329	2302	7783	2739	7688	2709
r2	0.445	0.750	0.439	0.746	0.458	0.755	0.525	0.773	0.472	0.755	0.470	0.754

Table 11: SR and regional convergence -- annual estimation (continued)

	Current account openness		Inflation		Rule of law		Corruption		Bureaucracy quality	
	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU
L.distance	0.002	-0.046	0.017***	0.056***	-0.013	-0.120**	-0.006	-0.123***	-0.035***	-0.122**
	(0.00)	(0.05)	(0.00)	(0.01)	(0.01)	(0.06)	(0.01)	(0.04)	(0.01)	(0.05)

L.distance*SR	0.028***	0.120**	0.000	-0.084	0.008***	0.036***	0.008***	0.041***	0.019***	0.053***
	(0.01)	(0.06)	(0.03)	(0.09)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.02)
L.SR	-0.007	-0.063***	0.020	0.071**	-0.009***	-0.021***	-0.010***	-0.020***	-0.014***	-0.023***
	(0.01)	(0.02)	(0.02)	(0.04)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)
Frontier GDP growth	0.579***	0.791***	0.573***	0.781***	0.672***	0.797***	0.673***	0.800***	0.672***	0.794***
	(0.07)	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)	(0.06)	(0.05)	(0.07)	(0.06)
N	8818	2993	8464	2856	7107	2367	7107	2367	7107	2367
r2	0.436	0.747	0.436	0.752	0.507	0.768	0.509	0.773	0.509	0.766

B. Regional Allocative Efficiency and Structural Coherence

As discussed in the introduction, an important channel through which structural reforms can affect regional convergence is by increasing the efficiency of resource allocations. In this section we control for measures of allocative efficiency in Equation (6) to see how it would affect the estimates of the interaction terms between SR variables and distance-to-frontier. Specifically, we control for two aspects of allocation efficiency at the regional level: (1) the efficiency in allocating labor across sectors, and (2) structural coherence, defined as the degree of coherence between the capital intensity of a region's industrial structure and the country's capital endowment level.

Following Wurgler (2000)[12], we approximate the cross-sector labor allocation efficiency as the coefficient obtained by regressing a sector's employment growth on lagged growth rate of the sector's output share in the total output of the region:[13]

$$\Delta\text{Employment}_{j,i,t} = \gamma_{0_{ji}} + \gamma_{1_{ji}} \Delta\text{OutputShare}_{j,i,t-1} + \varepsilon_{j,i,t}$$

[12] Wurgler (2000) used a similar regression to measure the investment efficiency at the country level. Regional investment by industry/sector data is scarce in our sample. Thus we adopt the regression specification for labor allocation.

[13] There are six sectors in each region in our dataset: agriculture; mining, utility, and manufacturing; construction; whole sale and retail trade; finance and business services; other services and public administration. The sectoral data is only available for the OECD countries, starting from the latter half of the 1990s.

The coefficient $\gamma_{1_{ji}}$ measures to what extent region j in country i increases employment in its growing sectors and decreases employment in its declining sectors. Therefore, a higher $\gamma_{1_{ji}}$ indicates more efficiency in labor allocation in Region j.[14]

Following Che (2010), we construct an indicator for structural incoherence (SI) at the regional level as the absolute gap between the standard score of the capital intensity of a region's sectoral structure and the standard score of the country's lagged capital endowment:[15]

$$SI_{j,i,t} = \left| \text{k.intensity}_{j,i,t} - \text{k.endowment}_{i,t-1} \right|$$

The idea is that the optimal capital intensity level of a region's sectoral structure should reflect the country's capital endowment level. For example, it is more efficient for countries that have high capital endowment to develop larger capital-intensive industries. Therefore, the smaller the gap is between a region's capital intensity level and the capital endowment level of the country that it belongs to, the more coherent is the region's sectoral structure.[16]

Table 12 report the regression results of Equation (6), augmented by the two efficiency measures of resource allocation and their interactions with the distance-to-frontier. The first column under each SR variable heading presents results controlling for allocative efficiency in labor. Column (2)s present results with the structural coherence controls.[17] The interaction between labor allocation efficiency and distance-to-frontier are positive and significant across all regressions, indicating that regions which are more effective in relocating their labor factor to growing sectors tend to converge faster. Meanwhile, the interaction between structural incoherence indicator and distance-to-frontier is negative and mostly significant, suggesting that regions that are more structurally coherent converge faster.

The interactions between structural reform variables and distance-to-frontier maintained their original signs and significance levels for the most part, with a few exceptions. Specifically, the interaction for trade openness is now negative. The financial development interaction also becomes negative, but only in the regression with the structural coherence controls. In addition,

[14] There is of course an important caveat to this conclusion. In some models, whether labor should flow to or flow away from the sectors that are expanding in terms of real output depends on the elasticity of substitution between sectors. The former applies when the elasticity of substitution is greater than one. There is some evidence supporting this assumption; see Che (2010).

[15] The capital intensity of a region's sectoral structure is calculated as the Spearman rank correlation between sectors' real output shares and sectors' capital/output ratios. A country's capital endowment is measured by the ratio of the country's total capital stock over total employment. The capital endowment variable is lagged 3 years to take into account the time lag needed for the adjustment in sectoral structure corresponding to capital endowment changes.

[16] For detailed discussion on the relationship between structural coherence and growth, see Che (2010), which explored this relationship at the country level.

[17] Since the data sample is now limited to OECD countries. We do not report the EU sub-sample results separately.

the interactions for labor tax wedge and rule of law are now less significant than before. It is worth noting that the loss of significance or change of sign for the interaction terms of certain SRs does not mean that those SRs do not facilitate regional convergence. It is more likely that their facilitating role mainly works through improving resource allocations. Overall, the results indicate that the impact of structural reforms on regional convergence goes beyond increasing the allocative efficiency.

Table 12: SR and convergence, controlling for allocative efficiency and structural coherence

	Domestic finance		Trade openness		Unemployment benefit		Labor tax wedge		Minimum wage		Severance payment	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
L.distance	0.064	1.326***	0.680***	7.073***	0.345***	1.262***	0.036	0.483**	-0.021	-0.278*	-0.100	0.261
	(0.05)	(0.22)	(0.19)	(0.54)	(0.09)	(0.16)	(0.16)	(0.20)	(0.08)	(0.16)	(0.19)	(0.36)
Distance*SR	0.120*	-1.235***	-0.560***	-7.579***	-0.227**	-1.301***	0.223	-0.337	0.269**	0.600***	0.296	0.023
	(0.07)	(0.25)	(0.21)	(0.60)	(0.10)	(0.19)	(0.23)	(0.31)	(0.13)	(0.17)	(0.20)	(0.35)
L.SR	-0.014	0.374***	0.380**	2.591***	0.024	0.224	0.050	2.098***	0.097	0.114	-0.082	-0.213
	(0.05)	(0.10)	(0.16)	(0.35)	(0.07)	(0.32)	(0.13)	(0.39)	(0.06)	(0.15)	(0.25)	(0.18)
Distance*labor allocation efficiency	0.191**		0.161*		0.148*		0.214**		0.157*		0.183**	
	(0.09)		(0.09)		(0.09)		(0.10)		(0.08)		(0.09)	
Allocative efficiency	-0.134**		-0.117**		-0.109**		-0.145**		-0.106**		-0.121**	
	(0.06)		(0.06)		(0.05)		(0.06)		(0.05)		(0.05)	
Distance*structural incoherence		-0.073***		-0.062***		-0.089***		-0.064**		-0.034		-0.065**
		(0.02)		(0.02)		(0.02)		(0.03)		(0.02)		(0.03)
Structural incoherence		0.055***		0.049***		0.081***		0.042*		0.034*		0.043**
		(0.02)		(0.01)		(0.02)		(0.02)		(0.02)		(0.02)
Frontier GDP growth	0.610***	1.489***	0.594***	1.349***	0.584***	1.074***	0.655***	1.301***	0.596***	1.277***	0.602***	1.298***
	(0.07)	(0.12)	(0.06)	(0.05)	(0.06)	(0.07)	(0.08)	(0.11)	(0.05)	(0.11)	(0.06)	(0.12)
N	1050	298	1059	299	970	298	873	284	1001	298	1001	298
r2	0.612	0.834	0.611	0.878	0.600	0.854	0.609	0.835	0.621	0.819	0.613	0.807

Table 12: SR and convergence, controlling for allocative efficiency and structural coherence (continued)

	Current account openness		Inflation		Law and order		Corruption		Bureaucracy quality	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
L.distance	-0.182*	-1.077**	0.171***	0.282***	-0.615***	0.366	-0.554***	-0.642***	-0.425**	-1.035***
	(0.11)	(0.43)	(0.03)	(0.04)	(0.17)	(0.37)	(0.11)	(0.07)	(0.19)	(0.29)
Distance*SR	0.371***	1.356***	-0.153	1.973***	0.147***	-0.015	0.165***	0.198***	0.167***	0.347***
	(0.13)	(0.44)	(0.22)	(0.47)	(0.03)	(0.06)	(0.03)	(0.01)	(0.06)	(0.08)
L.SR	-0.028	0.831*	-0.064	-0.564**	-0.085***	0.063*	-0.073***	-0.036**	-0.030	-0.330***
	(0.07)	(0.43)	(0.10)	(0.28)	(0.02)	(0.04)	(0.02)	(0.02)	(0.03)	(0.07)
Distance*labor allocation efficiency	0.196**		0.181*		0.246**		0.181**		0.221**	
	(0.09)		(0.09)		(0.10)		(0.08)		(0.10)	
Allocative efficiency	-0.136**		-0.131**		-0.161***		-0.119**		-0.145**	
	(0.06)		(0.06)		(0.06)		(0.05)		(0.06)	

Distance*structural incoherence		-0.054** (0.02)		-0.060*** (0.02)		-0.065*** (0.02)		-0.086*** (0.01)		-0.075*** (0.02)
Structural incoherence		0.030* (0.02)		0.033* (0.02)		0.042** (0.02)		0.064*** (0.01)		0.052*** (0.02)
Frontier GDP growth	0.582*** (0.06)	1.322*** (0.11)	0.556*** (0.05)	1.353*** (0.06)	0.671*** (0.08)	1.339*** (0.06)	0.650*** (0.07)	1.344*** (0.04)	0.620*** (0.08)	1.301*** (0.06)
N	1059	298	966	264	874	299	874	299	874	299
r2	0.619	0.813	0.610	0.832	0.633	0.811	0.678	0.911	0.619	0.825

C. Structural Reform and Potential Productivity Growth

As mentioned in Section 3A, SRs can facilitate a region's growth by increasing the probability of current productivity gain, through functions such as fostering efficient resource allocation in capital and labor, alleviating borrowing constraints of enterprises, reducing the costs of innovation and adoption of new technology. And in similar ways, SRs can also enhance growth by increasing the long-run potential productivity growth of the country. In this section we explicitly examine the latter effect of structural reforms by assuming that function $g_i(SR)$ has a linear form:

$$g_i(SR) = \varphi \bar{g}_i \cdot SR,$$

where $\bar{g}_i = g_i(a_1, SR_1)$. Thus a positive effect of the underlining SR on potential growth would translate into a positive φ. With this new functional form, we rewrite equation (5) as

$$\begin{aligned} G(a, SR) \cong\ & \bar{g}_i + \mu'_{SR}(a_1, SR_1)\left(\frac{1+g_i(SR_1)}{a_1} - 1\right)(SR - SR_1) + \frac{\mu(a_1, SR_1)}{a_1}\varphi \bar{g}_i (SR - SR_1) \\ & + \left[\frac{\mu(a_1, SR_1)(1+g_i(SR_1))}{a_1} - \mu'_a(a_1, SR_1)\left(1+g_i(SR_1) - a_1\right)\right](\ln a_1 - \ln a) \\ & + \begin{bmatrix} +\mu'_{SR}(a_1, SR_1)\left(\dfrac{1+g_i(SR_1)}{a_1}\right) + \dfrac{\mu(a_1, SR_1)}{a_1}\varphi \bar{g}_i \\ -\mu''_{a,SR}(a_1, SR_1)\left(1+g_i(SR_1) - a_1\right) - \mu'_a(a_1, SR_1)\varphi \bar{g}_i \end{bmatrix}(SR - SR_1)(\ln a_1 - \ln a) \end{aligned}$$

Again, using the frontier region's growth rate as an approximate for $g_i(a_1, SR_1)$, we arrive at an empirical counterpart of the above equation, by extending Equation (6) to include an interaction term between the growth rate of the frontier region and the structural reform factors.

$$\begin{aligned} \Delta Y_{j,i,t} = & \alpha_0 + \alpha_1 \text{distance}_{j,i,t-1} + \alpha_2 \text{distance}_{j,i,t-1} \times SR_{i,t-1} + \alpha_3 SR_{i,t-1} \\ & + \alpha_4 \Delta Y_{frontier,i,t} \times SR_{i,t-1} + \alpha_5 \Delta Y_{frontier,i,t} + e_{j,i,t} \end{aligned} \tag{9}$$

If SRs indeed have positive effects on the country's long-term growth potential, g_i, then α_4 should be positive. Equation (9) also serves as a partial test of Proposition 1. Specifically, according to the 2nd point of Proposition 1, if we observe that $\alpha_2 < 0$ and $\alpha_3 \geq 0$ in our estimation of equation (6), then the estimated α_4 should be ≥ 0 in equation (9) for the same SR factor.

Note that aside from the interpretation derived from our theoretical model, there is another way to understand equation (9). If we take first derivative of the dependent variable with respect to the frontier growth rate, the derivative coefficient ($\alpha_4 SR_i + \alpha_5$) tells us how much of the frontier growth is "transferred" to the other regions. From this perspective, a positive α_4 may indicate that the underlining SR helps increase the technology transfer from the frontier region to other regions.

Table 13 reports the estimates of equation (9). The results show that trade openness, lower labor tax, and lower minimum wage are associated with a higher coefficient of the frontier growth variable, though the interaction between trade openness and frontier growth is only significant in the whole sample, and the interaction for labor tax wedge is only significant in the EU sample. In contrast, lower unemployment benefit, lower severance payment, and higher inflation rate have significantly negative α_4 s, though the interaction for unemployment benefit is only significant in the whole sample. Interestingly, for all the three institutional infrastructure variables, the interaction terms are negative and mostly significant, except for corruption.

In our baseline regressions of equation (6), two SR variables, unemployment benefit and labor tax wedge, have $\alpha_2 < 0$ and $\alpha_3 \geq 0$. Now looking at the estimated α_4 s for these two SRs, we can see that they are either positive or indifferent from zero, as predicted by proposition 1, except for the α_4 for unemployment benefit in the whole sample, which turns out to be negative.

It is interesting to note that for some SR factors, coefficients α_3 and α_4 have different signs. According to our model, the signs of the two coefficients are dependent upon the signs of $\mu'_{SR}(a_1, SR_1)$ and $g'_i(SR)$, which are, again, SR's impact on the probability of current productivity increase for the closest-to-frontier region, and SR's impact on the country's potential productivity growth. Interpreting the results of table 13 from this perspective, we can see that SR factors such as trade openness and lower minimum wage may not be so positive for the current output growth of the advanced region, but they are associated with higher growth of the country's potential productivity, at least when the whole sample is used. In contrast, lower severance payment and lower unemployment benefit are good for the immediate output growth

of the currently more developed region, but their effect on the frontier productivity growth is negative.[18]

Compared to the baseline regressions, the signs, significance levels, and magnitudes of the interactions between distance-to-frontier and structural reforms are basically unchanged after adding the new interaction term. In some cases the distance-to-frontier interactions are even of a slightly higher magnitude.

Table 13: SR effect on potential productivity growth

	Domestic finance		Trade openness		Unemployment benefit		Labor tax wedge		Minimum wage		Severance payment	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU
L.distance	-0.010	-0.118	-0.035	0.621	0.166***	0.405***	0.407***	0.719***	0.007	0.061	-0.056**	0.054
	(0.02)	(0.07)	(0.02)	(0.42)	(0.06)	(0.09)	(0.09)	(0.11)	(0.02)	(0.06)	(0.03)	(0.19)
L.distance*SR	0.111***	0.456***	0.141***	-0.462	-0.128**	-0.334***	-0.459***	-0.809***	0.076**	0.179	0.133***	0.161
	(0.03)	(0.14)	(0.04)	(0.46)	(0.06)	(0.09)	(0.11)	(0.17)	(0.04)	(0.12)	(0.04)	(0.21)
frontier growth*SR	0.060	-0.194	0.301***	-0.811	-0.304*	0.133	-0.347	2.444**	0.339**	0.379*	-0.652***	-0.598***
	(0.12)	(0.16)	(0.10)	(1.12)	(0.17)	(0.17)	(0.59)	(1.06)	(0.15)	(0.22)	(0.13)	(0.14)
L.SR	-0.018	-0.202***	-0.212***	0.182	0.172**	0.100	0.541***	0.190	-0.127**	0.086*	1.146**	-0.296
	(0.03)	(0.06)	(0.06)	(0.20)	(0.08)	(0.07)	(0.11)	(0.14)	(0.06)	(0.05)	(0.53)	(0.24)
frontier GDP growth	0.518***	0.905***	0.330***	1.445	0.733***	0.673***	0.842**	-0.758	0.328***	0.470***	1.163***	1.296***
	(0.05)	(0.08)	(0.06)	(0.98)	(0.14)	(0.15)	(0.37)	(0.66)	(0.09)	(0.10)	(0.11)	(0.12)
N	1810	613	1821	613	1729	582	1311	537	1790	613	1790	613
r2	0.616	0.752	0.615	0.737	0.594	0.741	0.529	0.739	0.617	0.754	0.623	0.747

Table 13: SR effect on potential productivity growth (continued)

	Current account openness		Inflation		Law and order		Corruption		Bureaucracy quality	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU
L.distance	-0.028	-0.207	0.052***	0.193***	-0.100***	-1.001***	-0.081***	-0.535***	-0.181***	-0.611***
	(0.02)	(0.14)	(0.01)	(0.03)	(0.03)	(0.36)	(0.02)	(0.16)	(0.05)	(0.20)
L.distance*SR	0.126***	0.467***	0.211***	0.044	0.039***	0.235***	0.042***	0.164***	0.085***	0.232***
	(0.04)	(0.18)	(0.07)	(0.22)	(0.01)	(0.07)	(0.01)	(0.04)	(0.02)	(0.06)
frontier growth*SR	0.159	-0.101	-2.216***	-2.569***	-0.003	-0.121***	-0.015	-0.056	-0.015	-0.139**
	(0.14)	(0.30)	(0.48)	(0.75)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.06)
L.SR	0.021	-0.154*	-0.035	0.098	-0.043***	-0.125***	-0.031***	-0.060***	-0.037*	-0.084***
	(0.04)	(0.08)	(0.07)	(0.10)	(0.01)	(0.03)	(0.01)	(0.02)	(0.02)	(0.03)

[18] This result seems to confirm the argument of Acemoglu & Shimer (2000), that higher unemployment insurance increases the quality of labor market matches and thus increase the overall productivity. Another explanation for the result is that higher unemployment benefits and other social security measures encourage entrepreneurship and hence the productivity growth of the society.

frontier GDP growth	0.407***	0.820***	0.552***	0.753***	0.609***	1.431***	0.661***	0.997***	0.617***	1.235***
	(0.08)	(0.24)	(0.05)	(0.06)	(0.15)	(0.21)	(0.11)	(0.19)	(0.15)	(0.18)
N	1848	613	1681	564	1599	517	1599	517	1599	517
r2	0.617	0.742	0.625	0.767	0.614	0.757	0.620	0.763	0.619	0.740

D. Productivity Convergence

In this section we look at the effect of structural reforms on regional labor productivity convergence, instead of output convergence. We estimate Equation (6) with 5-year labor productivity growth as the dependent variable. The distance-to-frontier of region j is now the gap between the labor productivity of the frontier region and that of region j.

Table 14 reports the estimation results. Compared to the baseline estimation for output convergence, the interaction terms between distance-to-frontier and structural reforms are somewhat less significant than before, especially in the EU sample. This is not a surprise, as the measurement of productivity contains more noise than that of output. However, the signs of the interaction terms remain the same as before for most SR variables.

Table 14: SR and regional productivity convergence

	Domestic finance		Trade openness		Unemployment benefit		Labor tax wedge		Minimum wage		Severance payment	
	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU
L.productivity distance	-0.040	0.213	-0.033	2.301*	0.094	0.199**	0.028	-0.316	-0.081*	0.159	0.071***	-0.014
	(0.03)	(0.13)	(0.06)	(1.29)	(0.06)	(0.09)	(0.15)	(0.24)	(0.04)	(0.12)	(0.02)	(0.13)
L.productivity distance*SR	0.174***	-0.020	0.127*	-2.340	-0.032	-0.009	0.114	0.878**	0.224***	0.057	-0.010	0.218
	(0.05)	(0.16)	(0.07)	(1.44)	(0.07)	(0.16)	(0.21)	(0.41)	(0.06)	(0.14)	(0.03)	(0.14)
L.SR	-0.017	-0.049	-0.049	0.277	-0.025	0.251***	0.099	-0.293	-0.369***	-0.214**	0.121	-0.034
	(0.03)	(0.06)	(0.09)	(0.59)	(0.08)	(0.08)	(0.20)	(0.28)	(0.08)	(0.08)	(0.20)	(0.14)
Frontier GDP growth	0.204***	0.336***	0.182***	0.344***	0.183***	0.325***	0.232***	0.330***	0.171***	0.325***	0.190***	0.332***
	(0.03)	(0.05)	(0.03)	(0.06)	(0.03)	(0.06)	(0.04)	(0.06)	(0.03)	(0.06)	(0.03)	(0.05)
N	1183	406	1189	406	1104	406	889	406	1134	406	1134	406
r2	0.533	0.387	0.526	0.393	0.519	0.406	0.371	0.403	0.541	0.392	0.527	0.383

Table 14: SR and regional productivity convergence (continued)

	Current account		Inflation		Rule of law		Corruption		Bureaucracy	
	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU
L.productivity distance	-0.058	0.254	0.071***	0.181***	-0.040	-0.023	0.046	0.066	-0.091*	0.053
	(0.04)	(0.20)	(0.02)	(0.04)	(0.03)	(0.18)	(0.03)	(0.18)	(0.05)	(0.20)
L.productivity distance*SR	0.168***	-0.051	-0.220	0.757**	0.028***	0.041	0.013*	0.030	0.062***	0.037
	(0.04)	(0.22)	(0.25)	(0.32)	(0.01)	(0.03)	(0.01)	(0.04)	(0.02)	(0.05)
L.SR	-0.223***	-0.162*	-0.118	-0.177	0.004	-0.015	0.011*	0.015	-0.006	0.045*
	(0.06)	(0.10)	(0.10)	(0.13)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)

Frontier GDP growth	0.189*** (0.03)	0.365*** (0.05)	0.158*** (0.03)	0.338*** (0.05)	0.275*** (0.03)	0.317*** (0.06)	0.261*** (0.03)	0.304*** (0.06)	0.299*** (0.03)	0.287*** (0.06)
N	1189	406	1136	402	1090	406	1090	406	1090	406
r2	0.540	0.402	0.534	0.394	0.573	0.383	0.572	0.408	0.574	0.400

E. Endogeneity of Structural Reforms

As discussed in Section 3B, the specification of our model makes endogeneity of structural reform variables a less severe issue econometrically, compared to other studies relating growth to policy variables. However, conceptually it may still be argued that certain common factors can affect both structural reforms and the speed of regional convergence. For example, a country may decide to implement the kind of structural reforms documented in our sample, and at the same time takes other measures to diminish the development gaps among its regions. If that is the case, then the significant relationship we found between individual structural reforms and the speed of convergence may be overstated, as they may represent only elements in a whole package of reforms.

To deal with such possibilities, we instrument a country's structural reform variables in Equation (6) with the structural reform scores of neighboring countries. The idea is that countries that are geographically close to each other often share similar institutional arrangements and reforms, but structural reforms in Country i's neighbors should not have any impact on the regional convergence pattern of Country i (see Persson and Tabellini, 2005). The structural reform score of neighboring countries in reform X is calculated as the average score of X across all countries except country i, weighted by the inverse geographical distances between Country i and other countries:

$$\text{IV for } X_{i,t} = \sum_{k=1}^{n} \frac{1}{\text{GeoDistance}_{i,k}} X_{k,t}$$

The interaction between SR variable and distance-to-frontier is also instrumented, using the interaction between "distance" and neighboring countries' SRs.

Table 15 report regression results of Equation (6) using the IV estimator. The interactions of a few SR variables that were originally significant are now insignificant in the EU sample, including financial development, unemployment benefit, current account openness, and the three indicators of institutional infrastructure. However, these interactions are still significant in the whole sample, with the magnitudes of the coefficients either similar to or larger than those in the baseline regressions. Overall, compared to the baseline results, the IV estimates give very similar assessments regarding the relationship between structural reforms and regional convergence.

Table 15: SR and convergence (IV estimates)

Domestic finance		Trade openness		Unemployment benefit		Labor tax wedge		Minimum wage		Severance payment	
(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU	Whole sample	EU

L.distance	-0.013	0.154*	-0.032	1.927	0.676*	0.745	0.837***	0.848***	0.371	-0.954***	-2.032**	-0.935**
	(0.03)	(0.09)	(0.06)	(1.20)	(0.36)	(1.55)	(0.18)	(0.28)	(0.357)	(0.34)	(0.84)	(0.46)
L.distance*SR	0.122**	0.083	0.134	-1.930	-0.739*	-0.934	-1.042***	-0.983**	-0.522	1.496***	2.406***	1.176**
	(0.06)	(0.10)	(0.10)	(1.31)	(0.45)	(2.73)	(0.23)	(0.46)	(0.573)	(0.57)	(0.92)	(0.47)
L.SR	-0.040	-0.062	-0.075	0.592	0.873	-0.318	0.751	0.777	0.304	0.457	77.605	0.000
	(0.05)	(0.06)	(0.14)	(0.54)	(1.13)	(0.83)	(0.50)	(0.67)	(0.279)	(5.77)	(80.82)	(.)
Frontier GDP growth	0.558***	0.756***	0.545***	0.732***	0.520***	0.709***	0.613***	0.751***	0.632***	0.709***	0.482***	0.735***
	(0.04)	(0.07)	(0.04)	(0.07)	(0.11)	(0.08)	(0.06)	(0.07)	(0.050)	(0.10)	(0.13)	(0.06)
N	1810	613	1821	613	1729	582	1311	537	1436	613	1790	613

Table15: SR and convergence (IV estimates, continued)

	Current account openness		Inflation		Law and order		Corruption		Bureaucracy quality	
	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU	(1) Whole sample	(2) EU
L.distance	-0.051	0.078	0.054***	0.208***	-0.141**	0.170	-0.505***	-6.998	0.407	0.308
	(0.04)	(0.15)	(0.01)	(0.04)	(0.06)	(0.57)	(0.14)	(21.59)	(0.89)	(4.28)
L.distance*SR	0.166***	0.150	0.222***	0.023	0.049***	0.013	0.181***	1.527	-0.126	-0.176
	(0.06)	(0.17)	(0.08)	(0.14)	(0.02)	(0.11)	(0.05)	(4.52)	(0.32)	(1.33)
L.SR	-0.008	-0.085	-0.176***	-0.086	-0.074***	-0.107**	-0.038**	-0.649	-1.701	-4.032
	(0.06)	(0.10)	(0.05)	(0.06)	(0.02)	(0.05)	(0.02)	(2.07)	(2.30)	(13.91)
Frontier GDP growth	0.522***	0.750***	0.509***	0.693***	0.619***	0.844***	0.593***	0.522	1.494	3.338
	(0.04)	(0.07)	(0.04)	(0.06)	(0.05)	(0.11)	(0.04)	(0.49)	(1.32)	(9.24)
N	1848	613	1681	564	1599	517	1599	517	1599	517

V. CONCLUSION

The degree of regional income disparity varies considerably across countries. And there is an inverse relationship between the cross-region dispersion of GDP and a country's development level. In this paper we evaluate what kinds of policies and structural reforms can help reducing the income disparity across regions through increasing the speed of regional convergence, and thus boost the country's growth performance as a whole.

We find that financial development, trade and current account openness, and sound institutional infrastructure manifested as more rule of law, less corruption and higher bureaucracy quality are conductive to the catch up of backward regions. Some labor market liberalization policies, such as lowering minimum wages and severance payments, foster regional convergence, while others, such as lowering unemployment benefits and labor tax wedge, are negatively related to the speed of regional convergence. In addition, countries that have higher inflations tend to have faster regional convergence.

The results also show that certain SR factors, though facilitating faster convergence of less developed regions, may be ambiguous for regions close to the country's development frontier. Those SR factors include financial development, trade openness, inflation, and several long-term institutional factors. We also tried to differentiate the more immediate effect of SR factors on

regional growth from the structural reforms' impact on a country's potential productivity growth. We found that the two were not always pointing to the same direction.

The same estimation model applied to regional productivity convergence produces similar results. Most of our baseline results are robust to changing the time unit of estimation, to controlling for measures of regional allocation efficiency across sectors, and to the use of IV estimator.

What we presented in this paper is one aspect of the various effects of structural reforms. Numerous factors need to be taken into account when making any policy decisions. Policies such as minimum wages and severance payments have social and humanitarian values that are separate from the concern of economic efficiency. The actual policy judgment is complicated, and beyond the scope of this paper.

APPENDIX A: STRUCTURAL REFORM (SR) VARIABLES

The following SR indices are taken from the International Monetary Fund's structural reform database:

Domestic finance: domestic financial development, averaged of six sub-indices. Five of them relate to banking: (i) interest rate controls, such as floors or ceilings; (ii) credit controls; (iii) competition restrictions; (iv) the degree of state ownership; and (v) the quality of banking supervision and regulation. The sixth sub-index relates to securities markets and covers policies to develop domestic bond and equity markets. Each sub-index is coded from zero (fully repressed) to three (fully liberalized).

Trade openness: average tariff rates. Index normalized to be between zero and unity: zero means the tariff rates are 60 percent or higher, while unity means the tariff rates are zero.

Unemployment benefit: gross replacement rate, average of 1st and 2nd year.

Labor tax wedge: average labor tax wedge.

Minimum wage: ratio of minimum wage to mean wage.

Severance payment: severance payment after 9 months, in months.

Current account openness: financial restrictions on current account transactions, scale 0-1, higher score means less restrictions.

The following SR indices are from the International Country Risk Guide:

Law and order: law and order index, each sub-component equal half of the total. The "law" sub-component assesses the strength and impartiality of the legal system, and the "order" sub-component assesses popular observance of the law. Each sub-component comprises 1 to 3 points, from low to high assessment.

Corruption: A measure of corruption within the political system that is a threat to foreign investment by distorting the economic and financial environment, reducing the efficiency of government and business by enabling people to assume positions of power through patronage rather than ability, and introducing inherent instability into the political process. The score ranges 1 to 6, high score meaning low corruption.

Bureaucracy quality: Bureaucracy quality index. The institutional strength and quality of the bureaucracy serves as shock absorber that tends to minimize revisions of policy when governments change. Therefore, high points are given to countries where the bureaucracy has the strength and expertise to govern without drastic changes in policy or interruptions in government services. The score rage: 1-4.

APPENDIX B: THEORETICAL MODEL

In this appendix, we present a more elaborated theoretical model based on Aghion et al (2005).

We assume that there are M regions in a country, each with a fixed population 1. Production factors are only mobile within a region, but technology and ideas can be spread and copied across regions. Agents live two periods, each endowed with 2 units of labor in time t and nothing in time t+1. The agent's utility function is $U = c_1 + \beta c_2$.

A final good is produced competitively in each region by labor and an intermediate good:

$$Z_t = A_t^{1-\alpha} x_t^{\alpha};\ 0<\alpha<1$$

where x_t is the quantity of the intermediate good used in time t, and A_t is the productivity of the intermediate good industry. Let the price of the final good be equal to unity. The price of the intermediate good is equal to its marginal product:

$$p_t = \alpha\left(\frac{x_t}{A_t}\right)^{\alpha-1} \tag{10}$$

In each period there is an entrepreneur in the region born at t-1, who invents/adopts new technologies to try to increase the productivity of intermediate good industry. The productivity improvement is gradual and takes the form

$$A_t = \mu_t \overline{A}_t + (1-\mu_t) A_{t-1};\qquad 0<\mu<1$$

Here $\overline{A}_t$ is the frontier productivity of the country at time t. and μ_t is an parameter indicating the degree of technological improvement relative to the last period. μ_t is an increasing function of the entrepreneur's investment in innovation. Let g_i denote the long-term potential growth rate of country i's development frontier. $\overline{A}_t = \overline{A}_{t-1} g_i$. g_i is a function of the structural reform factors.

With the current period technology, the entrepreneur can produce any amount of the intermediate good using one unit of final good per unit of output, while other producers in the same industry can copy his technology and produce the latest version of the good at unit cost $\chi > 1$, which will also be the market price of the intermediate good. Using equation (10), we have

$$x_t = \left(\frac{\alpha}{\chi(SR_t)}\right)^{1/(1-\alpha)} A_t$$

Thus the profit of a successful entrepreneur will be

$$\pi(SR) = (\chi(SR) - 1)\left(\frac{\alpha}{\chi(SR)}\right)^{1/(1-\alpha)} A_t \tag{11}$$

Here we assume that χ, and hence π, can both be affected by structural reform factors.

And the gross output of the final good is

$$Z_t = \left(\frac{\alpha}{\chi}\right)^{\frac{\alpha}{1-\alpha}} A_t$$

As mentioned, an investment is needed to do innovation. Given the extent of technology improvement μ, the innovation costs

$$\begin{aligned} N_{t-1} &= n(\mu_t)\overline{A}_t \\ &= (\eta\mu_t + \delta\mu_t^2 / 2)\overline{A}_t, \ \eta, \delta > 0 \end{aligned} \tag{12}$$

Thus given the amount of innovation investment $n\overline{A}_t$, the region's productivity will advance by

$$\mu(n) = \left((\eta^2 + 2\delta n)^{1/2} - \eta\right) / \delta$$

In the equilibrium, μ_t^* is chosen to maximize

$$\beta\mu_t\pi_t\overline{A}_t - (\eta\mu_t + \delta\mu_t^2 / 2)\overline{A}_t .$$

Therefore, when there is no constraint on innovation investment, the optimal degree of technology improvement is

$$\mu_t^*(SR_t) = (\beta\pi_t(SR_t) - \eta) / \delta .$$

This, combined with equations (11) and (12), gives

$$n^*(SR) = \frac{\eta}{\delta}\left[\beta\left(\chi(SR) - 1\right)\left(\frac{\alpha}{\chi(SR)}\right)^{1/(1-\alpha)} - \eta\right] + \frac{\eta^2}{2\delta}\left[\beta\left(\chi(SR) - 1\right)\left(\frac{\alpha}{\chi(SR)}\right)^{1/(1-\alpha)} - \eta\right]^2$$

Define distance to frontier as $a_t = A_t / \overline{A}_t$. In this frictionless scenario, a_t evolves according to

$$a_t = \mu^*(SR_{t-1}) + \frac{1 - \mu^*(SR_{t-1})}{1 + g_i(SR_{t-1})} a_{t-1} .$$

However, in reality there can be multiple frictions that affect the cost of innovation and make the optimal innovation investment deviate from its ideal level. For example, there may be credit constraint that limit the funds available for new investment; ineffective financial system may not be able to allocate funds to their optimal usage, hence increasing the overall borrowing cost; low

labor mobility across sectors and high cost of hiring and firing can make innovation more difficult; low efficiency of the government can increase the operational cost of the firms. Suppose because of these institutional constraint, the actual innovation investment cannot exceed a proportion, $f(SR)$, of the final output:

$$n\bar{A}_{t+1} \le f(SR_t)\left(\frac{\alpha}{\chi(SR_t)}\right)^{\frac{\alpha}{1-\alpha}} A_t$$

That is,

$$n \le f(SR_t)\left(\frac{\alpha}{\chi(SR_t)}\right)^{\frac{\alpha}{1-\alpha}} \frac{a_t}{1+g_i(SR_t)}$$

Here we assume that imitation cost χ and frontier productivity growth rate g_i are both functions of the structural reform factors.

Denote the actual degree of innovation as $\bar{\mu} = \mu(n) = \mu(SR_t, a_t)$. Then a region's distance to productivity frontier evolves according to

$$a_t = \mu(SR_{t-1}) + \frac{1-\mu(SR_{t-1})}{1+g_i(SR_{t-1})} a_{t-1}$$

where

$$\mu(a, SR) = \begin{cases} \bar{\mu}(a, SR) & \text{if } n < n^* \\ \mu^*(SR) & \text{otherwise} \end{cases}.$$

Here we assume that function $\mu(a, SR)$ has the following properties: (1) μ is infinitely differentiable; (2) $\mu'_a(a, SR) \ge 0$, and $\mu''_{a,SR}(a, SR) < 0$, for all $(a, SR) \ge (a_1, SR_1)$. Notice that we do not prescribe the sign of μ'_{SR}, as we assume that it depends on the specific SR factor under discussion.

The productivity growth rate of region j in country i can be written as

$$1 + G_{j,i,t} = \frac{A_{t+1}}{A_t} = \frac{a_{t+1}}{a_t}(1 + g_i(SR_t))$$

Therefore,

$$G_{j,i,t} = G(a_t, SR\ ) = \mu\left(a_t, SR_t\right)\left(\frac{1+g_i(SR_t)}{a_t} - 1\right) \tag{13}$$

Let SR_1 be the current level of SR of the country, and a_1 the highest level of a achievable by a region. Second-order Taylor expansion around (SR_1, a_1) gives:

$$\begin{aligned} G(a, SR) \cong\ & G(a_1, SR_1) + G'_{SR}(a_1, SR_1)(SR - SR_1) + G'_a(a_1, SR_1)(a - a_1) \\ & + \frac{1}{2} G''_{SR}(a_1, SR_1)(SR - SR_1)^2 + G''_a(a_1, SR_1)(a - a_1)^2 \\ & + G''_{a,SR}(a_1, SR_1)(SR - SR_1)(a - a_1) \end{aligned}$$

Rewriting it using equation (11) and omitting the quadratic terms, we arrive at equation (5):[19]

$$\begin{aligned} G(a, SR) \cong\ & g_i + \left[\mu'_{SR}(a_1, SR_1)\left(\frac{1 + g_i(SR_1)}{a_1} - 1 \right) + \frac{\mu(a_1, SR_1)}{a_1} g'_i(SR_1) \right](SR - SR_1) \\ & + \left[\frac{\mu(a_1, SR_1)(1 + g_i(SR_1))}{a_1} - \mu'_a(a_1, SR_1)\left(1 + g_i(SR_1) - a_1\right) \right](\ln a_1 - \ln a) \\ & + \left[\begin{array}{l} + \mu'_{SR}(a_1, SR_1)\left(\dfrac{1 + g_i(SR_1)}{a_1} \right) + \dfrac{\mu(a_1, SR_1)}{a_1} g'_i(SR_1) \\ - \mu''_{a,SR}(a_1, SR_1)\left(1 + g_i(SR_1) - a_1\right) - \mu'_a(a_1, SR_1) g'_i(SR_1) \end{array} \right](SR - SR_1)(\ln a_1 - \ln a) \end{aligned}$$

[19] Here we used $\ln a - \ln a_1 \approx \dfrac{a - a_1}{a_1}$.

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