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Determinants of technology catch-up in MENA and SSA countries: a panel data analysis

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Abstract

This paper estimates the determinants of TFP in the case of a panel of African and Middle-East countries for the period 1970-2010. We get two main results. Firstly, the degree of openness of a country is the only variables that have a positive and robust effect on the TFP growth. Secondly, convergence is not an automatic phenomenon for all countries. The possibility of a convergence effect depends on the ability of countries to adopt foreign technology. The most robust determinant of a country absorptive capacity is its stock of human capital. To a lesser extent the degree of financial market development could also be considered as a factor explaining the absorptive capacity but its significance depends on the list of regressors selected in the specification.

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DETERMINANTS OF TECHNOLOGY CATCH-UP IN AFRICA AND IN THE MIDDLE EAST: A PANEL DATA ANALYSIS

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Abstract

This paper examines and extends Benhabib and Spiegel (2005) model of technology diffusion in the case of a panel of African and Middle-East countries for the period 1970-2010. We get two main resultts. Firstly, the stock of human capital and the degree of openness of a country are the only variables that have a positive and robust effect on the TFP growth. Secondly, convergence is not an automatic phenomenon for all countries. The possibility of a convergence effect depends on the ability of countries to adopt foreign technology. The absorptive capacity depends on the stock of human capital and the degree of financial market development.

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1-Introduction

There are now empirical evidences showing that "technology" appears to be the central factor underlying divergence in growth rates across countries. Caselli (2005) estimates that about 60% of the variation in cross-sectional income gaps can be explained by differences in technological progress between countries in 1996. As regards developing countries, technology transfer is the major driver of productivity changes. Serranito (2013) using a growth model with an imperfect international technological diffusion function point out that if the coefficient of technological diffusion is sufficiently high, then a process of catch-up towards the income level of the leading country can begin for developing countries. Furthermore, the diffusion of technology is not constant over time and could depend on economic policy. Therefore policies aiming to improve the absorption of foreign advanced technology could promote development.

This paper deals with explaining the determinants of productivity in MENA (Middle-East and North African) and SSA (Sub-Saharan African) countries as it is considered as the main constraint to growth (Easterly & Levine, 1997, Devarajan et al., 2003 and Badunenko *et al.*, 2014)[1]. Focusing on Middle-East and African countries deserves some comments. Firstly, after decades of negative growth, Africa's economic performance has been buoyant since the 2000s. A large part of the explanation has come from improvements in productivity and not just from a higher accumulation of factors of production. Indeed, the growth rate of the Total Factor Productivity[2] (TFP) has been negative since the 1970s but it has finally turned positive in the 2000s (Rodrick, 2016). Secondly, as stated by Coulibaly *et al.* (2016) the integration of African countries in the international trade architecture is quite unique. African countries export a large share of commodities goods; and they import mostly manufacture goods from developed countries. They show that Africa's openness has a positive impact on income and this effect is channelled by improvements in TFP mostly. Thirdly, since the 1970s, there has been diverging trends in TFP dynamics between the different developing countries: compared to the US level, TFP is increasing for Asia, it is quite stable for Latin America and it is decreasing for Africa (Naanwaab & Yeboah, 2013). The bulk of difference between Asia's growth rate and that of Africa and Latin America is explained by labour productivity gaps stemming from differences in the contribution of the structural change (Mc Millan & Rodrick, 2014).

This paper estimates the main determinants of technology transfer and absorptive capacity in the case of MENA and SSA countries for the period 1970-2010 period. We extend previous literature on modelling TFP dynamics in several ways. First, we estimate the determinants of productivity with panel data including fixed effects in order to model time-invariant country specific heterogeneity. Indeed, according to Danquah *et al.* (2014), including country specific effects is crucial in explaining TFP growth rates. Second, we extend the possible candidates of the absorptive capacity beyond the human capital stock by exploring a larger set of potential explanatory variables. Third in order to account for a potential endogeneity of the regressors, we employ the "Difference GMM" panel estimator of Arellano and Bover (1995)[3]. The paper is outlined as follows. In section 2 we run a growth accounting exercise in order to evaluate the impact of the TFP growth rate on labour

[1] See Danquah & Ouattara (2015) for a review on the empirical literature.
[2] TFP simply measures all influences on GDP growth other than increases in capital and labour.
[3] Indeed a potential feedback from TFP to some of the potential explanatory variables might occur. For example, a more technological country could be more open because of its better capacity to compete in international markets; it would then attract more foreign capital which could finance its education expenditures.

productivity changes. Section 3 presents a review of the empirical determinants of technological catch-up and reports our empirical results and finally some conclusions are given in section 4.

2- Growth Accounting in MENA and SSA Countries

Growth accounting has been probably the most popular method for estimating TFP since Solow (1957). This approach computes TFP growth as the value of the production function residual after accounting for the contribution of the growth of the inputs to the growth of output. We run a growth accounting exercise for the 32 African and Middle-East countries available in the PWT8.0 for the period 1970-2011[4]. Table 1 reports the simple average contribution of inputs to income for all countries and some regional groupings (SSA, MENA and Gulf countries) and table 2 provides a description of the dataset.

It is worth noting that for 20 out of 32 countries in our sample, the average growth rate of TFP has been negative over the period (table 1). The most striking result is that income is mostly determined by capital accumulation (56.7%) and technology improvements (40%) in the entire sample (table 1). The (direct) contribution of education (or human capital) to income is almost negligible when compared to the other two inputs (3.1%). If the sample is split up between different regions, results remain the same. The contribution of capital accumulation is the highest in the Gulf countries (79%) and the lowest in SSA countries (50%). TFP contribution to income is the highest in SSA countries (46%) and the lowest in the Gulf countries (only 20%). MENA countries are in-between position with a contribution of capital to income of 61% and about 36% for the contribution of technology.

Our results are qualitatively similar to those of previous studies such as Ndulu & O'Connel (2003) and Cazzavillan *et al.* (2013). Ndulu & O'Connel (2003) applied the growth accounting framework in order to compare growth in different regions of the World. They have compared 19 countries in Sub-Saharan Africa with 45 other developing countries and 20 industrial countries. For the 1960-2000 period, both physical and human capital accumulations have a positive contribution whereas TFP has a negative one. The main growth driver is physical capital which represents 71% of the labour productivity growth. However, for the 1995-2000 period and for all regions but Latin America & Caribbean the contribution of TFP to labour productivity growth is the main determinant: TFP growth contributes to 44% of the GDP per worker productivity in East Asia & Pacific, 46% in the Middle East and North Africa and 61.5% in industrial countries. In a recent study, Cazzavillan *et al.* (2013) performed a growth accounting exercise in the case of SSA countries with the PWT7.0 database. They estimate that the contribution of capital, TFP and education are respectively 55.3%, 41.5% and 3.2%. With the new version of the PWT 8.0, the estimate stock of capital is higher in poor countries. So these new estimates of capital should imply that the contribution of TFP in explaining output should be reduced in poor countries comparing to earlier studies. Our results reveal that this is not the case; on the contrary the contribution of TFP to income

[4] Using PWT 8.0 allows to better estimate the TFP series. This new dataset extends the growth accounting framework in four ways: (1) they do not impose a Cobb-Douglas production function, (2) the share of labour income is now country and time specific, (3) the initial capital stock measure is improved, and (4) the measure of capital input takes into account the differences in asset composition across countries and over time (Feenstra *et al.*, 2015).

has increased in Africa. Therefore, the role of technology is even more important in explaining African growth than expected.

There is a very high level of heterogeneity in the data in our sample of Middle-East and African countries[5]: the two most productive countries are as expected Turkey and Israel with an average technological gap of 96% and 92% respectively (see table 1). So these countries can be considered as being producing very close to the world technological frontier. On the contrary the two lowest productive countries are Burundi and Togo with an average TFP ratio gap of 12%. The most productive countries in the SSA region are Gabon, Zimbabwe and Mauritius with an average gap of 89%, 79% and 77% respectively. This rank of relative TFP levels is quite similar to that obtained by Di Liberto et al. (2011).

3- Technology Transfer, Absorptive Capacity and TFP Dynamics: Some Empirical Results

If technology diffusion is not instantaneous and complete as in the Solow (1956) model, then the level of technology catching-up will depend on the extent of technology spillovers from technology leaders to less developed countries the so-called "advantage of backwardness" (Gerschenkron, 1952). However, for some lagging countries due to a low absorptive capacity the technological convergence process could not have been triggered[6]. According to Nelson & Phelps (1966), the level of human capital is the only determinant of the capability to learn and adopt the new technology. TFP growth is higher when the economy is far from the technology frontier because the country could engage in imitation activities. However, technology transfer requires the receiving country population to have the skills in order to master foreign technologies and adapt them to the local environment[7]. Benhabib & Spiegel (2005) extend the previous model by introducing a non-linear effect of the distance to the technological frontier variable. They consider a logistic diffusion process that allows for impediments to imitation and divergence in world income. Thus the convergence path can be trigged only if a threshold level of human capital is reached.

Following Roy (2009) and Di Liberto *et al.* (2011), we estimate the determinants of TFP growth ($\Delta\ln(\mathrm{A})$) by running the following equation:

$$\Delta\ln(\mathrm{A}_{\mathrm{it}}) = \beta_{\mathrm{a}}\ln\left(\frac{\mathrm{A}}{\mathrm{A}^{\mathrm{US}}}\right)_{\mathrm{it}-1} + \alpha_{1\mathrm{i}}Z_{\mathrm{it}} + \alpha_{2\mathrm{i}}\ln\left(\mathrm{Z}.\frac{\mathrm{A}}{\mathrm{A}^{\mathrm{US}}}\right)_{\mathrm{it}-1} + \beta_{\mathrm{i}}\mathrm{X}_{\mathrm{it}} + \alpha_{\mathrm{i}} + \epsilon_{\mathrm{it}}$$

[5] Increasing the heterogeneity is an important issue as we introduced the distance to the frontier variable in the list of the exogenous variables. We need to have countries very close and very far from the frontier in order to estimate robustly TFP determinants. Due to data constrains, we have only three out of the nine countries belonging to the North Africa region. The average distance to the technological frontier of these four countries is quite low (see table 1). So taking into account these countries along with SSA countries is not sufficient to highlight the heterogeneity. We thus extend our sample in order to take into account the MENA region and not only North African countries because these countries share a common heritage and/or similar structural economic characteristics that have influenced their economic performance (Abeb & Davoodi, 2003). Turkey and Israel are often included in the MENA region, even if this this issue could be still controversial.

[6] See Gong & Keller (2003) for a review of the empirical literature on technological diffusion and per capita income convergence.

[7] For Acemoglu *et al.* (2006) the low absorptive capacity of a country could be also explained by the low quality of its institutions.

The first variable is the traditional technological catch-up effect, the interacting terms are proxies for each country absorptive capacity (if the coefficients of the Z_{it} variables are negative)[8], X_{it} is a set of control variables , α_i is a country fixed effect and ϵ_{it} is a disturbance term with mean zero.

3.1- Potential Determinants of TFP:

In the growth literature the choice of the explanatory variables is a tricky one because a lot of variables are not robust. Furthermore some variables may influence GDP growth through the accumulation of factors and not through TFP changes[9]. We rely on Danquah *et al.* (2014) as regards the relevant control variables to be taken into account. Accordingly, the potential determinants of TFP can be grouped into the following categories:

- ✓ Technological catch-up effect: Technological backwardness is the main determinant of TFP (Gerschenkron, 1962). We apply the distance to the US technological frontier as measure of the technological gap.
- ✓ Factor supply variables: since Nelson & Phelps (1966) the human capital stock is the most important driver of TFP growth. There are other dimensions in the concept of human capital that should be taken into account such as health (Aghion *et al.*, 2011). For example, agents with higher life expectancy are likely to invest more in education, which in turn should be growth enhancing[10].
- ✓ International variables: trade policy is a major determinant of technological spillovers across countries (Coe & Helpman, 1995 and Keller, 2000). The openness variable is calculated as the ratio of the sum of current imports and exports to current GDP. Foreign direct investment (FDI) is another channel for technological spillovers across countries (Keller, 2010)[11]. Changes in the terms of trade (TOT) should have impact on the per capita income of the countries in our sample as they export mainly commodity goods (oil, minerals ...). An increase in their terms of trade should raise income which should allow these countries to import more capital goods. Capital goods imports are now considered as a channel of technology transfer (Lee, 1995)[12].
- ✓ Infrastructure variables: a consensus has emerged that, under the right conditions, infrastructure development can play a major role in promoting growth[13]. Escribano et al. (2010) provide an empirical assessment of the impact of infrastructure quality on

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[8] In this specification the effect of distance on diffusion is no longer linear: unless a critical value of the Z variable is reached, the Nelson-Phelps catch-up mechanism is not activated. Di Liberto *et al.* (2011) applying panel data techniques point out that the estimated threshold is so low that it is not a binding constraint for most countries.

[9] Therefore a non-significant regressor cannot be interpreted as not affecting GDP growth in general. However, Miller & Upadhyay (2000) emphasized that most variables applied in growth regressions might affect income growth only through their impact on productivity.

[10] Health measures should account for illness as well as mortality. Canning (2010) shows that population mortality and illness measures tend to move closely together, so in empirical studies life expectancy could be used as a reasonable proxy for population health.

[11] De Mello (1999) on a sample of OECD and non-OECD countries for the period 1970-90 shows that the degree to which FDI is growth enhancing depends on the extent of complementarity and substitution between FDI and domestic investment. Ng (2006) examines the linkages between FDI and TFP for eight Asian economies and he finds little evidence in favor of FDI causing technical change in the sample economies. On the contrary, Woo (2009) with a cross-country regression of 82 countries for the period 1970-200, finds a positive and significant effect of FDI on average TFP growth.

[12] Coe, Helpman and Hoiffmaister (1997), using data for 77 developing find that a country can gain in productivity by importing intermediate and capital goods which embody recent technologies.

[13] See Ndulu (2006) and Ayogu (2007) for surveys of this empirical literature.

the total factor productivity (TFP) of African manufacturing firms. On the whole Infrastructures are estimated to contribute between 20 and 70% of African firm's TFP. We will use two different variables in order to measure infrastructure. The first measure of infrastructure is the electricity-generating capacity in kilowatts (Canning 1998). The second one is a measure of transportation costs (Causa, Cohen & Soto, 2006). Indeed poor infrastructure (acting as a barrier to trade, foreign direct investment, and competition) is bound to create serious price distortions. And then it is associated with rising trading costs.

- ✓ Finance variables: According to Aghion *et al.* (2005), the level of financial development is the most important factor in explaining cross-country growth differentials. Following Aghion *et al* (2005) as our preferred measure of financial development is defined as the value of total credits by financial intermediaries to the private sector, divided by GDP.
- ✓ Demographics variables: we will introduce in the regression the urban population and the skilled emigration rate. The share of urban population could affect TFP through agglomeration effects (Kumar & Kober, 2012). The rationale for using the skilled emigration rate variable is the debate on the impact of the brain drain on economic growth (Beine, Doquier & Rapoport, 2001)[14].

3.2- Empirical Results

In Table 3 are reported all the estimate outcomes. We first consider the simplest model that considers that the TFP growth can be explained only by past technological gap, the stock of human capital and the level of financial development. According to theoretical models of Benhabib & Spiegel (2005) and Aghion *et al* (2005), the absorptive capacity of a country is uniquely determined by the last two variables (see model (1) in column 2 of table 4). The coefficient of the technological gap (α_{1i}) is not consistent with the negative expected theoretically value. Indeed, this coefficient is positive and significant. So, in our sample there is not a tendency for an absolute convergence of the countries that have the lowest levels of technology. In the case of African and Middle-East countries, the "advantage of backwardness" does not occur. On the contrary, the closer a country is to the technological frontier and the higher the growth of TFP. However, our results do not imply a lack of convergence as the coefficients of the interacting variables (α_{2i}) are negative and significant. Indeed, the convergence hypothesis is accepted if the growth rate of TFP is negatively correlated with the increased level of technological gap. Therefore, a country could catch-up with the technological level of the leading country if its stock of human capital is large enough and if the financial market is sufficiently developed. If we evaluate the h and credit variables at their mean values, then the speed of convergence is respectively 10.4% per year for the all sample but only 7.8% for SSA and 15.1% for MENA countries. The direct effect of the level of financial development is not significant. This means that in the long run the level of technology is independent of the level of financial development. The stock of human capital has a long run impact on the growth rate of TFP: an increase of the stock of human capital of 10% will increase the long run technological level by 7.6%[15].

[14] Actually Beine, Doquier & Rapoport (2001) distinguish two different growth effects of skilled emigration. There is an ex ante « brain effect» in which migration prospects foster human capital accumulation because of higher returns abroad ; and there is also an ex post « drain effect » because educated agents actually migrate. A positive impact of brain drain on growth emerges when the first effect dominates.

[15] Our result confirm that of Badunenko et al. (2014) and Danquah et al. (2014) that human capital is the most important driver of TFP growth.

Next we will introduce one by one all the other possible determinants of TFP growth. In the second model, we introduce the openness variable as a supplementary regressor (see model (2) in table 4). If international trade promotes technology transfer then the openness coefficient should be positive. The estimated coefficient is consistent with the expected value: if a country's openness increases by 10%, then the growth of TFP increases by 7.6%. The introduction of this new regressor does not affect the estimates of the other variables. In model (3) we introduce the FDI variable and in model (4) its interaction with the initial technological gap. The estimated coefficients are not significant in both models. So the FDI variable has neither a direct nor an indirect effect on TFP growth rate. In these models, the initial technological gap, the human capital and the openness variable remain significant.

The transportation cost has a negative effect on TFP growth as expected but its effect is not significant (model 5). As expected the health variable has a positive impact of TPF growth: a country with a higher life expectancy has also a higher TFP growth rate but this effect is not significant (model 7). We confirm the existence of a drain effect in our sample. Indeed the coefficient of the emigration rate of skilled people has a negative impact on the TFP growth but again this effect is not significant (model 9). The estimated coefficients of the urban population and power capacity variables have the wrong sign but these estimates are not significant (models 8 and 10).

As a robustness check, we introduced simultaneously all the potential determinants in one regression. Our results are slightly similar (model 11). The openness variable is still the main determinant of the TFP. The human capital plays a significant role only through its impact on the absorptive capacity. It is worth noting however that once the power capacity variable is introduced the level of financial development is no more a significant regressor[16].

4- Conclusion

This paper estimates the determinants of TFP in the case of a panel of African and Middle-East countries for the period 1970-2010. We get two main results. Firstly, the degree of openness of a country is the only variables that have a positive and robust effect on the TFP growth. Secondly, convergence is not an automatic phenomenon for all countries. The possibility of a convergence effect depends on the ability of countries to adopt foreign technology. The most robust determinant of a country absorptive capacity is its stock of human capital. To a lesser extent the degree of financial market development could also be considered as a factor explaining the absorptive capacity but its significance depends on the list of regressors selected in the specification.

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[16] This result may be explained by the decrease in the number of countries included in the dataset in this case.

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Table 1: Growth Accounting in MENA and SSA countries, 1970-2011

							Contribution of (in %)		
country	$\bar{y}$	$\bar{k}$	$\bar{h}$	$\overline{Ln(a)}$	$\overline{A^i/A^{US}}$	$\overline{\Delta Ln(a)}$	**Capital**	**Education**	**TFP**
Bahrain	40932.25	234189.2	2.26	2.52	1.16	-0.020	74.4	2.8	23.8
Benin	2975.09	9027.39	1.38	4.41	0.31	0.001	42.0	2.9	55.1
Botswana	15041.14	43446.99	2.18	1.55	0.69	0.004	81.3	2.5	16.2
Burundi	1044.88	2258.66	1.31	4.67	0.12	-0.009	29.7	3.1	67.2
Cameroon	4717.74	9713.066	1.74	3.86	0.39	-0.003	50.9	3.4	45.9
Central Af. Rep	1520.246	5768.05	1.40	0.50	0.25	0.007	92.1	1.1	6.8
Ivory Coast	5533.77	10444.04	1.49	4.33	0.48	-0.006	47.3	2.5	50.2
Egypt	8267.53	13259.47	1.77	2.67	0.91	-0.006	67.7	2.2	30.1
Gabon	23522.82	133873.50	1.97	1.98	0.89	-0.003	77.8	2.4	19.8
Iran	20355.88	99535.56	1.96	1.89	0.77	-0.013	78.7	2.1	19.2
Israel	51264.76	127268.0	3.03	5.31	0.92	0.002	44.9	6.0	49.1
Jordan	15761.04	84546.6	2.21	3.34	0.61	-0.007	61.6	3.8	34.6
Kenya	3971.70	6479.65	1.87	5.18	0.27	-0.003	32.3	5.1	62.6
Kuwait	72582.68	199410.2	1.96	1.49	2.38	-0.034	85.4	1.3	13.3

Lesotho	2345.93	11048.88	1.88	4.28	0.15	0.006	38.7	5.2	55.1
Mauritania	5581.03	21709.34	1.48	4.11	0.30	-0.012	49.4	2.8	47.8
Mauritius	20106.21	47213.2	2.16	4.00	0.77	0.018	55.6	4.0	40.4
Morocco	9414.67	21519.09	1.50	4.22	0.64	-0.002	51.6	2.2	46.2
Mozambique	934.43	1829.83	1.16	2.36	0.21	0.013	64.5	0.9	34.6
Niger	2293.015	14309.61	1.15	3.49	0.20	-0.007	53.5	1.1	45.4
Qatar	110747.7	466350.5	2.05	1.23	1.86	-0.004	87.9	1.4	10.7
Rwanda	2056.12	2408.83	1.39	4.72	0.29	0.001	34.7	3.2	62.1
Saudi Arabia	59329.8	216627.9	2.07	3.12	1.35	-0.012	60.9	2.5	28.6
Senegal	4289.45	15539.12	1.62	2.22	0.39	0.003	71.3	2.2	26.5
Sierra Leone	2803.18	6665.35	1.33	4.36	0.40	-0.006	42.3	2.6	55.1
South Africa	20670.94	47740.23	2.25	4.92	0.72	-0.011	45.9	4.6	49.5
Swaziland	13120.98	81879.58	2.04	4.93	0.48	0.010	42.5	5.2	52.3
Tanzania	2104.17	4863.21	1.71	3.17	0.23	0.004	54.9	3.5	41.6
Togo	2080.27	7067.14	1.65	5.84	0.12	-0.022	17.1	6.4	76.5
Tunisia	15716.63	52910.55	1.81	3.79	0.76	0.005	57.8	2.9	39.3
Turkey	27484.73	38916.39	1.88	3.29	0.96	-0.001	65.4	2.2	32.4
Zimbabwe	7663.47	2253.81	2.02	5.54	0.79	-0.010	33.4	4.6	62.0

Regional Average									
ALL	19019.49	66960.29	1.80	3.52	0.67	-0.004	56.9	3.1	40.0
MENA	21180.75	62565.10	2.02	3.50	0.79	-0.003	61.1	3.1	35.8
GULF	70898.11	279144.50	2.08	2.09	1.69	-0.018	78.9	2.0	19.1
SSA	6747.82	21875.32	1.68	3.84	0.40	-0.001	50.4	3.3	46.3

The elements of this table represent the mean values of the log of per worker real GDP ($\bar{y}$) measured in millions of 2005 US dollars, per worker capital ($\bar{k}$) measured in millions of 2005 US dollars, the human capital ($\bar{h}$) and Solow's residual or TFP ($\overline{Ln(a)}$). The column ($\overline{A^{\iota}/A^{US}}$) represents the distance to the frontier ant that of ($\overline{\Delta Ln(a)}$) stands for the average growth rate of the TFP series. In the contribution column, the elements represent the average contribution of each input to total output. According to data availability, mean values might be computed using a different number of years. Series are annually and run from 1971 to 2011, Source: PWT8.0

Table 2: Variable definition and sources

Variable	Source	Definition
$\Delta\ln(A)$	PWT 8.0	Growth Rate of Total Factor Productivity
A^i/A^{US}	PWT 8.0	Distance to frontier: ratio of TFP level of a country to that of the US
Credit	WDI, World Bank	Total credits by financial intermediaries to the private sector as a share of GDP
h	PWT 8.0	Stock of human capital: calculated according to the methodology advocated by Hall & Jones (1999).
open	PWT 7.0	Exports plus imports as a share of GDP
FDI		Gross Foreign Direct Investment as a share of GDP
MCIF/XFOB	IFS, IMF	Transportation cost measured with the ratio of CIF value of imports to FOB value of exports
TOT	PWT 8.0	Terms of trade: ratio of the price of exports on the price of imports.
Health	WDI, World Bank	Life expectancy at birth of total population
Urban_Pop	WDI, World Bank	Ratio of the urban population over the total population.
Skilled_Emigration	Defoort (2008)	Emigration rate is defined as the ratio of the number of skilled emigrants aged 25+ to the six major receiving countries (USA, UK, Germany, France, Canada and Australia) to the total number of skilled natives aged 25+ (residents + emigrants). Skilled workers are those with a post-secondary certificate
Power_Capacity	Canning & Farahani (2007)	Electricity-generating capacity in kilowatts

Table 3: Determinants of TFP growth: GMM estimations

Dependant variable $\Delta\ln(A_{it})$											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$\ln(A^{i}/A^{US})_{t-1}$	0.226* (1.86)	0.316** (2.19)	0.331** (2.45)	0.281* (1.89)	0.176 (0.136)	0.139 (1.03)	0.406*** (3.57)	0.224** (2.33)	0.379* (1.87)	0.319** (2.57)	0.365** (2.00)
$\ln(Credit_{it})$	-0.013 (0.64)	-0.002 (-0.12)	-0.001 (-0.06)	0-.006 (-0.34)	-0.004 (-0.20)	-0.015 (-1.19)	-0.003 (-0.15)	0.040** (2.60)	-0.034 (-1.41)	-0.030 (-1.04)	-0.030 (-1.05)
$\ln(h_{it})$	0.078* (1.70)	0.079* (1.89)	0.081** (2.05)	0.0715 (0.98)	0.062** (1.70)	0.027 (0.48)	0.075* (1.96)	0.061 (1.54)	0.081 (1.24)	0.230*** (2.86)	0.116 (1.33)
$\ln(open_{it})$		0.076*** (2.48)	0.078*** (3.23)	0.076*** (2.79)	0.056** (2.41)	0.050* (1.79)	0.091*** (3.03)	0.086*** (2.73)	0.072* (1.94)	0.056* (1.69)	0.102** (2.59)
FDI_{it}			0.0002 (0.12)	.0011 (0.57)	0.0002 (0.21)	-0.0004 (-0.27)	-0.002 (-0.95)	-0.005 (-0.33)	-0.005 (-1.34)	-0.0004 (-0.24)	-0.002 (-0.99)
$\ln(MCIF/XFOB_{it})$					-0.022 (-1.10)						-0.046 (-0.99)
$\ln(TOT_{it})$						0.012 (0.70)					0.005 (0.24)

$\ln(\text{Health}_{it-1})$							0.026 (0.34)				0.108 (0.90)
$\ln(\text{Urban\_Pop}_{it-1})$								-0.101 (-1.45)			-0.012 (-0.21)
$\ln(\text{Skilled\_Emigration}_{it-1})$									-0.003 (-0.09)		0.0005 (0.975)
$\ln(\text{Power\_Capacity}_{it})$										-0.044 (-0.99)	-0.030 (-0.83)
$\ln(\text{FDI})\ln(A^i/A^{US})_{\text{it}-1}$				-.0010* (-1.87)							-0.002 (-1.63)
$\ln(\text{h}) \times \ln(A^i/A^{US})_{\text{it}-1}$	-0.166** (-2.02)	-0.23*** (-2.36)	-0.24*** (-2.64)	-.212*** (-2.21)	-0.137 (-1.63)	-0.110 (-1.21)	-0.29*** (-3.89)	-0.158** (-2.45)	-0.27*** (-2.13)	-0.23*** (-2.90)	-0.273** (-2.40)
$\ln(\text{Credit})\ln(A^i/A^{US})_{\text{it}-1}$	-.001*** (-2.38)	-.002*** (-2.30)	-.001*** (-2.38))	-.001*** (-2.45)	-.001*** (-3.11)	-.001*** (-3.11)	-0.008 (-1.58)	-.002*** (-3.93)	-0.009 (-0.387)	-0.001 (-1.54)	-0.005 (-0.91)
Individual Fixed Effect	Yes										
Temporal Fixed Effect	Yes										
NT	1069	1040	972	902	956	972	922	972	654	697	587
N	32	32	31	31	30	31	29	31	31	31	28

# Instruments	89	81	88	69	119	103	79	71	57	96	81
Average T	33.41	32.50	31.35	29.1	31.87	31.35	31.79	31.35	21.20	22.48	20.96
AR(1)	-2.87 (0.003)	-2.80 (0.005)	-2.68 (0.007)	-2.55 (0.008)	-2.69 (0.007)	-2.73 (0.006)	-2.62 (0.008)	-2.75 (0.006)	-2.53 (0.011)	-2.52 (0.012)	-2.35 (0.019)
AR(2)	-1.70 (0.089)	-1.64 (0.101)	-1.55 (0.122)	-1.38 (0.166)	-1.49 (0.136)	-1.43 (0.153)	-1.57 (0.116)	-1.34 (0.182)	-1.66 (0.098)	-1.57 (0.117)	-1.52 (0.128)
χ^2 Hansen's test	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)

t statistics in parentheses ; ***,** and * denote 1%, 5% and 10% level of significance. In all regressions, we use collapsing instruments in order to avoid the problem of proliferation of instruments that can overfit endogenous variables (Roodman 2009a). AR(1) and AR(2) are Arellano-Bover tests for autocorrelation. Standard errors are consistent with panel-specific autocorrelation and heteroskedasticity in one-step estimation. Available on request are estimates of time effects.