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Catching up of Emerging Economies: The Role of Capital Goods Imports, FDI Inflows, Domestic Investment and Absorptive Capacity

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Abstract:
We assess the role of capital goods imports and inflows of foreign direct investment (FDI) as transmission channels through which major emerging economies (BRICs, i.e., Brazil, Russian Federation, India and China) could catch up with advanced source countries in terms of total factor productivity (TFP). We find that the importance of these transmission mechanisms depends on the BRICs' local capacity to absorb superior technologies and on domestic investment.

Keywords: total factor productivity; imports; foreign direct investment; absorptive capacity; BRICs.

JEL classification: F14; F21; O47

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1. Introduction

International technology transfer from advanced to emerging economies is widely perceived as crucial for economic convergence. Imports of capital goods and inflows of foreign direct investment (FDI) are deemed to be major transmission channels through which emerging economies can tap the potential of technology transfer.[1]

In contrast to most of the previous literature, our empirical analysis covers both the trade and the FDI channel to assess the impact of technology transfer on total factor productivity (TFP) in the so-called BRIC countries (Brazil, Russia, India and China) relative to the TFP in 18 advanced OECD countries.[2] We also assess whether the import- and FDI-related transmission channels reinforce each other. We account for a composite index of local absorptive capacity and its interaction with both transmission channels, in order to analyze whether import- or FDI-related effects on TFP are conditional on complementary local inputs (e.g., skills, infrastructure and institutions). As another novel aspect, we scrutinize possible complementarities and synergies between domestic investment and imports or FDI inflows. Finally, in contrast to most of the literature, the dyadic structure of our empirical model allows us to account for differences in the technology gaps between source-recipient country dyads and to assess technological convergence between them.

[1] For surveys of the relevant literature, see Saggi (2002) and Keller (2004).

[2] While earlier studies typically focus on either imports or FDI, there are some notable exceptions: For instance, Yasar and Morrison Paul (2007) assess international linkages in several dimensions and their effects on the productivity of Turkish plants in selected industries. Blind and Jungmittag (2004) find positive effects of imports and FDI on innovations by German firms in the service sector. Perkins and Neumayer (2012) analyze the impact of FDI and import-related spillovers on the CO_2 intensity in the recipient countries, finding FDI-induced CO_2 efficiency spillovers. Hübler and Keller's (2010) results, on the contrary, question significant effects of FDI on the energy intensities of developing countries. See Appendix A for list of advanced source countries.

2. Model and data

Our empirical model reads as follows:

$$dTFP_{srt} = \alpha \cdot AC_{r(t-3)} + \beta \cdot DI_{r(t-3)} + \gamma \cdot FI_{sr(t-3)} + \delta \cdot IM_{sr(t-3)} + \eta_{sr} + \lambda_t + \nu + \varepsilon_{srt}$$

The dependent variable, *dTFP*, is defined as the growth rate of relative TFP, i.e., the change in the natural logarithm of relative TFP.[3] Relative means that the TFP of an emerging (BRIC) country, *r*, is divided by the TFP of an advanced (OECD) country, *s*, in each year, *t*. The *sr*-country dyads are connected via capital goods trade and FDI flows. Positive values of *dTFP* indicate catching up of the emerging recipient, *r*, vis-à-vis the advanced source country, *s*, i.e., narrowing TFP gaps between *sr*-dyads and hence convergence.[4]

IM and *FI* represent the two transmission mechanisms through which technology transfer from *s* to *r* can narrow the TFP gap between *r* and *s*. From the viewpoint of *r*, *IM* denotes imports of capital goods and *FI* denotes FDI inflows. Both are measured as the natural logarithm of their ratio over *r*'s gross domestic product (GDP) to make them independent of the economic size of *r*.[5] *IM* and *FI* are defined bilaterally for specific *sr*-dyads at time *t*. The dyadic structure takes into account that the technology gap varies between *sr*-dyads.

As FDI and imports can substitute or complement each other, it could be "problematic to include only one of the two variables. If the two possibilities to supply a foreign market are substitutes, then the influence of the solely included variable is biased towards zero, whereas

[3] See Hübler and Pothen (2013) for details on the TFP calculation and Appendix B for detailed definitions of variables..

[4] Technological progress that improves TFP in both countries to the same extent leaves the dependent variable unaffected (*dTFP* = 0). The relative TFP definition resembles Mayer-Foulkes and Nunnenkamp (2009), who perform convergence regressions with the host countries' per-capita income relative to the per-capita income of the technologically leading United States as their dependent variable.

[5] Import and output (GDP) data are taken from the WIOD database (http://www.wiod.org/new_site/data.htm), while FDI data are taken from the OECD database (http://stats.oecd.org/index.aspx?DataSetCode=CRS1) with missing entries filled where appropriate with UNCTAD data (http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=en).

it is overestimated if they are complements" (Blind and Jungmittag 2004: 207).[6] Hence, we include the interaction term, *IM x FI*, in one specification to test if both transmission mechanisms reinforce each other in reducing TFP gaps between *r* and *s*.

We control for the rate of domestic investment, *DI*, and let it interact with *IM* and *FI* in order to identify possible complementarities. We also account for a composite index of absorptive capacity, *AC*. Specifically, we use nine indicators of absorptive capacity to perform a principal component analysis (PCA). We obtain *AC* as the first component from the PCA.[7] Notably, we let *AC* interact with *IM* and *FI* in order to analyze whether and how improvements in *AC* support technology transfer. The overall constant is v, and ε is the error term.

We use three-year moving averages of all variables, covering the period 1995-2009.[8] Possible endogeneity concerns are addressed in several ways. Most importantly, we include fixed-effects, η, defined for *sr*-dyads to account for time invariant characteristics and to mitigate omitted variable bias. We also include time fixed-effects, λ, to account for shocks affecting all dyads at time *t* in the same way. Furthermore, we define the dependent variable in first differences and in relative terms and let the explanatory variables enter with three-year time lags to mitigate possible reverse causality problems.

[6] Horizontal FDI and exports are widely regarded as alternative modes of serving foreign markets. In contrast, vertical FDI and trade complement each other.
[7] See Appendix B for the list of indicators and the PCA.
[8] See Appendix C for summary statistics.

3. Results

Table 1 presents our main results. In column (1), we consider the four standard explanatory variables – BRICs' local absorptive capacity, *AC,* domestic investment, *DI*, FDI inflows, *FI*, and capital goods imports, *IM* – and the *IM x AC* interaction. Higher *AC* is associated with higher relative TFP growth in the BRICs, whereas the negative coefficient of *DI* proves to be statistically insignificant at conventional levels. A striking difference exists between the import and the FDI channel. Higher *IM* is associated with higher relative TPF growth in the BRICs. The significantly positive coefficient of the interaction term, *IM x AC*, reveals that the TFP promoting effects working through the import channel are stronger when BRICs have higher absorptive capacity. Figure 1 visualizes this effect.

Table 1 about here

Figure 1 about here

In contrast to *IM*, higher *FI* per se appears to widen the TFP gap between the recipient BRIC and the advanced source countries. This result also holds in column (2) where we replace the interaction *IM x AC* by the interaction *FI x AC*. However, the latter interaction term resembles the former in that its coefficient proves to be significantly positive. This implies that better absorptive capacity renders it less likely that FDI flows to the BRICs exert a significantly negative impact on convergence of *sr*-dyads. All the same, Figure 2 suggests that it would require *AC* values that are rarely observed in our sample for the impact to turn positive.

Figure 2 about here

We obtain weaker results when replacing the two interactions with *AC* by alternative interaction terms in columns (3) to (5). The results on the four standard explanatory variables are largely as before. Yet, the effect of *FI* is not always significantly negative, and *DI* has a weakly significant and positive effect in column (4). We do not find evidence for capital

goods imports and FDI inflows reinforcing each other; the insignificant interaction between *IM* and *FI* in column (3) may result from the heterogeneity of (horizontal versus vertical) FDI in the BRICs. Complementarities with *DI* prove to be significantly positive for the import channel in column (4), whereas they are statistically insignificant for the FDI channel in column (5).

In columns (6) and (7) of Table 1, we simultaneously account for the interactions of *IM* and *FI* with *AC* and *DI*. Importantly, all interaction terms now point to significant complementarities. The evidence on *IM x AC* and *FI x AC* is very similar to that in columns (1) and (2). In addition to higher *AC*, the impact of both *IM* and *FI* on TFP convergence rates is also significantly reinforced through complementarities with *DI*.

Our major findings on import- and FDI-related transmission channels and the complementarities with BRICs' absorptive capacity and domestic investment essentially hold in several robustness tests.[9] First, we replicate the estimations in columns (6) and (7) of Table 1 after excluding one of the BRICs at a time. The results are hardly affected when excluding Russia, and only modestly when excluding Brazil or India. In contrast, several effects prove to be weaker when excluding China, which is not surprising considering that China has caught up most quickly with advanced source countries. All the same, the interaction terms without China still point to significant complementarities (except for *IM x AC*).

Second, we exclude Japan, Sweden or the United States to check whether the results on the import- and FDI-related transmission channels are driven mainly by technologically leading source countries in terms of company spending on R&D. Concerning the interaction terms, the previous evidence on complementarities is unaffected when excluding Sweden. In contrast, two interactions (*IM x AC* and *FI x DI*) appear to be largely driven by import and FDI relations with the United States.

[9] Detailed results on robustness tests are presented in Appendix D.

Third, we modify the length of the lags used for our explanatory variables from three years to either two or four years. Shorter lags have minor effects on our results. Among the interaction terms, just one loses its significance (*IM x AC*). When re-running the specification with FDI-related interactions in column (7) of Table 1 with longer lags, some of our standard explanatory variables are no longer statistically significant. Importantly, however, the interactions with *AC* still suggest that both the import and the FDI channel have stronger effects on the dependent TFP variable when BRICs have better absorptive capacity.

4. Conclusion

We assess the role of capital goods imports and FDI inflows as transmission channels through which the BRICs (Brazil, Russia, India and China) could catch up with advanced source countries in terms of total factor productivity (TFP). First, we find a striking difference between these channels. While higher capital goods imports are associated with higher relative TPF growth in the BRICs, FDI inflows per se appear to widen the TFP gap between the BRICs and the advanced source countries. Second, the impact of both imports and FDI inflows depends on the BRICs' absorptive capacity. In particular, better absorptive capacity renders it less likely that FDI inflows exert a negative impact on TFP convergence. Third, the impact of both capital goods imports and FDI inflows on TFP convergence rates is also reinforced through complementarities with domestic investment. Finally, our major findings on import- and FDI-related transmission channels and the complementarities with local absorptive capacity and domestic investment prove to be fairly robust to the exclusion of particular source or recipient countries and modified lags.

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Table 1: Effect of FDI inflows and capital goods imports (*FI* and *IM*, both in log intensity form) on the growth rate of total factor productivity (*TFP* in log relative form) for BRIC recipients with time and dyad fixed-effects and 3-year time lags.

	(1) *dTFP*	(2) *dTFP*	(3) *dTFP*	(4) *dTFP*	(5) *dTFP*	(6) *dTFP*	(7) *dTFP*
AC, absorp. capac.	0.012****	0.021****	0.0081****	0.0077****	0.0081****	0.012****	0.026****
	(5.3e-06)	(2.7e-06)	(2.1e-05)	(5.0e-06)	(1.6e-05)	(5.8e-06)	(1.7e-07)
DI, domestic inv.	-0.0089	-0.0024	-0.0076	0.13**	0.034	0.13***	0.15*
	(0.50)	(0.86)	(0.58)	(0.017)	(0.67)	(0.0070)	(0.075)
FI, foreign dir. inv.	-0.0025*	-0.0042****	-0.0080	-0.0028*	0.010	-0.0029**	0.039
	(0.071)	(0.0018)	(0.28)	(0.062)	(0.67)	(0.049)	(0.10)
IM, imports	0.0058**	0.0053**	-0.0016	0.039***	0.0044*	0.041****	0.0052**
	(0.023)	(0.026)	(0.85)	(0.0087)	(0.059)	(0.0015)	(0.034)
IM x AC	0.00043**					0.00046**	
	(0.048)					(0.030)	
FI x AC		0.0015****					0.0021****
		(0.0023)					(0.00014)
FI x IM			-0.00068				
			(0.45)				
IM x DI				0.015**		0.015****	
				(0.015)		(0.0048)	
FI x DI					0.0051		0.018*
					(0.60)		(0.071)
Constant	0.020	0.017	-0.037	0.32**	0.12	0.33****	0.38*
	(0.58)	(0.65)	(0.60)	(0.011)	(0.56)	(0.0027)	(0.059)
Num. of obs.	724	724	724	724	724	724	724
Num. of dyads	72	72	72	72	72	72	72
R-squared	0.536	0.541	0.534	0.547	0.534	0.551	0.545

Robust *p*-values in parentheses:
**** $p<0.005$, *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Figure 1: Effect of capital goods imports on the growth rate of (relative) TFP of BRICs over the range of absorptive capacity (*AC*) based on column (1) of Table 1.

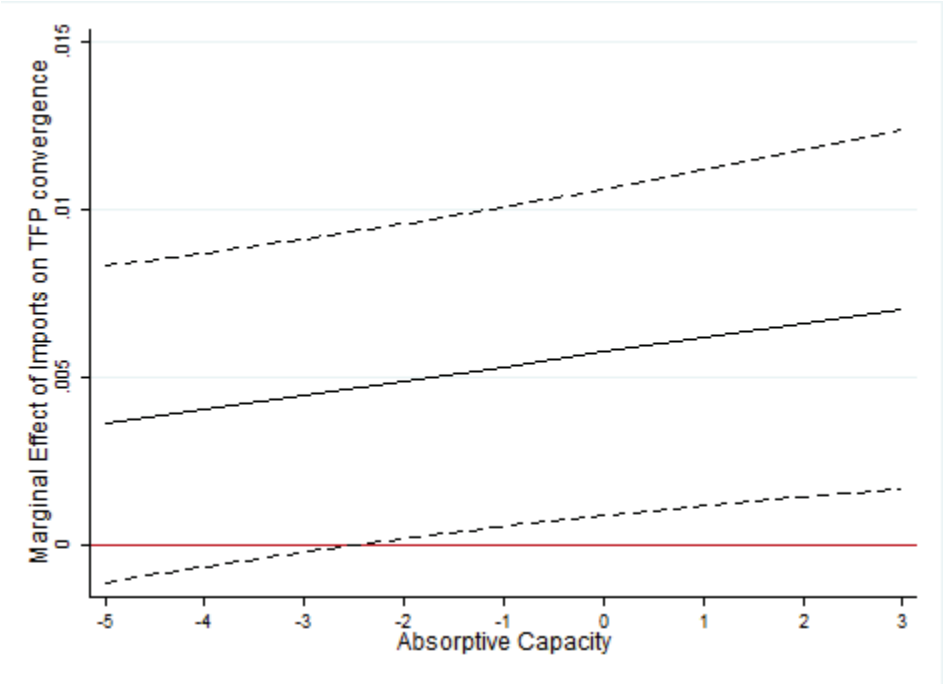
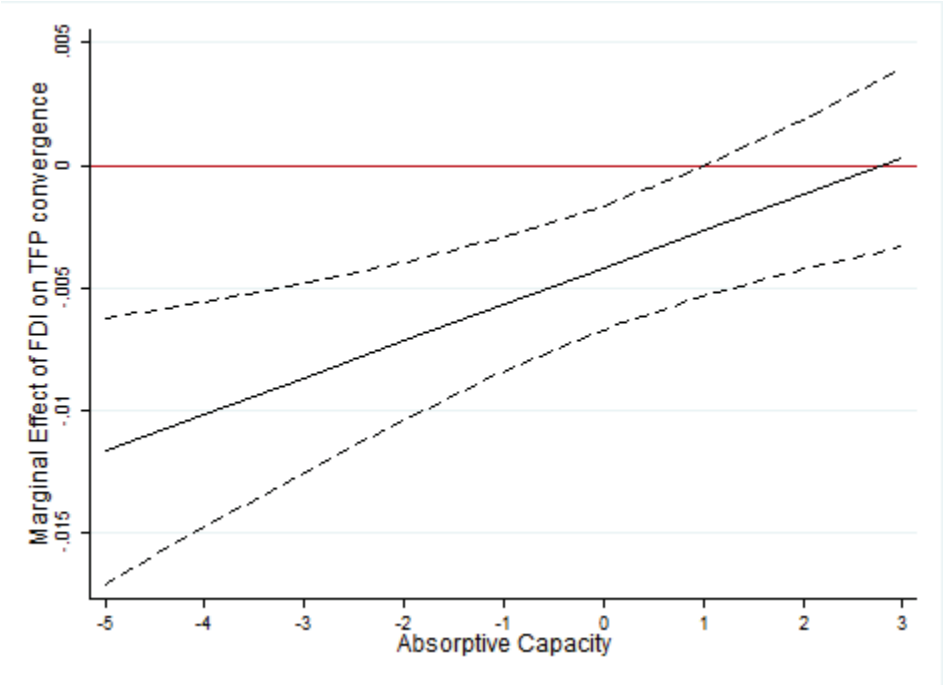


Figure 2: Effect of foreign direct investment on the growth rate of (relative) TFP of BRICs over the range of absorptive capacity (*AC*) based on column (2) of Table 1.



Appendix A: List of advanced source countries

Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, United States

Appendix B: Description of variables

Convergence in TFP levels is measured as

$$dTFP_{srt} = \ln\left(\frac{tfp_{r(t+1)}}{tfp_{s(t+1)}}\right) - \ln\left(\frac{tfp_{rt}}{tfp_{st}}\right)$$

where tfp_{rt} and tfp_{st} denote (three-year moving averages of the) total factor productivities of recipient country r and source country s, respectively (for details, see Hübler and Pothen 2013).

Capital goods import intensity is defined as

$$IM_{srt} = \ln\left(\frac{im_{srt}}{y_{rt}}\right)$$

where im_{srt} denotes (the three-year moving average of) aggregate flows of investment goods from s to r and y_{rt} denotes aggregate output in r. Both variables are measured in current prices and millions of US-dollars.

FDI intensity is measured as

$$FI_{srt} = \ln\left(\frac{fi_{srt}}{y_{rt}} + 0.0001\right)$$

where fi_{srt} denotes (the three-year moving average of) aggregate FDI flows from s to r in current prices and millions of US-dollars. We set $fi_{srt} = 0$ if $fi_{srt} < 0$, and add 0.0001 in order not to lose zero observations.

Domestic import intensity is written as

$$DI_{rt} = \ln\left(\frac{di_{rt}}{y_{rt}}\right)$$

where di_{rt} denotes (the three-year moving average of) aggregate flows of investment goods within r.

Absorptive capacity, *AC*, is derived from a principal component analysis (PCA) with the following indicators (data source in brackets): high-skilled labor share (WIOD), index of Economic Freedom (Heritage Foundation), tertiary education rate (World Development Indicators, WDI), internet rate (WDI), telephone rate (WDI), scientific article rate (WDI), patent rate (WDI), trademark rate (WDI), and service sector share (WIOD).

Table B1: Loadings matrix for the first component of a PCA on nine indicators of absorptive capacity using the varimax rotation.

	AC
HL High-skilled labor share (*log*)	0.0010
EF Economic Freedom index (*log*)	0.1465
TE Tertiary education rate (*log*)	0.4469
IN Internet rate (*log*)	0.4200
TP Telephone rate (*log*)	0.4919
SA Scientific article rate (*log*)	0.1529
PA Patent rate (*log*)	0.0277
TM Trademark rate (*log*)	0.5731
SE Service sector share (*log*)	-0.0889

Appendix C: Summary statistics

Table C1: Summary statistics for the variables used in the empirical analysis

	$dTFP_{srt}$	AC_{rt}	DI_{rt}	FI_{srt}	IM_{srt}
Observations	988	1080	1080	1032	1080
Mean	0.0023	-0.2895	-2.3181	-8.4218	-9.1089
Median	0.0013	0.2356	-2.3296	-8.8489	-8.8498
Std. dev.	0.0195	2.3243	0.2187	0.9173	1.9931
Min.	-0.0624	-5.0061	-2.6570	-9.2103	-15.8609
Max.	0.0779	2.6160	-1.9482	-5.0253	-5.6637

Table C2: Correlation statistics between variables used in the empirical analysis

	$dTFP_{srt}$	AC_{rt}	DI_{rt}	FI_{srt}	IM_{srt}
$dTFP_{srt}$	1.0000				
AC_{rt}	0.1790	1.0000			
DI_{rt}	0.1527	-0.7218	1.0000		
FI_{srt}	-0.0848	0.2627	-0.2240	1.0000	
IM_{srt}	-0.0775	0.0074	-0.0339	0.5283	1.0000

Appendix D: Robustness tests

Table D1: Effect of FDI inflows and capital goods imports (*FI* and *IM*, both in log intensity form) on the growth rate of total factor productivity (*TFP* in log relative form) with time and dyad fixed-effects and 3-year time lags, excluding one BRIC at a time (specification as in columns 6 and 7 of Table 1).

	Brazil excluded (RIC)		Russia excluded (BIC)		India excluded (BRC)		China excluded (BRI)	
	dTFP	*dTFP*	*dTFP*	*dTFP*	*dTFP*	*dTFP*	*dTFP*	*dTFP*
AC, absorp. capac.	0.012****	0.029****	0.015****	0.030****	0.010****	0.019****	0.00027	0.019*
	(0.000013)	(2.8e-07)	(9.9e-08)	(5.6e-08)	(0.00022)	(0.00049)	(0.96)	(0.083)
DI, domestic inv.	0.12**	0.11	0.12**	0.16*	0.18***	0.11	0.067	0.18
	(0.027)	(0.15)	(0.022)	(0.075)	(0.0085)	(0.27)	(0.16)	(0.10)
FI, foreign dir. inv.	-0.0022	0.034	-0.0030	0.044*	-0.0037**	0.020	-0.0024	0.053
	(0.30)	(0.16)	(0.11)	(0.097)	(0.023)	(0.46)	(0.11)	(0.10)
IM, imports	0.046***	0.0084****	0.041****	0.0069**	0.044**	0.0034	0.025**	0.0022
	(0.0052)	(0.00073)	(0.0022)	(0.012)	(0.010)	(0.30)	(0.039)	(0.28)
IM x AC	0.00039		0.00055**		0.00049**		0.00037	
	(0.11)		(0.011)		(0.021)		(0.37)	
IM x DI	0.016**		0.014**		0.017**		0.0096*	
	(0.027)		(0.013)		(0.010)		(0.062)	
FI x AC		0.0022****		0.0023****		0.0015**		0.0025**
		(0.00020)		(0.00012)		(0.017)		(0.027)
FI x DI		0.015		0.020*		0.010		0.023*
		(0.12)		(0.073)		(0.37)		(0.078)
Constant	0.36****	0.34*	0.34****	0.45**	0.42**	0.27	0.15	0.42
	(0.0042)	(0.084)	(0.0040)	(0.046)	(0.010)	(0.29)	(0.18)	(0.12)
Num. of obs.	543	543	543	543	543	543	543	543
Num. of dyads	54	54	54	54	54	54	54	54
R-squared	0.635	0.631	0.606	0.601	0.571	0.562	0.437	0.440

Robust *p*-values in parentheses
**** $p<0.005$, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table D2: Effect of FDI inflows and capital goods imports (*FI* and *IM*, both in log intensity form) on the growth rate of total factor productivity (*TFP* in log relative form) with time and dyad fixed-effects and 3-year time lags, source countries with highest R&D spending excluded (specification as in columns 6 and 7 of Table 1).

	Japan excluded		Sweden excluded		USA excluded	
	dTFP	*dTFP*	*dTFP*	*dTFP*	*dTFP*	*dTFP*
AC, absorp. capac.	0.012****	0.027****	0.012****	0.027****	0.010****	0.021****
	(0.000060)	(0.000042)	(0.000013)	(1.2e-07)	(0.000081)	(0.000018)
DI, domestic inv.	0.14****	0.20**	0.13***	0.16**	0.13**	0.072
	(0.0029)	(0.013)	(0.0068)	(0.046)	(0.018)	(0.46)
FI, foreign dir. inv.	-0.0027*	0.056**	-0.0033**	0.043*	-0.0024	0.018
	(0.067)	(0.019)	(0.029)	(0.070)	(0.17)	(0.51)
IM, imports	0.044****	0.0054**	0.041****	0.0053**	0.040***	0.0053**
	(0.00069)	(0.035)	(0.0014)	(0.031)	(0.0058)	(0.032)
IM x AC	0.00040		0.00045**		0.00027	
	(0.10)		(0.034)		(0.20)	
IM x DI	0.017****		0.015****		0.015**	
	(0.0025)		(0.0048)		(0.014)	
FI x AC		0.0021****		0.0022****		0.0014***
		(0.0044)		(0.000066)		(0.0064)
FI x DI		0.024**		0.019**		0.0090
		(0.012)		(0.045)		(0.43)
Constant	0.38****	0.53***	0.33****	0.42**	0.35***	0.21
	(0.00094)	(0.0085)	(0.0027)	(0.036)	(0.0091)	(0.40)
Num. of obs.	676	676	684	684	676	676
Num. of dyads	68	68	68	68	68	68
R-squared	0.529	0.520	0.549	0.544	0.546	0.538

Robust *p*-values in parentheses
**** $p<0.005$, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table D3: Effect of FDI inflows and capital goods imports (*FI* and *IM*, both in log intensity form) on the growth rate of total factor productivity (*TFP* in log relative form) with time and dyad fixed-effects, different time lags (specification as in columns 6 and 7 of Table 1).

	2-year time lags		4-year time lags	
	dTFP	*dTFP*	*dTFP*	*dTFP*
AC, absorp. capac.	0.0089****	0.021****	0.012****	0.027****
	(0.00065)	(0.000016)	(0.00011)	(0.000010)
DI, domestic inv.	0.12****	0.20***	0.12*	0.078
	(0.00041)	(0.0051)	(0.073)	(0.51)
FI, foreign dir. inv.	-0.0013	0.053***	-0.0033**	0.019
	(0.37)	(0.0069)	(0.036)	(0.58)
IM, imports	0.033****	0.0023	0.037**	0.0042
	(0.000031)	(0.40)	(0.035)	(0.11)
IM x AC	0.00032		0.00044*	
	(0.15)		(0.080)	
IM x DI	0.013****		0.014*	
	(0.000081)		(0.059)	
FI x AC		0.0017****		0.0022****
		(0.0013)		(0.0010)
FI x DI		0.023****		0.0097
		(0.0049)		(0.49)
Constant	0.28****	0.46****	0.27*	0.17
	(0.00028)	(0.0045)	(0.076)	(0.56)
Num. of obs.	796	796	652	652
Num. of dyads	72	72	72	72
R-squared	0.516	0.514	0.525	0.524

Robust *p*-values in parentheses
**** $p<0.005$, *** $p<0.01$, ** $p<0.05$, * $p<0.1$