Transportation Infrastructure and Market and Supplier Access: How Do They Shape Foreign Direct Investment?

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Keywords: Foreign Direct Investment, Liner Shipping Connectivity Index, Market Access, Transportation Infrastructure.

Abstract: Although the benefits of transportation infrastructure for economic and social development are generally unquestionable, depending on the transportation mode and the economic development of countries, sometimes transportation infrastructure does not have the expected positive impacts, or it may even hinder economic development. In this paper, we focus on the impact of different types of transportation infrastructure on foreign direct investments, in a close relation to the market/supplier access as an essential determinant for FDIs and thus, a potential significant interaction term with transportation infrastructure. Based on the new economic geography models, we attempt to distinguish between international and domestic transportation infrastructure in destination countries and test their impact on bilateral FDI stocks, in a gravity type setting. We take the liner shipping bilateral connectivity index as a proxy for international infrastructure and railroads density as a proxy for the domestic one. Using a panel dataset from 2008 to 2012, we find evidence that different transportation infrastructures have different impacts depending on the countries' economic development level: international infrastructure has a strong and significant positive impact on FDIs, whereas the impact of railroads depends on destination countries' economic development.

1 INTRODUCTION

In over 50 years of accelerating globalization, foreign direct investments (FDIs) have increased dramatically, because of decreasing trading and transportation costs, financial liberalization, increasing market potential in developed and developing countries etc. Between 1980 and 2020, global inward FDIs have been multiplied by 60 reaching almost 50% (48.8%) of world GDP in 2020.

In order to attract FDIs, governments around the world try to adopt policies based on financial incentives, but also long-term economic development measures such as improving communication and transportation infrastructure. More precisely, related to the latter, improvements and innovations in the transportation have been associated with basically every wave of the Schumpeterian growth model: waterpower in the first wave, rail in the second, the internal combustion engine in the third, aviation in the fourth, digital networks in the fifth wave. However, researchers have questioned the type of infrastructure that would be the most beneficial as well as its distributional effects. Fogel (1962, 1964) argues that in the US, investment was misdirected towards railroads because of government policies promoting rail transportation and that the river networks were much more important for economic development than railroads. Rose, Savage, Jenkins and Fransman (2017) summarizes several transport infrastructure projects failing to generate the expected high economic benefits. Among them, the Coega project (an industrial development zone around the port of Coega in South Africa) mainly designed to attract FDIs has failed to deliver he expected results.

Thus, we choose to focus on the link between transportation infrastructure and FDI, in order to identify the type of infrastructure that would be the most efficient in attracting FDIs, as a function of countries' level of development. Martin and Rogers (1995) and Behrens, Gaigné, Ottaviano and Thisse, 2007 (2007) show that in relatively poor countries, improving the international infrastructure may lead to industrial companies leaving the country, whereas improving domestic, local infrastructure may lead to industrial companies relocating into the country. But

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these main results have never been tested empirically. Without attempting a full structural estimation of these models, we follow Martin and Rogers (1995) and Behrens et al. (2007) and try to disentangle the direct and indirect effects that different types of transportation infrastructure may have on FDIs, as a function of countries' economic development. We take maritime transportation infrastructure (LSCI, the bilateral liner shipping connectivity index) as a proxy for international infrastructure and rail transportation as a proxy for domestic infrastructure. Maritime transportation allows many connections between points in two different countries, whereas rail transportation allows relatively less. Accordingly, Redding and Turner (2015) show that rail appears as the preferred mode for domestic transportation in terms of ton-kilometres.

Consequently, the main value added of our study is to test for the impact of different types of transportation infrastructure on FDIs, in a gravity panel type setting, as well as for interaction effects between transportation infrastructure and recipient countries' level of economic development. To our knowledge, the bilateral LSCI has never been tested before as a determinant of bilateral FDIs. We also deal with the market and supplier access issue put forward by NEG models. The market access, also called market potential, is a major FDI determinant, which has usually been proxied by GDP or measures based on GDP and distance. We follow Redding and Venables (2004) and consider a more comprehensive measure of market as well as supplier access based on countries' capacity to export and import and their proximity to world markets.

Finally, our paper is structured as follows: after a review of the theoretical and empirical literature in section 2, section 3 describes the empirical model with its theoretical background as well as the data and methodology; in section 4, we present and discuss the results, while section 5 concludes.

2 LITERARURE REVIEW

Research on the macro- or microeconomic links between transportation infrastructure and FDI is scarce. However, given that it deals with trade costs which commonly also include transportation costs, some theoretical insights can be drawn from the NEG and the international trade literature. Especially, footloose capital models (Martin & Rogers, 1995; Baldwin, Forslid, Martin, Ottaviano, & Robert-Nicoud, 2003) allow us to draw some conclusions on the link between trade/transportation costs and international capital flows. One of the most important conclusions of those models is that in the presence of capital mobility, decreasing trade costs trigger the agglomeration of economic activity in locations with the biggest markets, with capital tending to relocate to locations with the highest reward. Martin and Rogers (1995) focus on the impact of different types of transportation infrastructure on industry location. They show that poor countries with good domestic infrastructure attract foreign firms, whereas those improving their international transportation infrastructure encourage firms to leave the country. On the other hand, the multinational firms literature refines the analysis by taking into account the different motives for companies to invest abroad. More precisely, Markusen (1995) and Markusen and Venables (1998) explain how relatively high trade costs foster rather horizontal FDI, whereas Fujita and Thisse (2006) explain how decreasing trade costs foster vertical FDIs between developed and developing countries. Empirical research on transportation infrastructure and FDI is even scarcer than the theoretical one. There is ample evidence on the importance of transportation (especially infrastructure) for economic development and location of economic activity, but mostly at national and regional level within countries, with no consideration for FDIs.

Among the few notable contributions dealing with transportation infrastructure and FDI, Hong (2007) focuses on logistics firms, Castellani, Lavoratori and Scalera (2021) focus on R&D and HQ activites, Yeaple (2003) and Hanson, Mataloni, and Slaughter (2005) deal with the importance of freight costs, whereas Blyde and Molina (2015) analyse the impact of a logistics index on FDIs and Shahbaz, Mateev, Abosedra, Nasir and Jiao (2021) focus on FDI determinants, including transportation infrastructure, in France. Chen et al. (2023) show a positive impact of infrastructure on FDI, but they deal mostly with communications, not transportation infrastructure. Saidi et al. (2020) show a positive impact of transportation infrastructure on FDI attractiveness, but they only focus on road transportation.

3 THE EMPIRICAL MODEL

3.1 Theoretical Background

Our empirical analysis is based on the NEG and international trade literature. More precisely, we refer to NEG models (Krugman, 1991; Baldwin et al., 2003; Venables, 1996; Fujita & Thisse, 2006),

assuming monopolistic competition in the production of industrial goods and capital mobility, as well as on those of the multinational activity literature (Markusen, 1995; Markusen & Maskus, 2002; Markusen & Venables, 1998; Fujita & Thisse, 2006). Regarding FDI determinants and to the extent that "regions" in NEG models may also represent "countries" in the real world, we get three major conclusions from these models:

- when trade/transportation costs are exogenous/endogenous, FDIs are attracted to countries with high/low market potential or market/supplier access
- in poor countries, domestic transportation infrastructure has a positive impact on FDIs
- in poor countries, international transportation infrastructure has a negative impact on FDIs.

Consequently, we have two main research questions:

1. How is international transportation infrastructure impacting FDI decisions as opposed to domestic transportation infrastructure?
2. To the extent that the market/supplier access can be viewed as a proxy for countries' economic development level, how do market/supplier access and transportation infrastructure shape FDI decisions, in rich as opposed to poor countries?

In this regard, we define the following baseline gravity equations:

$$OFDI_{ijt} = MA_{it} + MA_{jt} + IntTRinfr_{jt} + DomTRinfr_{jt} + Control_{jt} \quad (1)$$

$$OFDI_{ijt} = SA_{it} + SA_{jt} + IntTRinfr_{jt} + DomTRinfr_{jt} + Control_{jt} \quad (2)$$

where subscripts i, j and t define home country, host country and time, respectively, OFDI represents bilateral outward FDIs, MA represents the market access, SA represents the supplier access, IntTRinfr is our measure of international transportation infrastructure, DomTRinfr is our measure of domestic transportation infrastructure and Control is a vector of control variables considering different aspects of host countries' global competitiveness.

3.2 Data and Methodology

We conduct our study on a heterogeneous panel of outward bilateral FDI stocks, including a wide variety of developing and developed countries. Due to data availability for our main variables, we focus on the 2008-2012 period. Regarding the links with outward FDs, our main variables of interest are the market access and transportation infrastructure, but we also consider time fixed effects and several destination country specific variables, to control for different aspects of host countries global competitiveness, such as availability of human capital, governance, macroeconomic environment.

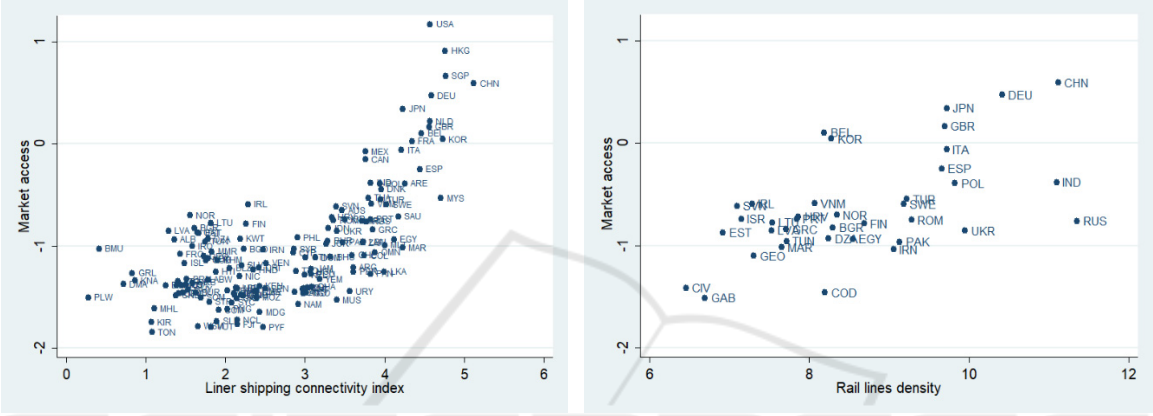
We choose bilateral outward FDI stocks as our dependent variable rather than inward FDI, given that the location decision comes from origin countries not destination ones. Also, the literature on outward FDI determinants is a lot scarcer than the one on inward FDI determinants and it deals especially with cross section data (mostly BRICS countries) rather than panel data (Chou, Chen & Mai, 2011; Zhang & Daly, 2011; Wang, Hong, Kafouros & Boateng, 2012; Anwar & Mughal, 2012). Regarding the market and supplier access, we follow Redding and Venables (2004) and compute these measures. Interestingly, this measure of market/supplier access allows considering at the same time countries' market size, their integration into world markets, trade costs as well as unobserved heterogeneity via home and host country fixed effects. As a proxy for international transportation infrastructure, we take maritime transportation. As a proxy for domestic transportation infrastructure, we take rail transportation. If maritime transportation appears as an obvious choice for international transportation, Redding and Turner (2015) shows that, in a rather heterogeneous sample of developed and developing countries, rail appears as the preferred mode for domestic transportation in terms of ton kilometres. Also, in Europe, over the period 2007-2016, around 55% of the rail freight is national freight, with countries like the United Kingdom, Turkey or Portugal approaching even 80 to 90% (author's calculation based on Eurostat data). For maritime transportation, we use UNCTAD's bilateral index for liner shipping connectivity (LSCI). This very interesting measure of maritime transportation includes 5 components, considering the transportation capacity as well as the competition on services connecting two countries. Finally, we add control variables considering host countries' global competitiveness in terms of human capital, governance, macroeconomic environment. Table 1 summarizes variables, data and sources. Consequently, our equations to be estimated become:

$$OFDI_{ijt} = MA_{it} + MA_{jt} + LSCI_{ijt} + RAIL_{it} + Control_{jt} \quad (3)$$

$$OFDI_{ijt} = SA_{it} + SA_{jt} + LSCI_{ijt} + RAIL_{it} + Control_{jt} \quad (4)$$

Table 1: Data and sources.

Variable	Data	Source
OFDI	Bilateral outward FDI	UNCTAD (US$ millions, stocks)
MA/SA	Market/Supplier Access	Author's calculation (index)
LSCI	Bilateral liner shipping connectivity	UNCTAD (index)
RAIL	Rail lines density	World Bank (total route-km/km^2)
Control variables in host countries		
SEC	Secondary enrollment	World Bank (units)
CORRUPT	Corruption Index	Transparency International (index)
UNEMP	Unemployment rate	World Bank (% of total labour force)



(a) (b)

Figure 1: Transportation infrastructure and the market access (2015, log scale): (a) LSCI; (b) Rail lines density.

We follow a two-step analysis. In a first step, given that there is no database for the market and the supplier access for our time span, we are concerned with their computation. Consequently, we follow Redding and Venables (2004) and compute the market and supplier access for all the countries in our sample, between 2008 and 2012, with improved econometric treatment allowing to take into account the heteroskedasticity of bilateral trade flows, traditionally used for this kind of computation. In a second step, we use non-parametrical as well as different parametrical estimators for gravity equations, given that our dependent variable is the bilateral outward FDIs. As one can already see in Figure 1, the market access seems to be rather positively related to the transportation infrastructure, especially when it comes to the maritime infrastructure.

One can notice the case of Belgium, Netherlands, Hong Kong or Singapore, small economies, but with very high market access, given their high openness and integration into the world economy, whereas China and the US show high market access especially thanks to their very important domestic markets. Just as transportation infrastructure, countries with high market access also receive relatively higher FDI stocks (Figure 2).

Studies on FDIs and the market access as defined above are basically inexistent. Fugazza and Trentini (2014) discuss the impact of the market access on different types of FDIs, but their measure of the market access is based on tariffs, which could be assimilated to a de jure measure. Our measure of market access is a rather de facto one, given that it is based on actual trade flows between countries.

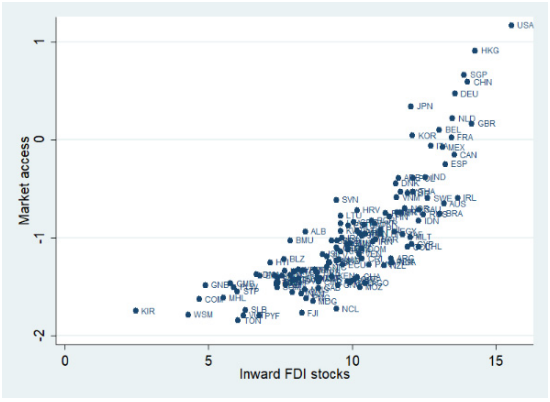


Figure 2: Market access and FDI (2015, log scale).

Vechiu and Makhlouf (2014) use Mayer's (2009) real market potential, a similar variable, but analyse its impact on EU countries' sectorial specialization in production not on FDIs. Hering and Paillacar (2016) and Fally, Paillacar and Terra (2010) compute this measure of market access but use it to discuss migration and wages respectively. Finally, Candau and Dienesch (2017) compute and use this measure of market access to discuss multinational companies' location decision via count models (number of foreign affiliates) instead of FDIs. To our knowledge, the only notable contribution on the link between this de facto measure of market access and FDIs is Vechiu (2018).

3.3 The Non-Parametric Assessment and Parametric Estimation Strategy

In a preliminary analysis, we proceed to a non-parametric analysis of our main variables of interest: bilateral outward FDIs (OFDI), the market and supplier access (MA and SA) of destination countries and the transportation infrastructure of destination countries (LSCI and RAIL). The Kendall's rank correlation (results available on request) shows us positive statistically significant connections between all our variables, with the international component of transportation infrastructure (LSCI) relatively more correlated with FDIs than the domestic one (RAIL). Regardless of the development level of host countries, lower transportation costs between home and host countries as well as within host countries do attract FDIs, especially when it comes to international transportation. This also suggests evidence for export platform FDIs, with home countries seeking to serve third markets, including their own, from foreign locations.

Before proceeding to the parametric estimations, summary statistics and density analysis (results available on request) show two main problems related to our dependent variable: overdispersion and heteroskedasticity. These are current problems related to bilateral FDI data, which require quite specific econometric treatment. As stated by Silva and Tenreyro (2006, 2008), the heteroskedasticity inherent to gravity equations could be dealt with by using the Poisson Pseudo Maximum Likelihood (Poisson PML) estimator.

The latter remains consistent even in the presence of overdispersion when the dependent variable is continuous. Furthermore, Head and Mayer (2014) suggest using OLS, as well as Poisson and Gamma PML as robustness checks. Also, economists are often concerned with endogeneity coming from reverse causality (here, especially market access and infrastructure variables endogeneity) as well as the omitted variables bias.

In gravity equations, reverse causality should not be a significant problem, given that the dependent variable is bilateral, while the independent ones are not (Naughton, 2014; Head & Mayer, 2014): for instance, FDI coming from one partner country should not have a significant impact on the market access of a country. However, as a robustness check allowing to solve the problem of potential endogeneity of the market access and the infrastructure variables, we also run all our regressions by replacing the variables with their lagged variables (first lag). Finally, we tackle the problem of omitted variables bias by considering several control variables, while our MA and SA variables also take into account origin and destination country fixed effects. Time fixed effects are also included in all our regressions to control especially for the 2008-2009 global crisis. We follow Head and Mayer (2014) and use the three suggested estimators for comparison and robustness checks.

4 RESULTS AND DISCUSSION

4.1 Direct Effects

Table 2 reports results for the estimation of (3), using OLS, PPML and GPML. The results for the estimation of (4) are available on request. Our results remain rather robust regardless of the method used, with the remark that all estimators perform globally better with the market access than the supplier access. PPML and GPML estimates are highly similar, suggesting that indeed heteroskedasticity is a problem and OLS estimates are unreliable. Transportation infrastructure variables perform very differently, with the bilateral maritime index having a very strong positive impact on OFDIs, whereas the rail transportation impact is mostly non-significant. The impact of the bilateral LSCI is very strong and very significant as compared to most other variables, confirming the previous non-parametric results and especially in estimations taking into account the supplier access. Consequently, multinational companies seek foreign locations with high market potential and goods access to suppliers, as well as good connections to the home market: foreign locations are more attractive if they allow exporting back to the home market relatively cheaper and at the same time supplying more easily foreign affiliates

Table 2: Transportation infrastructure, market access and FDI.

Dependent variable $OFDI_{ij}$			
	OLS	*PPML*	*GPML*
$LnMA_i$	0.998***	1.243***	0.946***
	(-0.113)	(-0.14)	(-0.11)
$LnMA_j$	0.485**	1.336***	0.520**
	(-0.199)	(-0.237)	(-0.202)
$LnLSCI_{ij}$	2.321***	1.815***	1.822***
	(-0.273)	(-0.274)	(-0.238)
$LnRAIL_j$	-0.036	-0.269***	-0.016
	(-0.068)	(-0.068)	(-0.072)
$LnSEC_j$	0.445***	-0.063	0.244***
	(-0.068)	(-0.091)	(-0.062)
$LnUNEMP_j$	-0.057	0.186	0.123
	(-0.101)	(-0.122)	(-0.098)
$LnCORRUPT_j$	1.949***	1.544***	1.678***
	(-0.236)	(-0.239)	(-0.196)
Constant	-0.315	7.474***	3.830***
	(-1.368)	(-1.563)	(-1.052)
Time fixed effects	yes	yes	yes
Obs	1,355	1,458	1,458
R^2	0.377		

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

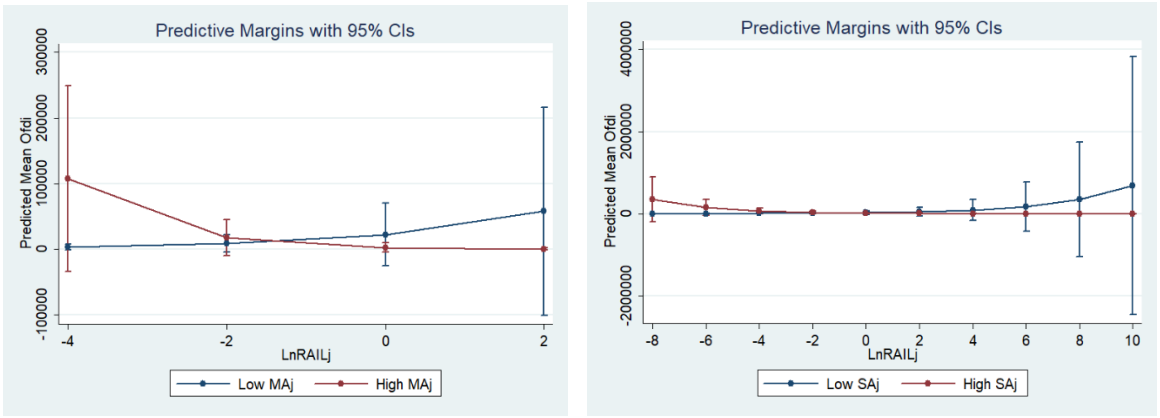
with home inputs. Corruption also stands out as a powerful FDI determinant, with multinationals being attracted to foreign location with low corruption levels, as already highlighted in the literature (Candau & Dienesch 2017; Vechiu 2018).

We are however concerned with the possible endogeneity of some variables especially the market/supplier access and the bilateral LSCI, therefore we replicate the estimations by replacing all independent variables with their first lag. Results do not change significantly and are available on request.

4.2 Indirect Effects

As emphasized by Martin and Rogers (1995), the impact of transportation infrastructure on FDIs might depend on countries' level of richness. Consequently, we re-run all our regressions by integrating interaction terms between transportation infrastructure variables and the market/supplier access (we add $LnLSCI_{ij} \times LnMA_j$.and $LnRAIL_j \times LnMA_j$ in (3) and then, $LnLSCI_{ij} \times LnSA_j$ and $LnRAIL_j \times LnSA_j$ in (4)). We take the market/supplier access as a proxy for countries' level of richness, given that they are highly correlated (Redding & Venables, 2004; Mayer, 2009). Results for the regressions taking into account the market and the supplier access are available on request. Following the same reasoning as in sub-section 4.1, estimations have been run replacing all covariates with their first lag. Results are also available on request.

Estimations allow highlighting some interesting findings, namely regarding rail transportation infrastructure, which becomes highly significant both independently and via the interaction term. Interpreting railroads in host countries as a detrimental factor for outward FDIs is rather counterintuitive, but however, the interaction term does support Martin and Rogers' (1995) view. While estimation results allow reading the statistical significance of the estimated coefficients, they are less straightforward to interpret. Consequently, Figure 3 presents the predictive margins for high and low MA/SA in host countries. More precisely, in rich host countries (high MA/SA), improving a poor rail infrastructure has a negative impact on FDIs getting in the country. Then, as the rail infrastructure improves, its impact becomes null. On the other hand, in poor countries (low MA/SA), rail infrastructure has a positive impact on FDIs getting in the country. The impact is very small for poor rail infrastructure, but it becomes higher and higher, as rail infrastructure improves. Accordingly, improving local infrastructure in poor countries is a way to attract



(a) (b)

Figure 3: The impact of rail infrastructure on bilateral OFDIs, as a function of destination countries': (a) MA; (b) SA.

FDIs, as suggested by Martin and Rogers (1995). However, regarding their conclusion that improving international infrastructure might lead to capital leaving poor countries, we find limited proof: maritime transportation might have a positive impact on FDIs getting in countries with low SA, but a negative one in countries with high SA. Thus, improving access to foreign suppliers becomes a substitute for the low SA, consequently reassuring and attracting foreign investors.

5 CONCLUSIONS

The importance of transportation infrastructure and transportation services for economic development has already been highlighted in theoretical as well as empirical research. Transportation supports mobility, thus contributing to economic growth and shaping location decisions of consumers as well as companies. However, if and how it impacts FDI decisions has been less analysed.

This paper fills this gap by showing how different types of transportation infrastructure affect FDI decisions. Based on the conclusions of NEG models, we have shown that transportation infrastructure has different impacts on FDI depending on its international versus domestic reach as well as on countries' economic development. If maritime infrastructure is shown to have a strong significant impact regardless of countries' economic development, rail transportation seems to be more beneficial to poor countries than to rich ones.

Consequently, especially on developing and poorer countries, public policies regarding transportation should focus on infrastructure designed to improve access and mobility first of all on a national and local level and then, more sophisticated infrastructure that allows a better connection with global markets.

Finally, this work opens up perspectives for future research, in order to better understand the linkages between transportation infrastructure, FDI and market/supplier access. More recent and more detailed data (sectorial FDI, other types of transportation infrastructure) would help define more precise policy recommendations.

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APPENDIX

Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Australia, Bahrein, Bangladesh, Barbados, Belgium, Belize, Benin, Bermudas, Brazil, Brunei, Bulgaria, Cabo Verde, Cambodia, Canada, Chili, China, Colombia, Comores, Costa Rica, Côte

d'Ivoire, Croatia, Cyprus, Democratic Republic of the Congo, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Estonia, Fidji, Finland, France, French Polynesia, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guyana, Haiti, Honduras, Hong Kong, India, Indonesia, Iran, Iraq, Ireland, Island, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kuwait, Latvia, Lebanon, Liberia, Lithuania, Madagascar, Malaysia, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Moldova, Morocco, Mozambique, Myanmar, Namibia, Netherlands, New Caledonia, New Zealand, Nicaragua, Nigeria, Norway, Oman, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Portugal, Qatar, Republic of the Congo, Romania, Russia, Saint Kitts and Nevis, Samoa, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Singapore, Slovenia, Solomon Islands, South Africa, South Korea, Spain, Sri Lanka, Suriname, Sweden, Syria, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, Unites States, Uruguay, Vanuatu, Venezuela, Vietnam, Yemen