Multilevel analysis of firms' performance in Emerging Economies: The role of transport infrastructures and logistics as contextual factors

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Abstract

Firms as part of an ecosystem are constrained by many context facets, having different dimensions and effects on their performance. In this work, we explore differences in firm performance in emerging economies by introducing contextual factors at country-level along with firm-level factors into the analysis. Especially, our focus is on a country's transport infrastructure endowment and logistics services as a source of heterogeneity in firm performance. We perform a multilevel analysis that allows us to define a two-level hierarchical structure, where firms are nested in countries. The empirical framework adopted allows us not to neglect other contextual bases by relying on their multidimensionality and global diversity. Our results confirm that part of the country-level variability in firm performance is explained by transport infrastructure and logistics services. The impact is, however, heterogeneous across infrastructures: network-type infrastructures, such as roads, railways, and logistics services, have a larger effect on firm-level performance, while transport nodes, such as airports and ports, show little or no effect. This research provides useful implications for both theory and practice, especially for policymakers and organizations.

Keywords: firm performance, transport infrastructures, logistics, multilevel approach, emerging economies.

1. Introduction

The success or failure of an economy can be largely ascribed to the performance of its enterprises (North and Thomas, 1973; McMillan and Woodruff, 2002; Lewis 2003). From an empirical point of view, the pioneering work of Birch (1981) shows that firms are the main driver of job creation and, hence, of a country's economic growth. His work has been followed by others that further document the role of firms in promoting economic growth and development (Brock and Evans, 1989; Malecki, 1994; Arzeni,

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1997; Audretsch and Thurik, 2000; Reynolds et al., 2001; Audretsch and Fritsch, 2002). This body of literature has its origins in Schumpeter's (1934) theory of endogenous growth, which argues that in order to promote economic growth, it is essential to understand the determinants of entrepreneurial performance and to encourage it. Indeed, the development of a country starts from the bottom (Caplan, 1994), and “development-from-below” relies significantly on local resources, enterprises and actors (Helmesing, 2005).

It is widely recognised that differences in performance between firms are due to their internal resources and to their behaviour (Davis et al., 1998; Jensen and McGuckin, 1997; Bernard et al., 2012; Coad et al., 2018). However, firms do not exist in isolation, they are part of an ecosystem (Stam and Van de Ven, 2021) operating within a specific national context whose attributes may influence their creation, performance and even survival (Ndiaye et al., 2018). Therefore, for an in-depth understanding of firm performance, country-level factors should be considered together with firm-level factors (Commander et al., 2008; Commander and Svejnar, 2011; Goldszmidt et al., 2011). Among the country level factors, transport infrastructure and logistics services might play a crucial role. In aggregate economic growth and development their role is, in fact, relevant (Owen, 1964; Fromm, 1965; Ahmed et al., 1976; Aschauer, 1989; Calderón and Servén, 2004; Button, 2010), especially in the context of emerging economies where the infrastructure endowment is lower than in more developed economies, so its improvement is likely to have a greater impact on their economy as a whole (Baum-Snow et al., 2017; EBRD, 2017; Li and Li, 2013).

Several studies on emerging economies explore the relationship between the heterogeneity of firms' performance and perceived barriers to doing business, including transport infrastructure (Beck et al., 2005, Ayagari et al., 2005, Driemeier et al., 2006; Dethier el al., 2010). Although they provide interesting insights, the results of these studies could be influenced by a potentially biased perception of constraints by firms (Carlin et al., 2006). To the best of our knowledge, there are no papers that address the link between a country's objective measures of transport infrastructure endowment and logistic services and firm-level performance. Yet, well-developed transport infrastructure is expected to improve a country's accessibility, which is crucial for firms since a substantial part of their activities requires moving inputs and outputs.

This paper contributes to the literature by assessing the effect of country-level transport infrastructure provision and logistics on firm performance in emerging economies. Specifically, in this paper, to assess their relationship with firm performance, we consider different types of infrastructure: network infrastructures, such as roads and railways, and nodes, such as airports and ports. In addition, we also consider logistics services.

Due to the coexistence in the analysis of factors that, at different levels, might influence firm performance, we examine them in an integrated framework through the multilevel approach. This approach allows us to define a two-level hierarchical structure, where firms are nested in countries, and, at the same time, to separate the effect of firm-level factors from the effect of the endowment of transport infrastructure and logistics services at the country level on the heterogeneity of firms' performance.

For the purpose of this research, we combine firm-level data on 32 countries in Eastern Europe and Central Asia from the fourth round of the Business Environment and Enterprise Performance Survey (BEEPS V) conducted in 2012-2016, by the European Bank for Reconstruction and Development (EBRD) and the World Bank

(WB), with country-level data on transport infrastructure and logistics services collected from institutional data sources.

The rest of the paper is structured as follows. Section 2 briefly provides an overview of the role of transport infrastructure in the literature on economic growth and firm performance, with a focus on emerging economies. Section 3 outlines the description of the data and the construction of the variables. Section 4 presents the methodology used to investigate the determinants of firm performance. Section 5 shows and discusses the empirical results. Section 6 reports the empirical results with a focus on transport infrastructure and logistics. In Section 7 the robustness of the previous analysis is investigated. Finally, concluding remarks are summarized in Section 8.

2. Literature review

In a seminal article, Aschauer (1989) shows that the stock of public infrastructure capital is a significant determinant of aggregate total factor productivity (TFP) in the United States. Since then, many articles have tried to identify the effects of infrastructure capital on output and productivity[1].

Some papers examine the long-run effect of infrastructure provision. Calderón and Servén (2004) assess the role of the quantity and quality of infrastructure on economic growth and income distribution in Latin American countries. They show that increased availability and quality of infrastructure has a positive effect on both accelerating growth and reducing inequality. Canning and Pedroni (2008) investigate the long-run consequences of various types of physical infrastructure provision (such as telephone access, electricity generation capacity and paved roads) for a panel of countries from 1950 to 1992, providing evidence of a positive long-run impact of infrastructure on GDP per capita. Similarly, Calderón et al. (2015), using data on infrastructure stocks covering 88 countries in the years 1960-2000, find a statistically and economically significant role of infrastructure in countries' output.

Regarding transport infrastructure, the positive link with economic development and growth has been widely demonstrated (Owen, 1964; Fromm, 1965; Ahmed et al., 1976; Aschauer, 1989; Calderón and Servén, 2004; Button, 2010), especially for emerging economies.

Both the quantity and quality of transport infrastructure contribute to growth and development through different channels, such as reducing transaction costs by ensuring convenient market access and connectivity, facilitating trade and attracting foreign direct investment, creating new markets and improving the efficiency of production and consumption of goods and services, thus in the process further accelerating growth and reducing poverty (Fromm, 1965; Agénor and Moreno-Dodson, 2006; Henckel and McKibbin, 2017). Even so, the impact of transport infrastructure on economic growth depends on a country's level of development. At a given stage of economic development, a certain level of transport provision is required to maximise its potential growth (Button, 2010) to avoid bottlenecks to socio-economic development and national integration (Ahmed et al., 1976; Owen, 1964). However, infrastructure development in the developing world - where it is most needed - has been very limited, except in parts of East Asia (Fay et al., 2011).

[1] See Straub (2008, 2011) for reviews.

In general, all countries in the EBRD region[2] appear to have lower levels of infrastructure provision than expected based on country characteristics, at least for one of the transport sectors. Indeed, their level of development and population size would require higher levels to narrow the gap with advanced economies and to support income convergence and expected future growth. Considering the need for catch-up investment, these emerging economies have an estimated annual infrastructure need of more than 25% of their annual GDP, with transport infrastructure accounting, on average, for about 64% of the share of total infrastructure investment needed (EBRD, 2017).

More recent studies focus on Asian emerging economies, where infrastructure investment has been higher, partly due to their growing role in the global economy. Along with expanding demand, infrastructure development can also foster regional economic convergence. From a regional perspective, urban rail and highway configurations have influenced the urban form of Chinese cities, displacing population and decentralising economic activities to surrounding regions since the 1990s (Baum-Snow et al., 2017).

Some studies consider the impact of mode-specific transport infrastructure on different economic outcomes. In emerging economies, road infrastructure is found to positively influence growth (Fan et al., 2002; Luo, 2004). In particular, the rapid growth of Chinese provinces seems to be explained by higher road density (Démurger, 2001). As per Shepherd and Wilson (2008), improved roads could lead to a 50% increase in regional trade, along with other institutional developments, such as trade liberalisation. In addition, different transport infrastructures are found to generate a positive impact on a country's trade activities by lowering the costs of trade (Limão and Venables, 2001).

Road infrastructure also seems to influence the location and spatial organization of firms (Stam and Spigel, 2018), since transport network characteristics determine issues of travel time, reliability, and flexibility, where the proximity to motorways is found to be a key locational factor for manufacturing firms in Spain (Holl, 2004; 2006) and in Netherlands (Stam and Van de Ven, 2021). Furthermore, Japanese foreign direct investors prefer to locate their firms in EU countries with a more extensive road network (Cieślik and Ryan, 2004), while road density has been shown to be a significant determinant for foreign firms.

Moreover, railway infrastructure plays a role in the development of a country. A comprehensive study by Donaldson (2018) assesses the benefits of the availability of rail links on the Indian economy. It finds that rail infrastructure significantly improves welfare by allowing regions to leverage gains from trade, as rail links reduce the cost of trade and increase trade volumes.

As well, the contextual influence of infrastructure nodes appears to be essential in shaping microprocess decisions. The presence of ports influences the location decisions of foreign direct investment (Belderbos and Carree, 2002; Deichmann et al., 2005). Similarly, airports attract new economic activities and generate spatial-economic spillovers (Howard, 1974; Hilsinger, 1976; French 1994). In addition, the introduction of new destinations produces a strong impact on regional development, while the increase in air traffic contributes to the creation of jobs and businesses (Bilotkach, 2015).

From a methodological perspective, existing studies on firm-level performance employ country dummies to control for contextual effects (see, among others, Dollar et

[2] For the list of countries in the EBRD region please see: Table 10 in Data Appendix and the EBDR website.

al., 2005; Carlin et al., 2006; Aterido el al., 2007), thus providing no explicit contribution in identifying the effects of country conditions on firm performance. Other studies, which explicitly count for country-level factors, focus mainly on general macroeconomic conditions, as measured by GDP and inflation (Beck et al., 2002). Other research examines the effects of different types of reported constraints on entrepreneurial activity on firm growth in emerging economies, although this approach entails methodological problems due to the subjectivity of firms' perceptions of constraints (Dethier et al., 2010).

The role of physical infrastructures as an element of the systemic nature of entrepreneurial ecosystem (Stam and Van de Ven, 2021) and its national dimension (Acs, Autio and Szerb, 2014; Urbano, Aparicio and Audretsch, 2019) is pointed out by scholars, despite that, studies that explain the heterogeneity of firm performance in emerging economies by integrates firm-level characteristics with transport infrastructure endowment are absent. There is, therefore, room to jointly consider different types of transport infrastructure and logistics services - an essential part of the transport chain - when modelling heterogeneity in firm performance, especially in emerging countries. We set to do it considering the firms' performance as a hierarchically structured phenomenon and use a multilevel approach (Skrondal and Rabe-Hesketh, 2012), which allows, at the same time, to count for other unobserved national contextual factors.

3. Data description and variables' construction

To explore the relationship between firms' performance and transport infrastructure endowment and logistics in emerging economies, we combine firm-level data on 32 countries in East Europe and Central Asia, drawn by the fifth round of BEEPS V conducted in 2012–2016 by the EBRD and the WB, with country-level data, collected from institutional data sources. Based on face-to-face interviews with firms' owners and managers, BEEPS V provides detailed performance information on about 16,000 firms from the main manufacturing and service sectors.

In the literature several variables are used to define firm performance, among which value added and sales are quite common. Given the information gathered from BEEPS V, we use sales, which are positive and highly correlated with value added of firms, also independent from firms' attributes and size (Daunfeldt et al., 2014; Klapper et al., 2004). Our dependent variable, thus, is the value of SALES in US dollars, expressed in natural logarithm.

We define the set of firm-level explanatory variables to control for internal factors that might explain the heterogeneity in performance.

Many empirical works investigate the relationship between firms' growth with size and age (Evans, 1987a, b; Dunne et al., 1989; Brown and Medoff, 1990; Davis et al., 1996; Coad et al., 2013). As these aspects are closely related to competitive processes, as innovation activities (Mateut, 2018), the relationships with firms' performance are expected to be positive (Jensen and McGuckin, 1997). Sometimes controversial, instead, is the relationship with age, since firms might incur in productivity losses as they become older (Burki and Terrell, 1998) by facing a real senescence problem (Loderer and Waelchli, 2010). Likely firm age-performance relationship depends on several institutional factors and is, thus, country-specific (Majumdar, 1997). On this basis, we define the variable AGE as the natural logarithm of the number of years since the firm began operations. To count for size, we construct four dummy variables:

MICRO, that represents firms which have less than 5 employees; SMALL, are firms with employees from 5 to 19; MEDIUM, represent firms which have from 20 to 99 employees; and LARGE, which refers to firms with more than 100 employees. MICRO is treated as the omitted category.

Exporting firms are typically considered more productive than non-exporting firms (Bernard and Jensen, 1995)[3]. Moreover, foreign participation in firms' ownership seems to positively affect performance, especially in emerging economies (Asiedu and Esfahani, 2001; Douma et al., 2006; Osman Gurbuz and Aybars, 2010; Hintošová and Kubíkovál, 2016). Thus, we include in the analysis the above-mentioned aspects by introducing the dummy variables: EXPORTER, equal to 1 if firm exports some of its outputs, 0 otherwise; and FOREIGN, equal to 1 if 1% of assets or more are owned by private foreign individuals, companies or organizations, 0 otherwise.

In a globalized and competitive marketplace, the endowment of a skilled workforce can explain why some firms outperform others (Barney, 1991; Coff, 1999; Barney et al., 2001; Acedo et al., 2006). The literature offers evidence on the positive link between human capital and overall firms' performance (Crook et al. 2011), especially for small firms (Lepak and Snell, 2002; Coder et al., 2017). Therefore, we define the variable QUALIFICATION as the share of permanent full-time employees holding a university degree.

Finally, to control for sectoral patterns, we define a set of industry dummies (SEC) grouped in seven categories as follows: (i) high technology; (ii) medium-high technology; (iii) medium-low technology; (iv) low technology; (v) construction, retail and distribution; (vi) knowledge intensive business services; and (vii) other business services[4]. Due to missing values, we end-up with 11,990 firms with complete observations.

To analyse the role of different kinds of transport infrastructure on firms' performance, we define the following variables: ROAD, the total roads in km per square km, including expressways, paved and unpaved urban roads; RAIL, the total railways in km per square km, including public and non-public railways; AIRPORT, the number of airports paved runways per 1,000 square km; PORT, the number of total ports, including the major seaports, riverports, container ports, oil and LNG terminals. Moreover, we also account for the role played by logistic system because the capacity to connect firms with suppliers and consumers is critical for contexts where predictability and reliability are becoming as important as costs in sourcing decisions. We employ the Logistic Performance Index (LPI), providing an assessment of the managerial and physical effectiveness of a country's logistics. LPI ranges from 1 (worst performance) to 5 (best performance). Usually, a value lower than 3 reflects an array of problems within a country's freight distribution system, causing undue delays and additional costs. Overall, this measure indicates the relative ease and efficiency with which products can be moved.

The sample of emerging economies considered in this work is composed of countries belonging to different income groups with disparities in terms of development. Therefore, we introduce the variable GAP, i.e., the ratio between the GDP per capita (expressed in PPP constant 2011 international USD) of the most developed economy in

[3] It should be recognized that export activity can be influence by firms' productivity (Bernard et al., 2007; Mayer and Ottaviano, 2007; Moxnes, 2010). The endogeneity issue needs to be considered when interpreting findings.

[4] The grouping criteria of industries follows the OECD (2011) and Eurostat classifications.

the sample and the observed country (Y*/Y where Y* is the most developed country in the sample and Y the observed country), to account for different levels of development across countries that can affect firms' performance.

Country-level data are collected from the European Commission, the World Bank and the Central Intelligence Agency for the reference year 2011[5]. In Table 1 we summarize the definitions and the data sources for the variables in the empirical analysis, while in Table 2 we provide general descriptive statistics.

Table 1: Variables' definition and related data sources.

Variable	*Description*	*Source*
Dependent variable		
SALES	Natural logarithm of total annual sales converted in USD at the national annual exchange rates at fiscal year 2011	BEEPS V (EBDR and World Bank)
Explanatory variables		
Firm-level		
AGE	Natural logarithm of the number of years since the firm began operations	BEEPS V (EBDR and World Bank)
MICRO	Equal to 1 if the firm has < 5 employees, 0 otherwise (omitted category).	BEEPS V (EBDR and World Bank)
SMALL	Equal to 1 if the firm has >= 5 and <= 19 employees, 0 otherwise.	BEEPS V (EBDR and World Bank)
MEDIUM	Equal to 1 if the firm has >= 20 and <= 99 employees, 0 otherwise.	BEEPS V (EBDR and World Bank)
LARGE	Equal to 1 if the firm has >= 100 employees, 0 otherwise.	BEEPS V (EBDR and World Bank)
EXPORTER	Equal to 1 if the firm exports some of its outputs directly or indirectly, 0 otherwise.	BEEPS V (EBDR and World Bank)
QUALIFICATION	Percentage of permanent full-time employees which have a university degree.	BEEPS V (EBDR and World Bank)
FOREIGN	Equal to 1 if 1% of assets or more are owned by private foreign individuals, companies or organizations, 0 otherwise.	BEEPS V (EBDR and World Bank)
Country-level		
GAP	The ratio between the GDP per capita (in PPP constant 2011 international USD) of the most developed economy in the sample and the observed country.	World Development Indicators (World Bank)
ROAD	Total roads in km per square km, including expressways, urban roads, paved and unpaved.	Eurostat and Central Intelligence Agency (World Bank for country surface)
RAIL	Total railways in km per square km, including public and non-public railways.	Eurostat and Central Intelligence Agency (World Bank for country surface)

[5] Where infrastructure data are not available for the reference year, it was considered the data available of the nearest year. The Logistic Performance Index survey is conducted by the World Bank every two years. We consider the average between the scores of 2010 and 2012.

AIRPORT	Number of airports paved per 1,000 square km.	Central Intelligence Agency (World Bank for country surface)
PORT	Number of total ports, including the major seaports, riverports, container ports, oil terminals, LNG terminals.	Central Intelligence Agency
LPI	The overall Logistic Performance Index score.	LPI Surveys (World Bank)

As it can be observed from Table 2, the mean of sales is about 6,6 million U.S. dollars displaying significant variation among firms. Around 86% of the firms in the sample are small and medium size and the average age of firms is around fifteen years, suggesting that the firms in emerging economies are quite young and relatively small. Overall, firms with participation of foreign capitals represent 7% of the sample, while only 23% of firms occur in export activities, with considerable variation across firms. The share of permanent employees holding a university degree reported by firms is around 33% of the total permanent full-time employees.

Table 2: Descriptive statistics.

Variable	*Obs.*	*Mean*	*St. dev.*	*Min*	*Max*
Firm-level variables					
Sales ('000 USD)	11990	6587	58400	5.97	2720000
Age	11990	15.04	12.13	1	174
Micro	11990	0.02	0.14	0	1
Small	11990	0.54	0.50	0	1
Medium	11990	0.32	0.47	0	1
Large	11990	0.12	0.33	0	1
Exporter	11990	0.23	0.42	0	1
Qualification	11990	32.60	30.64	0	100
Foreign	11990	0.07	0.26	0	1
Country-level variables					
Gap	32	3.26	3.14	1	15.01
Road	32	0.63	0.59	0.03	2.18
Rail	31	0.03	0.03	0	0.12
Airport	32	0.47	0.40	0.03	1.62
Port	32	3.19	2.87	0	11
LPI	31	2.82	0.31	2.25	3.43

Notes: no official data available for Cyprus on rail infrastructure and for Kazakhstan on LPI.

In Table 9 in Data Appendix, we provide additional descriptive statistics of the between and within variability of firm-level variables due to country clusters.

The variation in mean of firms' sales appears to be considerable among countries, from 633 thousand U.S. dollars for Tajikistan up to 18,7 million U.S. dollars for Slovenia. Figure 1 shows sales performance for each country in the sample. The sample composition by country is reported in Data Appendix in Table 10.

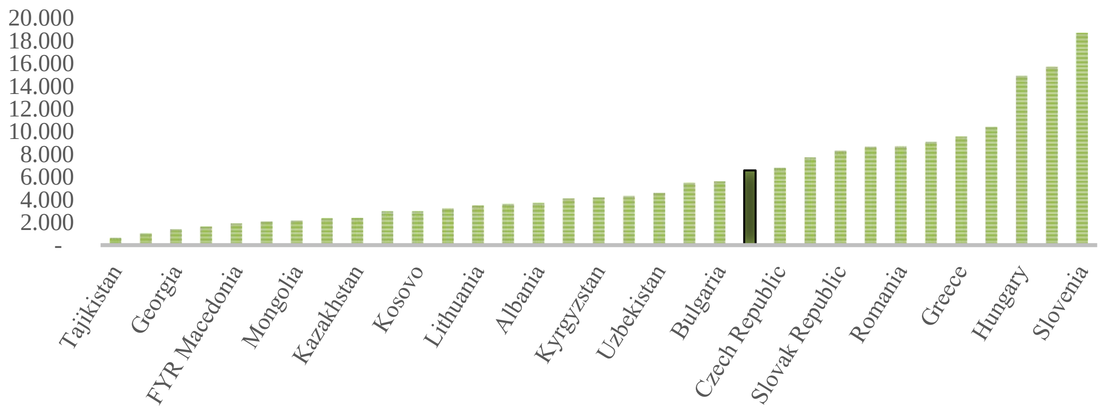


Figure 1: Mean of firms' sales by country clusters (in '000 US dollars)

In Table 11 reported in Data Appendix descriptive statistics of transport infrastructure and control variables are summarized, while Figure 3 in Data Appendix ranks countries in the sample by their transport infrastructure endowment. The density of roads and rails show considerable differences between countries. The average density (per square km) is 0.63 and 0.03 km, respectively. In this regard, the less endowed country is Mongolia for both kind of infrastructures, while the most endowed countries are Hungary and Czech Republic. The number of airports paved per 1,000 square km shows high variation, where Mongolia is the last country with a density value of 0.01, while Czech Republic and Cyprus have the highest airport density of the group, with a value of 1.62. As far as ports are concerned, Turkey is the country with the highest number of ports. Clearly, the presence of port facilities is due to the geographical position of a country[6]. Finally, the average score of LPI is 2.82. Poland has the best logistic performance of the sample countries, scoring 3.43 points, whereas Mongolia has the worst scoring, only 2.25 points.

4. Firms' performance nested in countries: the multilevel modelling approach

The hierarchical structure of the micro-level data – firms (level-1) nested in countries (level-2) – implies a violation of the assumption of independence among observations within the second-level units. To deal with this issue we refer to the class of multilevel models enabling us to explicitly model the hierarchical structure of the data and the unobserved heterogeneity (Raudenbush and Bryk, 2002; Goldstein, 2011; Rabe-Hesketh and Skrondal, 2012).

First, the level-1 model corresponds to the following linear regression model:

$$SALES_{ij} = \beta_{0j} + \beta_{1j}AGE_{ij} + \beta_{2j}SMALL_{ij} + \beta_{3j}MEDIUM_{ij} + \beta_{4j}LARGE_{ij} + \beta_{5j}EXPORT_{ij} + \beta_{6j}QUALIFICATION_{ij} + \beta_{7j}FOREIGN_{ij} + \sum_{k=1}\delta_{0k}SEC_{ik} + e_{ij} \quad (1)$$

where i indexes the firm and j the country, β_{0j} is the standard intercept, β_{1j} to β_{7j}

[6] There are six landlock countries in the sample: Mongolia, Tajikistan, Moldova, Armenia, FYR Macedonia and Kosovo.

are the standard slope coefficients and e_{ij} is the standard error term.

Second, the level-2 model assumes that the intercept (β_{0j}) and the coefficients (β_{1j} to β_{7j}) are nested in countries:

$$
\begin{aligned}
\beta_{0j} = \gamma_{00} + \gamma_{01}GAP_j + \gamma_{02}ROADS_j + \gamma_{03}RAILS_j + \gamma_{04}AIRPORTS_j + \gamma_{05}PORTS_j + \gamma_{06}LPI_j \\
+ u_{0j} \\
\beta_{1j} = \gamma_{10} + u_{1j} \\
\beta_{2j} = \gamma_{20} + u_{2j} \\
\beta_{3j} = \gamma_{30} + u_{3j} \\
\beta_{4j} = \gamma_{40} + u_{4j} \\
\beta_{5j} = \gamma_{50} + u_{5j} \\
\beta_{6j} = \gamma_{60} + u_{6j} \\
\beta_{7j} = \gamma_{70} + u_{7j}
\end{aligned}
\quad (2)
$$

By combining the level-1 model and level-2 model, the reduced form of the random-coefficents model can be expressed as:

$$SALES_{ij} = \gamma_{00} + \sum_{m=1}^{M} \gamma_{0m} Z_{mj} + \sum_{n=1}^{N} \gamma_n X_{nj} + \sum_{n=0}^{N} u_{nj} + \sum_{k=1} \delta_{0k} SEC_{ik} + e_{ij} \quad (3)$$

where n is the number of firm-level predictors (N=7), m is the number of country-level predictors (M=6), X_{nj} and Z_{mj} are respectively the predictor vectors and u_{nj} is the vector of random effects. The random effects $\sum_{n=0}^{N} u_{nj}$ represent all the factors at country-level that are not observed and are not be explained by firm-level characteristics, thus providing useful information on cross-country differences

We carry out the multilevel analysis going through different steps. First, to detect the existence of the hierarchical structure in the data, we consider the *variance-components model* that includes only the intercept among covariates. Second, by adding level-1 variables, we estimate a *random-intercept model*, where only the intercept is allowed to vary across countries. Third, we consider the *random-coefficient model*, with only level-1 variables, also allowing the estimated coefficients to vary across countries. Finally, we extend the latter model by introducing level-2 predictors to assess the effect of transport infrastructures and logistics in reducing level-2 variability, thus explaining intra-country firm’s performance differences not already explained by firm-level characteristics.

Further, the Likelihood-ratio test, which assumes under the null hypothesis that random effects are jointly equal to zero and that, is performed after each regression to test the goodness of our model decision.

5. Econometric results

The empirical analysis proceeds by implementing a simple multiple linear regression model using firm level variables as identified in the previously sections.

Table 3: OLS estimates with firm-level characteristics.

	Log of Sales in USD					
	(1)		*(2)*		*(3)*	
Firm-level variables						
Constant	11.0059***	(0.1231)	10.9362***	(0.1675)	9.9194***	(0.1742)
Age	0.2405***	(0.0210)	0.2324***	(0.0205)	0.1298***	(0.0199)
Small	0.9124***	(0.1102)	0.9402***	(0.1115)	1.1279***	(0.0985)
Medium	2.1585***	(0.1114)	2.1585***	(0.1126)	2.4925***	(0.1002)
Large	3.7471***	(0.1191)	3.8431***	(0.1201)	4.1581***	(0.1084)
Exporter	0.4832***	(0.0371)	0.6249***	(0.0383)	0.3254***	(0.0372)
Qualification	0.0012**	(0.0005)	0.0000	(0.0005)	0.0042***	(0.0005)
Foreign	0.5631***	(0.0672)	0.5439***	(0.0653)	0.5222***	(0.0606)
Sector dummies	No		Yes		Yes	
Country dummies	No		No		Yes	
Observations	11,990		11,990		11,990	
R-squared	0.344		0.372		0.484	
F-test	752.22***		466.64***		248.36***	

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10.

The three OLS models shown in Table 3 confirm the explanatory relevance of the covariates on firms' sales performance. Anyhow, in model (3), where country dummies are included besides sector dummies, the size of coefficients changes. The basic models suggest that country dummy variables are significant factors explaining sales performance of firms confirming the importance of the heterogeneity among countries.

The second segment of the empirical analysis is focused on modelling the heterogeneity among firms' performance by investigating main transport infrastructure endowments and logistics as country specific characteristics.

Before presenting the empirical findings of the multilevel model, we test for firms' performance variability across countries. In Table 4 we show the intra-class correlation (ICC) coefficients (ρ) across estimated models, which express the ratio between country-level variance and the total variance, showing the proportion of total variance in firm's performance that is accounted for by countries. The intra-class correlation quantifies the degree to which firms with a fixed degree of relatedness resemble each other in terms of a quantitative trait (operating within the same country).

Table 4: Intra-class correlation.

	ICC	
	ρ	s.e.
Variance-components model	0.164	0.035
Random-intercept model with firm-level variables	0.235	0.045
Random-coefficient model with firm-level variables	0.241	0.050

The coefficients ρ for each model are statistically significant with a value of about 16.4% for the variance-components model, which, after controlling for firm-level characteristics, increases up to 23.5% and up to 24.1% for the random-intercept and random-coefficient model, respectively. This is the evidence of the existence of a hierarchical structure in the data that needs to be modelled trough a multilevel approach.

Table 5: Results of variance-components model, random-intercept model and random-coefficient model.

	Variance-components model (1)		*Random-intercept model (2)*		*Random-coefficients model (2)*	
Fixed effects						
For intercept (β_{0j})						
Constant (γ_{00})	13.4063***	(0.1419)	10.7692***	(0.2064)	10.7769***	(0.2089)
For slopes (β_{1j} ... β_{5j})						
Age (γ_{1j})			0.1323***	(0.0196)	0.1355***	(0.0280)
Small (γ_{2j})			1.1220***	(0.0923)	1.0975***	(0.0925)
Medium (γ_{3j})			2.4847***	(0.0939)	2.4727***	(0.0973)
Large (γ_{4j})			4.1492***	(0.0994)	4.1185***	(0.1169)
Exporter (γ_{5j})			0.3305***	(0.0349)	0.3193***	(0.0537)
Qualification (γ_{6j})			0.0041***	(0.0005)	0.0040***	(0.0010)
Foreign (γ_{7j})			0.5237***	(0.0507)	0.5142***	(0.0787)
Sector dummies (δ_{0k})	Yes		Yes		Yes	
Random effects						
Constant (u_{0j})	0.7951*	(0.1019)	0.7717**	(0.0979)	0.7762*	(0.1064)
Age (u_{1j})					0.0913***	(0.0352)
Small (u_{2j})					0.00002***	(0.0001)
Medium (u_{3j})					0.1328***	(0.0518)
Large (u_{4j})					0.3119***	(0.0723)
Exporter (u_{5j})					0.2068***	(0.0555)
Qualification (u_{6j})					0.0042***	(0.0009)
Foreign (u_{7j})					0.3092***	(0.0741)
Residuals	1.7955***	(0.0117)	1.3911***	(0.0090)	1.3784***	(0.0090)
Log Likelihood	-24,095.78		-21,043.59		-21,003.38	
Level-1 firms	11,990		11,990		11,990	
Level-2 countries	32		32		32	
LR test	1,649.00***		2,175.10***		2,255.52***	

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.10.

In Table 5 we collect the estimates of the *variance-components model*, reported in Column (1), the *random-intercept model* and the *random-coefficient model* with only firm-level variables, reported in Column (2) and (3), respectively. Fixed effects are reported for the intercept and the slopes in the upper part of the table, while the random effects are shown in the lower part of the table. All regressions include industry dummies. The LR test reported at the bottom of the table for each regression confirms that the multilevel model is preferred to the linear model.

The *variance-components model* provides evidence of the existence of random effects at country-level. Firm's performance differs in mean by countries of about 0.8 standard deviation, which captures the unobserved country-level heterogeneity. The random intercept is statistically significant at 10% level.

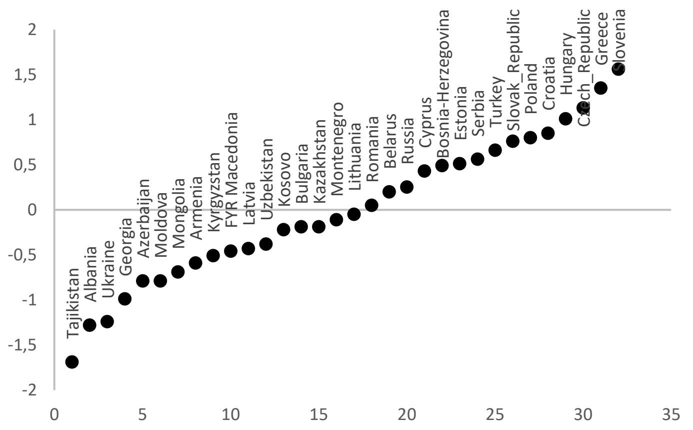
The *random-intercept model* with firm-level variables shows a reduction of level-1 residuals. The intercept has a magnitude of about 0.77 standard deviation from the mean and it is statistically significant at 5% level. This indicates that there are differences across countries. Some countries have better performances, other worst. The measure is given by how widely the random-intercept is distributed around the estimated mean by country. The predicted country random-intercept lies for 44% of the countries in a range of [0.09, 1.49], meaning that, for these countries, the context positively affects their firm's performance. Oppositely, for countries showing a negative predicted country random-intercept, the unobserved characteristics are related to a lower performance of firms with respect to the overall mean.

We start the discussion by looking first at fixed-effects of firm-level variables. All of them are statistically significant, with the expected signs, and consistent across the *random-intercept* model in Column (2) and the *random-coefficient* model in Column (3). Particularly, AGE_{ij} has a positive coefficient, suggesting that older firms are likely to have better performance that younger firms. Similarly, the variables $SMALL_{ij}$, $MEDIUM_{ij}$ and $LARGE_{ij}$ have positive coefficients meaning that small, medium and large firms have better performance than micro firms. Additionally, the size of coefficients increases as we move from small to large firms, thus entailing that firms' performance increases with dimension. $EXPORTER_{ij}$ has a positive and highly significant coefficient, providing evidence that exporting firms have better performance. $QUALIFICATION_{ij}$ has a positive coefficient, suggesting that the presence of high qualified human capital increases firms' performance. Finally, $FOREIGN_{ij}$ has a positive coefficient, meaning that increased foreign participation in firm's assets is positively related to firm's performance.

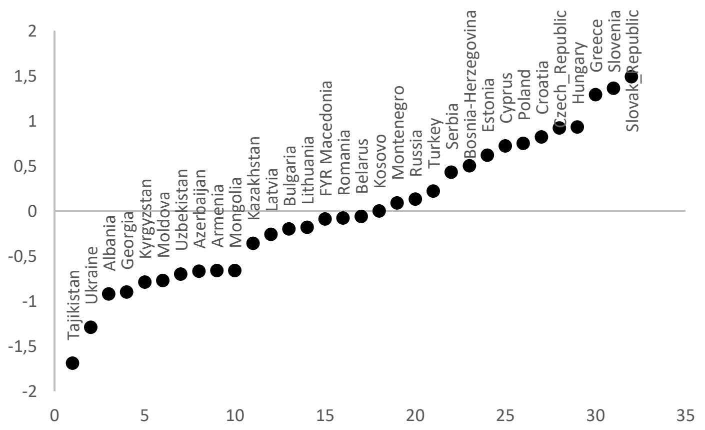
Turning the attention to the random-coefficients shown in Column (3), they are statistically significant at 1% level and the random intercept at 10% level. Recall that the random effects indicate how widely the estimated intercept and coefficients are distributed around the mean, shown in the fixed-effects part. The estimated random effects for variables AGE_{ij}, $EXPORT_{ij}$, $QUALIFICATION_{ij}$ and $FOREIGN_{ij}$ are largely widespread around their mean, while for SMALL, MEDIUM and LARGE, the magnitude of the random-effects is smaller than the estimated fixed-effects.

Figure 2 shows the predicted random effects of the country random-intercept, namely the standard deviations of each country from the overall sales mean[7]. For countries with positive values of random effects, the unobserved country-level factors positively affect firm' performance, instead for countries with negative values of random effects, the unobserved country-level factors negatively affect firms' performance.

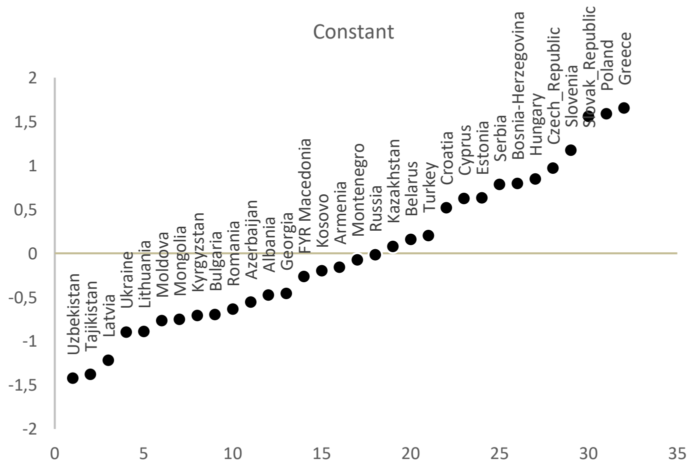
[7] The predicted random effects are computed as the mean of the posterior distribution of the random effects with parameter estimates plugged in, known as Empirical Bayes predictors (Rabe-Hesketh and Skrondal, 2012).



(a) variance-components model



(b) random-intercept model



(c) random-coefficients model

Figure 2: Ranking of country predicted random effects.

Figure 2(a) and Figure 2(b), show that, after controlling for firm-specific characteristics, greater differences emerge among countries. Most EU countries lie in the upper right-hand of the rank. These countries appear to be characterized by better conditions that might determine better business environments, also reflected in their higher firms' performance. We can observe from Figure 2(c), a small reduction of the random intercept, meaning that part of firms' performance heterogeneity is due to differences in firms' characteristics across countries.

6. Focus on transport infrastructures and logistic services

In Table 6, we collect the results of the *intercept-as-outcome model*, by which we can assess the effects of transport infrastructures and logistics variables, which are at the core of interest in this paper. Given the quite high correlation of country-level variables (see Table 12 in Data Appendix), we include them once at a time in the model.

The macro-control variable GAP_j is negatively related to firms' performance: it can be interpreted as the distance of the level of development of a given country from the most developed country in the sample, so that the larger the gap the worse the performance of firms in that country. Additionally, GAP_j is negatively correlated with all the transport infrastructures and logistics variables, suggesting that less developed countries have also worse transport infrastructure endowment.

We start the discussion by looking first at fixed-effects of firm-level variables. All of them are statistically significant, with the expected signs, and consistent across the *random-intercept model* in Column (2) and the *random-coefficient model* in Column (3). Particularly, AGE_{ij} has a positive coefficient, suggesting that older firms are likely to have better performance that younger firms.

Similarly, the variables $SMALL_{ij}$, $MEDIUM_{ij}$ and $LARGE_{ij}$ have positive coefficients meaning that small, medium and large firms have better performance than micro firms. Additionally, the size of coefficients increases as we move from small to large firms, thus entailing that firms' performance increases with dimension. $EXPORTER_{ij}$ has a positive and highly significant coefficient, providing evidence that exporting firms have better performance. $QUALIFICATION_{ij}$ has a positive coefficient, suggesting, as expected, that the presence of high qualified human capital increases firms' performance. Finally, $FOREIGN_{ij}$ has a positive coefficient, meaning that increased foreign participation in firm's assets is positively related to firm's performance.

Turning the attention to the random-coefficients shown in Column (3), they are statistically significant at 1% level and the random intercept at 10% level. Recall that the random effects indicate how widely the estimated intercept and coefficients are distributed around the mean, shown in the fixed-effects part. The estimated random effects for variables AGE_{ij}, $EXPORT_{ij}$, $QUALIFICATION_{ij}$ and $FOREIGN_{ij}$ are largely widespread around their mean, while for SMALL, MEDIUM and LARGE, the magnitude of the random-effects is smaller than the estimated fixed-effects.

Table 6: Results of *intercept-as-outcome models* with country-level predictors.

	Intercept-as-outcome models									
	(1)		*(2)*		*(3)*		*(4)*		*(5)*	
Fixed effects										
For intercept (β_{0j})										
Constant (γ_{00})	10.8315***	(0.2879)	10.9049***	(0.2576)	11.0045***	(0.2514)	11.2844***	(0.2768)	8.3470***	(0.9656)
Gap (γ_{10})	-0.1311***	(0.0288)	-0.1430***	(0.0312)	-0.1516***	(0.0315)	-0.1717***	(0.0361)	-0.1409***	(0.0311)
Road (γ_{20})	0.6177***	(0.1533)								
Rail (γ_{30})			10.6779***	(3.7152)						
Airport (γ_{40})					0.6060**	(0.2430)				
Port (γ_{50})							0.0374	(0.0441)		
LPI (γ_{60})									1.0170***	(0.3188)
For slopes (β_{1j} ... β_{5j})										
Age (γ_{1j})	0.1304***	(0.0196)	0.1273***	(0.0198)	0.1307***	(0.0196)	0.1344***	(0.0220)	0.1350***	(0.0200)
Small (γ_{2j})	1.0891***	(0.0937)	1.0974***	(0.0935)	1.0888***	(0.0937)	1.0909***	(0.0930)	1.1053***	(0.0943)
Medium (γ_{3j})	2.4673***	(0.0965)	2.4619***	(0.0964)	2.4668***	(0.0966)	2.4679***	(0.0966)	2.4908***	(0.0981)
Large (γ_{4j})	4.1136***	(0.1156)	4.1178***	(0.1169)	4.1133***	(0.1158)	4.1136***	(0.1164)	4.1330***	(0.1194)
Exporter (γ_{5j})	0.3181***	(0.0520)	0.3322***	(0.0523)	0.3192***	(0.0520)	0.3201***	(0.0526)	0.3177***	(0.0532)
Qualification (γ_{6j})	0.0041***	(0.0010)	0.0042***	(0.0010)	0.0041***	(0.0010)	0.0041***	(0.0010)	0.0042***	(0.0010)
Foreign (γ_{7j})	0.5145***	(0.0790)	0.5092***	(0.0790)	0.5153***	(0.0785)	0.5155***	(0.0786)	0.5059***	(0.0798)
Industry dummies (δ_{0k})	Yes		Yes		Yes		Yes		Yes	
Random effects										
Constant (u_{0j})	0.4292***	(0.0610)	0.4757***	(0.0809)	0.4876***	(0.0678)	0.5180***	(0.0762)	0.4637***	(0.0660)
Age (u_{1j})	0.0000	(0.0059)	0.0000**	(0.0001)	0.0000**	(0.0000)	0.0363**	(0.0564)	0.0000**	(0.0000)
Small (u_{2j})	0.0776**	(0.1005)	0.0628	(0.1225)	0.0759	(0.1059)	0.0517	(0.1603)	0.0545	(0.1573)
Medium (u_{3j})	0.1093***	(0.0799)	0.0975***	(0.0871)	0.1112***	(0.0797)	0.1218***	(0.0785)	0.1197***	(0.0858)
Large (u_{4j})	0.2961***	(0.0782)	0.3042***	(0.0812)	0.2978***	(0.0793)	0.3055***	(0.0819)	0.3171***	(0.0826)
Exporter (u_{5j})	0.1939***	(0.0553)	0.1918***	(0.0556)	0.1943***	(0.0555)	0.1985***	(0.0554)	0.1978***	(0.0562)
Qualification (u_{6j})	0.0041***	(0.0009)	0.0043***	(0.0009)	0.0043***	(0.0009)	0.0043***	(0.0009)	0.0043***	(0.0009)
Foreign (u_{7j})	0.3112***	(0.0610)	0.3087***	(0.0744)	0.3077***	(0.0739)	0.3084***	(0.0740)	0.3073***	(0.0753)
Residuals	1.3797***	(0.0090)	1.3841***	(0.0091)	1.3796***	(0.0090)	1.3793***	(0.0090)	1.3891***	(0.0092)
Log Likelihood	-20,987.07		-20,663.08		-20,990.79		-20,993.45		-20,356.89	
Level-1 firms	11,990		11,782		11,990		11,990		11,579	
Level-2 countries	32		31		32		32		31	
LR test	937.05***		1136.54***		1198.96***		1238.82***		1743.80***	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.10

The variables $ROAD_j$ and $RAIL_j$ have positive and statistically significant coefficients at level 1% of confidence, showing that the extension of the road and rail network explains firms' performance heterogeneity across countries. Particularly, road network significantly reduces the random intercept to about 0.43 standard deviation from the overall sales mean. Also, the variable $AIRPORT_j$ has a positive and significant coefficient at 5% level of confidence. Yet, part of the variability at country-level remains unexplained, due to other national factors possibly influencing it. Instead, the variable $PORT_j$ shows a positive but not statistically significant coefficient. We be of the opinion that this feature of transport infrastructure needs to be further investigated, while currently was not possible due to the lack of data available of other port infrastructure indicators in the emerging countries considered. Finally, the variable LPI_j has a positive and significant coefficient.

After the country-level variables are introduced, the coefficient of the intercept decreases considerably. The estimated value of the random intercept remains significant meaning that other country factors matter for firm's performance. The intra-class correlations reported in Table 7 confirm the role of national transport infrastructure variables in explaining part of the unexplained variance of firms' performance among countries. The intra-class correlations decrease up to 0.088 compared to 0.241 for the random-coefficient model.

Table 7: Intra-class correlation: intercept-as-outcome models.

Intercept-as-outcome models	ICC	
	ρ	(s.e.)
Model (1) – Road	0.088	0.023
Model (2) – Rail	0.106	0.027
Model (3) – Airport	0.111	0.027
Model (4) – Port	0.132	0.033
Model (5) – LPI	0.100	0.026

Overall, our findings suggest that an important part of firms' performance is surely explained by firm-level characteristics, but part of country-level variance is explained by transport infrastructures, with some aspects, such as road, rail, airport and logistics, being associated with better economic performance at the firm-level.

7. The Bayesian model based on Markov chain Monte Carlo approach

To investigate the robustness of the previous analysis, the Bayesian model based on Markov chain Monte-Carlo (MCMC) approach is computed in alternative to the frequentist analysis.

A multilevel problem concerns a population with a hierarchical structure. In samples from such a population can be described, the individual observations are in generally not independent. For example, firms in the same country tend to perform similar to each other, because of selection processes and because of the environment they share. It general, it occurs in survey research if the sample is not taken at random but cluster sampling from geographical areas is used instead. It is also called "design effect". It depends on both intraclass correlation and cluster size. As a result, the average correlation among firms in the same country can be higher than the average correlations between firms operating in different countries. Standard statistical tests lean heavily in the assumption of independence of the observations. If this assumption is violated, and in multilevel data this is almost always the case (Hox et al., 2010), the estimate of the standard errors of conventional statistical tests are much too small resulting in many spuriously "significant" results. The biases that may be the effect of violation of the assumption of independent observation is still an important assumption to check (Hobert, 2000).

Our previous model is completely informed by the data: in this view, everything that we need to know for the model is encoded in the training data we have available, which gives a single point estimate for the output. This can be interpreted as the most likely estimate, given the data.

However, we might like to express our estimate as a distribution of possible values. The aim of Bayesian approach is not to find the single "best" value of the model parameters, but rather to determine the posterior distribution for the model parameters.

In essence, a Bayesian model has two parts: a statistical model that describes the distribution of the response variable (y) given the unknown parameters (θ) of the model, and a prior distribution that describes beliefs about the unknown parameters (θ) independent from the data, where the statistical model is the likelihood function $L(\theta; \boldsymbol{y})$. Therefore, not only the response is generated from a probability distribution, but the model parameters are assumed to come from a distribution as well. We have a *posterior distribution* for the model parameters that is proportional to the likelihood of the data multiplied by the *prior* probability of the parameters. The updating from the prior distribution to the posterior distribution is carried out using Bayes' theorem:

$$p(\theta|\boldsymbol{y}) \propto f(\boldsymbol{y}|\theta) \cdot \pi(\theta) = L(\theta|\boldsymbol{y}) \cdot \pi(\theta) \quad (4)$$

where $f(\boldsymbol{y}|\theta)$ is the sampling distribution of the response variable and $\pi(\theta)$ is the prior distribution of θ.

Bayesian methods explicitly use probability distributions to quantify uncertainties about the unknown parameters. Probability describes degree of belief rather than long-run frequency. This is a considerable deviation from the classical statistics paradigm. As a result, Bayesian inference is carried out conditional on the observed data and does not rely on the assumption that a hypothetical infinite population of data exists.

We implement the Bayesian framework based on Markov chain Monte Carlo (MCMC) technique using Gibbs sampling algorithm. The analysis also compares the existence of the hierarchical structure of the data modelled through the multilevel approach with the linear regression model as reported in Table 8.

Table 8: Bayesian MCMC estimations of linear and multilevel models.

	Log of Sales in USD			
	Linear regression model		**Multilevel model**	
	Simulated posterior distribution of the parameters	95% credible intervals	Simulated posterior distribution of the parameters	95% credible intervals

	Mean	MCSE	Min.	Max.	Mean	MCSE	Min.	Max.
Firm-level variables								
Constant	9.9074	(0.0026)	9.8665	9.9449	10.7856	(0.0181)	10.4039	11.1567
Age	0.1214	(0.0004)	0.1147	0.1274	0.1322	(0.0002)	0.0938	0.1708
Small	1.1710	(0.0018)	1.1425	1.1988	1.1218	(0.0008)	0.9426	1.3027
Medium	2.5480	(0.0029)	2.5116	2.5885	2.4847	(0.0009)	2.2998	2.6693
Large	4.1706	(0.0025)	4.1471	4.1988	4.1492	(0.0009)	3.9538	4.3448
Exporter	0.3338	(0.0023)	0.3049	0.3664	0.3303	(0.0004)	0.2622	0.3988
Qualification	0.0040	(0.0000)	0.0034	0.0045	0.0041	(0.0000)	0.0031	0.0051
Foreign	0.5439	(0.0039)	0.4756	0.6147	0.5230	(0.0004)	0.4243	0.6236
Sector dummies			Yes				Yes	
Country dummies			Yes					
Country clustered							Yes	
Random intercept					0.6500	(0.0014)	0.3845	1.0739
Av. efficiency		0.007764				0.7403		
Log marginal likelihood		-21405.95				-20993.43		
DIC		41947.5				42002.78		

Note: Gibbs sampling is used for regression coefficients and variance components. MCMC sample size is 20,000. Default priors are used for model parameters.

Despite coefficient parameters estimates using the linear regression and the multilevel model are quite similar to the simulated posterior distribution of the parameters using the Bayesian approach, information about the fitted Bayesian model, as the average efficiency of the MCMC algorithm and marginal likelihood (ML)[8] , the multilevel one results overwhelmingly more appropriate to describe the data. The efficiency summaries for any parameter using the Bayesian approach are reported in Appendix (Table 13 and 14 in Dada Appendix).

8. Conclusions

This article explores the performance of firms in emerging economies by considering the factors that, at different levels, may influence it. Our focus is committed to shed light on the effect of country-level transport infrastructure endowment and logistics on firm performance from a micro-analysis perspective, while controlling for firm-level factors that are expected to influence firm performance. We consider different types of transport infrastructure, such as roads, railways, airports and ports, and the overall performance of the country's logistics services.

In doing so, we adopt the appropriate approach to study a hierarchically structured phenomenon such as firm performance. The multilevel approach allows us to model the unobserved country-level heterogeneity in firm performance and to test whether it is

[8] The best fitted model is the one that represents the smallest marginal likelihood (ML).

explained by the different types of transport infrastructure in each country. To the best of our knowledge, this is the first study to examine whether a country's transport infrastructure is directly associated with firm performance.

Our results show that although most of the variability in firms' performance is related to their internal characteristics, transport infrastructure also plays a role in their economic performance. In particular, we find evidence that the extent of the road and rail network have strong positive relationships with firm performance. The presence of airports and the level of logistics performance of a country are also able to capture differences in firm performance across countries, while port facilities seem to have no influence on them.

This paper contributes to the literature on business performance and transport economics by showing that the positive role of transport infrastructure on economic growth and development is also due to the positive impact it has at the firm level. It also highlights the role of transport infrastructure investment in emerging economies as a pathway to drive growth and accelerate the catch-up process. While in higher-income countries, investment in transport infrastructure mostly addresses the need for replacement and maintenance, in low-income countries, investment is needed to improve transport infrastructure to bring it up to the level of those in more advanced economies (EBRD, 2017). The findings further underline the role of transport infrastructure in supporting future growth.

Finally, this paper creates a paradigm for future studies to improve the understanding of the interdependence between different levels of analysis to design more complex and comprehensive transport investment strategies and logistics service development policies. We are aware, however, of the relevance that the availability of panel data over longer periods could have for determining the effect of changes in transport infrastructure on business performance. In addition, the availability of higher quality data for transport infrastructure, allowing a more detailed analysis of different types of networks and nodes to be determined, would improve research insights.

References

Article in a journal:

Acedo, F. J., Barroso, C., & Galan, J. L. (2006). The resource-based theory: dissemination and main trends. *Strategic management journal*, *27*(7), 621-636.

Acs, Z. J., Autio, E., & Szerb, L. (2014). National systems of entrepreneurship: Measurement issues and policy implications. *Research policy*, *43*(3), 476-494.

Arzeni, S. (1997) Entrepreneurship and Job Creation. *OECD Observer*, (209), 18–21.

Aschauer, D.A. (1989) Is Public Expenditure Productive? *Journal of Monetary Economics*, *23*(2), 177-200.

Aterido, R., Hallward-Driemler, M., & Pagés, C. (2011) Big constrains to small firms' growth? Business environment and employment growth across firms. *Economic Development and Cultural Change*, *59*(3), 609-647.

Audretsch, D. B., & Thurik, A. R. (2000) Capitalism and Democracy in the 21st Century: From the Managed to the Entrepreneurial Economy. *Journal of Evolutionary Economics*, *10*(1-2), 17–34.

Audretsch, D.B., & Fritsch, M. (2002) Growth regimes over time and space. *Regional Studies*, *36*(2), 113-124.

Barney, J. (1991) Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99-120.

Barney, J., Wright, M., & Ketchen Jr, D. J. (2001) The resource-based view of the firm: Ten years after 1991. *Journal of Management*, *27*(6), 625-641.

Baum-Snow, N., Brandt, L., Henderson, J. V., Turner, M. A., & Zhang, Q. (2017). Roads, railroads, and decentralization of Chinese cities. *Review of Economics and Statistics*, *99*(3), 435-448.

Beck, T., Demirgüç-Kunt, A. S. L. I., & Maksimovic, V. (2005). Financial and legal constraints to growth: does firm size matter?. *The journal of finance*, *60*(1), 137-177.

Belderbos, R., & Carree, M. (2002) The Location of Japanese Investments in China: Agglomeration Effects, Keiretsu, and Firm Heterogeneity. *Journal of the Japanese and International Economies*, *16*(2), 194–211.

Bernard, A. B., Jensen, J. B., & Lawrence, R. Z. (1995). Exporters, jobs, and wages in US manufacturing: 1976-1987. *Brookings papers on economic activity. Microeconomics*, *1995*, 67-119.

Bernard, A. B., Jensen, J. B., Redding, S. J., & Schott, P. K. (2007). Firms in international trade. *Journal of Economic perspectives*, *21*(3), 105-130.

Bernard, A. B., Jensen, J. B., Redding, S. J., & Schott, P. K. (2012). The empirics of firm heterogeneity and international trade. *Annu. Rev. Econ.*, *4*(1), 283-313.

Birch, D. L. (1981). Who creates jobs?. *The public interest*, *65*, 3.

Boudier-Bensebaa, F. (2005) Agglomeration Economies and Location Choice: Foreign Direct Investment in Hungary, *Economics of Transition*, *13*(4), 605–628.

Brock, W. A., & Evans D. S. (1989) Small Business Economics. *Small Business Economics 1*(1), 7–20.

Burki, A. A., & Terrell, D. (1998). Measuring production efficiency of small firms in Pakistan. *World Development*, *26*(1), 155-169.

Calderón, C., Moral-Benito, E., & Servén. L. (2015) Is infrastructure capital productive? A panel heterogeneous approach. *Journal of Applied Econometrics*, *3*(2), 177-198.

Canning, D., & Pedroni, P. (2008). Infrastructure, long-run economic growth and causality tests for cointegrated panels. *The Manchester School*, *76*(5), 504-527.

Cieślik, A., & Ryan, M. (2004). Explaining Japanese direct investment flows into an enlarged Europe: A comparison of gravity and economic potential approaches. *Journal of the Japanese and International Economies*, *18*(1), 12-37.

Coad, A., Holm, J. R., Krafft, J., & Quatraro, F. (2018). Firm age and performance. *Journal of Evolutionary Economics*, *28*(1), 1-11.

Coad, A., Segarra, A., & Teruel, M. (2013). Like milk or wine: Does firm performance improve with age?. *Structural Change and Economic Dynamics*, *24*, 173-189.

Coder, L., Peake, W. O., & Spiller, M. S. (2017). Do high performance work systems pay for small firms? An intellectual capital building perspective. *Journal of Small Business Strategy*, *27*(2), 13-35.

Coff, R. W. (1999). When competitive advantage doesn't lead to performance: The resource-based view and stakeholder bargaining power. *Organization science*, *10*(2), 119-133.

Commander, S., & Svejnar, J. (2011). Business environment, exports, ownership, and firm performance. *The Review of Economics and Statistics*, *93*(1), 309-337.

Crook, T. R., Todd, S. Y., Combs, J. G., Woehr, D. J., & Ketchen Jr, D. J. (2011). Does human capital matter? A meta-analysis of the relationship between human capital and firm performance. *Journal of applied psychology*, *96*(3), 443.

Davis, S. J., Haltiwanger, J. C., & Schuh, S. (1998). Job creation and destruction. *MIT Press Books*, *1*.

Démurger, S. (2001). Infrastructure development and economic growth: an explanation for regional disparities in China?. *Journal of Comparative economics*, *29*(1), 95-117.

Dethier, J. J., Hirn, M., & Straub, S. (2011). Explaining enterprise performance in developing countries with business climate survey data. *The World Bank Research Observer*, *26*(2), 258-309.

Dollar, D., Hallward-Driemeier, M., & Mengistae, T. (2005). Investment climate and firm performance in developing economies. *Economic Development and Cultural Change*, *54*(1), 1-31.

Donaldson, D. (2018). Railroads of the Raj: Estimating the impact of transportation infrastructure. *American Economic Review*, *108*(4-5), 899-934.

Fan, S., Linxiu, Z. and Xiaobo Z. (2002) Growth, Inequality, and Poverty in Rural China: The Role of Public Investments. *International Food Policy Research Institute*, vol. 125.

Fay, M., Toman, M., Benitez, D., Csordas, S. (2011). Infrastructure and sustainable development. *Postcrisis Growth and Development: A Development Agenda for the G*, *20*(22), 329-382.

Fernald, J. G. (1999). Roads to prosperity? Assessing the link between public capital and productivity. *American economic review*, *89*(3), 619-638.

Fromm, G. (1965) *Transport investment and economic development*. Brookings Institution Press, 4(1).

Goldszmidt, R. G. B., Brito, L. A. L., de Vasconcelos, F. C. (2011). Country effect on firm performance: A multilevel approach. *Journal of Business Research*, *64*(3), 273-279.

Henckel, T., McKibbin, W. J. (2017). The economics of infrastructure in a globalized world: Issues, lessons and future challenges. *Journal of Infrastructure, Policy and Development*, *1*(2), 254-272.

Hobert, J. P. (2000). Hierarchical models: A current computational perspective. *Journal of the American Statistical Association*, *95*(452), 1312-1316.

Holl, A. (2004). Manufacturing location and impacts of road transport infrastructure: empirical evidence from Spain. *Regional science and urban economics*, *34*(3), 341-363.

Holl, A. (2006). A review of the firm-level role of transport infrastructure with implications for transport project evaluation. *Journal of Planning Literature*, *21*(1), 3-14.

Hox, J. J., Moerbeek, M., Van de Schoot, R. (2017). *Multilevel analysis: Techniques and applications*. Routledge.

Jacoby, H. G. (2000). Access to markets and the benefits of rural roads. *The economic journal*, *110*(465), 713-737.

Jensen, J. B., MCGUCKJN, R. H. (1997). Firm performance and evolution: empirical regularities in the US microdata. *Industrial and Corporate Change, 6*(1), 25-47.

Lepak, D. P., Snell, S. A. (2002). Examining the human resource architecture: The relationships among human capital, employment, and human resource configurations. *Journal of management*, *28*(4), 517-543.

Li, H., Li, Z. (2013). Road investments and inventory reduction: Firm level evidence from China. *Journal of Urban Economics*, *76*, 43-52.

Limao, N., Venables, A. J. (2001). Infrastructure, geographical disadvantage, transport costs, and trade. *The world bank economic review*, *15*(3), 451-479.

Loderer, C.F., Waelchli, U. (2010). Firm age and performance. Available at SSRN: https://ssrn.com/abstract=1342248

Majumdar, S. K. (1997). The impact of size and age on firm-level performance: some evidence from India. *Review of industrial organization*, *12*(2), 231-241.

Mateut, S. (2018). Subsidies, financial constraints and firm innovative activities in emerging economies. *Small Business Economics*, *50*(1), 131-162.

McMillan, J., Woodruff, C. (2002). The central role of entrepreneurs in transition economies. *Journal of economic Perspectives*, *16*(3), 153-170.

Moxnes, A. (2010). Are sunk costs in exporting country specific?. *Canadian Journal of Economics/Revue canadienne d'économique*, *43*(2), 467-493.

Murphy, G. B., Trailer, J. W., Hill, R. C. (1996). Measuring performance in entrepreneurship research. *Journal of business research*, *36*(1), 15-23.

Ndiaye, N., Razak, L. A., Nagayev, R., & Ng, A. (2018). Demystifying small and medium enterprises'(SMEs) performance in emerging and developing economies. *Borsa Istanbul Review*, *18*(4), 269-281.

Robinson, K. C. (1999). An examination of the influence of industry structure on eight alternative measures of new venture performance for high potential independent new ventures. *Journal of Business Venturing*, *14*(2), 165-187.

Straub, S. (2011). Infrastructure and development: A critical appraisal of the macro-level literature. *The Journal of Development Studies*, *47*(5), 683-708.

Stam, E., & Van de Ven, A. (2021). Entrepreneurial ecosystem elements. *Small Business Economics*, *56*(2), 809-832.

Urbano, D., Aparicio, S., & Audretsch, D. (2019). Twenty-five years of research on institutions, entrepreneurship, and economic growth: what has been learned?. *Small Business Economics*, *53*(1), 21-49.

Weinzimmer, L. G., Nystrom, P. C., & Freeman, S. J. (1998). Measuring organizational growth: Issues, consequences and guidelines. *Journal of management*, *24*(2), 235-262.

<u>Working paper:</u>

Calderón, C., Servén, L. (2004). The Effects of Infrastructure Development on Growth and Income Distribution. Policy Research Working Paper, (3400). World Bank, Washington, D.C..

Deichmann, U., Kaiser, K., Lall, S.V., Shalizi, Z. (2005). Agglomeration, Transport, and Regional Development in Indonesia. *Policy Research Working Paper*, (3477). World Bank, Washington, D.C..

Commander, S., Svejnar, J., Tinn, K. (2008) Explaining the Performance of Firms and Countries: What Does the Business Environment Play? *Working Papers 836*, Graduate School of Management, St. Petersburg State University.

Luo, X. (2004). The Role of Infrastructure Investment Location in China's Western Development. Policy, Research working paper series;no. WPS 3345; *Policy Research Working Paper, (3345)*. World Bank, Washington, D.C.

Straub, S. (2008). Infrastructure and growth in developing countries: Recent advances and research challenges. *World Bank policy research working paper*, (4460). World Bank, Washington, D.C..

<u>Book:</u>

Agénor, P. R., Moreno-Dodson, B. (2006). *Public infrastructure and growth: New channels and policy implications* (Vol. 4064). World Bank Publications.

Goldstein, H. (2011). *Multilevel statistical models* (Vol. 922). John Wiley & Sons.

Lewis, W. A. (2013). *Theory of economic growth*. Routledge.

North, D. C., Thomas, R. P. (1973). *The rise of the western world: A new economic history*. Cambridge University Press.

Owen, W. (1964). *Strategy for Mobility:(Transportation for the Developing Countries)*. Brookings Institution.

Rabe-Hesketh, S., Skrondal, A. (2012). *Multilevel and longitudinal modeling using Stata*. STATA press.

Raudenbush, S. W., Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (Vol. 1). Sage.

Reynolds, P. D., Camp, S. M., Bygrave, W. D., Autio, E., Hay, M. (2001). GEM Global Entrepreneurship Report, 2001 Summary Report. *Kauffman Center for Entrepreneurial Leadership*.

Schumpeter, J. A. (1934) *The Theory of Economic Development*. Cambridge, MA: Harvard University Press.

Stam, E., & Spigel, B. (2018). Entrepreneurial ecosystems. In R. Blackburn, D. De Clercq, & J. Heinonen (Eds.), *The SAGE handbook of small business and entrepreneurship* (pp. 407–422). London: SAGE.

<u>Presentation at a conference:</u>

Shepherd, B., & Wilson, J. S. (2008, September). Road infrastructure in Europe and Central Asia: Does network quality affect trade?. In *17th International Itf/Oecd Symposium on Transport Economics and Policy: Benefiting from Globalisation, Transport Sector Contribution and Policy Challenges* (pp. 275-320).

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Data Appendix

Table 9: Descriptive statistics of firm-level variables clustered at country-level.

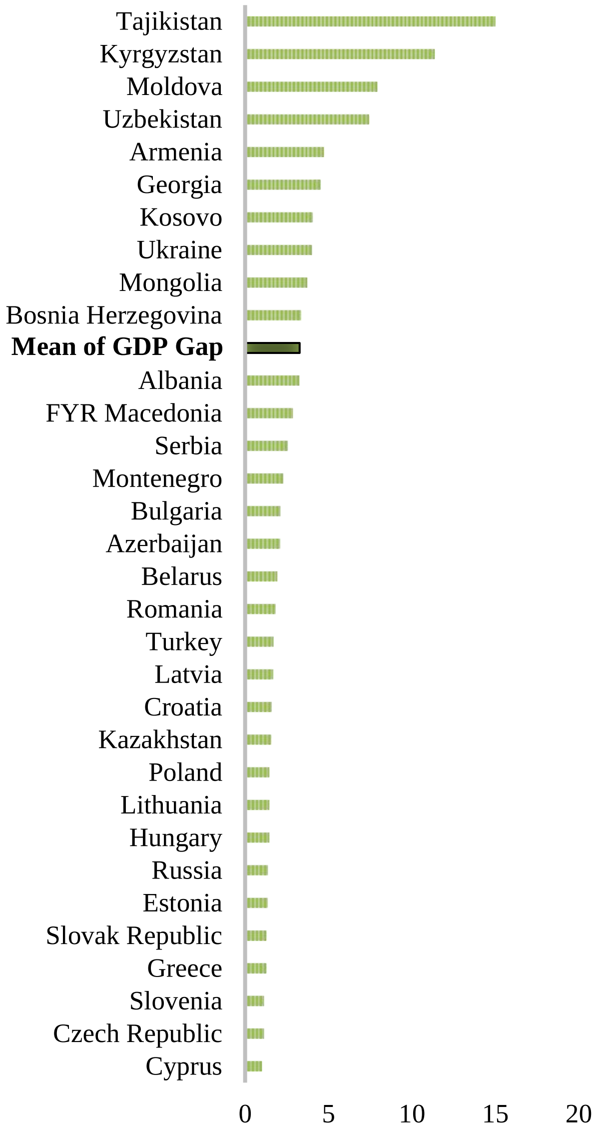
		Mean	*Std. Dev.*	*Min*	*Max*	*Observations*
Sales (000 USD)	overall	6,587	58,400	6	2,720,000	N = 11990
	between		4,470	633	18,700	n = 32
	within		58,200	-12,200	2,720,000	T-bar = 374.688
Age	overall	15.04	12.13	1	174	N = 11990
	between		3.50	10.97	25.14	n = 32
	within		11.60	-8.10	177.77	T-bar = 374.688
Micro	overall	0.021	0.14	0	1	N = 11990
	between		0.06	0	0.32	n = 32
	within		0.14	-0.30	1.02	T-bar = 374.688
Small	overall	0.537	0.50	0	1	N = 11990
	between		0.09	0.37	0.74	n = 32
	within		0.49	-0.20	1.17	T-bar = 374.688
Medium	overall	0.320	0.47	0	1	N = 11990
	between		0.06	0.19	0.45	n = 32
	within		0.46	-0.13	1.13	T-bar = 374.688
Large	overall	0.122	0.33	0	1	N = 11990
	between		0.05	0.04	0.23	n = 32
	within		0.32	-0.11	1.08	T-bar = 374.688
Export	overall	0.23	0.42	0	1	N = 11990
	between		0.15	0.03	0.57	n = 32
	within		0.39	-0.34	1.20	T-bar = 374.688
Qualification	overall	32.60	30.64	0	100	N = 11990
	between		13.42	9.35	59.68	n = 32
	within		26.51	-27.08	123.25	T-bar = 374.688
Foreign	overall	0.07	0.26	0	1	N = 11990
	between		0.05	0.00	0.20	n = 32
	within		0.26	-0.13	1.06	T-bar = 374.688

Table 10: Overview of the sample composition by country.

Country	**Obs.**	**Cum. freq. (%)**	**Sales Mean (000 USD)**	**Std. Dev. (000 USD)**
Albania	290	2.42	3,710	31,600
Armenia	238	1.98	1,624	5,511
Azerbaijan	208	1.73	2,359	11,400
Belarus	273	2.28	4,126	11,400
Bosnia-Herzegovina	291	2.43	3,240	7,500
Bulgaria	263	2.19	5,609	5,609
Croatia	317	2.64	9,093	42,100
Cyprus	208	1.73	3,644	10,900
Czech Republic	208	1.73	6,808	16,100
Estonia	228	1.90	4,334	15,200
FYR Macedonia	337	2.81	1,911	9,935
Georgia	254	2.12	1,408	6,654
Greece	255	2.13	9,563	34,800
Hungary	178	1.48	14,900	86,100
Kazakhstan	411	3.43	2,394	8,594
Kosovo	171	1.43	2,983	17,100
Kyrgyzstan	211	1.76	4,199	25,200
Latvia	226	1.88	2,983	9,819
Lithuania	195	1.63	3,485	11,500
Moldova	294	2.45	2,089	7,587
Mongolia	322	2.69	2,157	11,300
Montenegro	98	0.82	5,507	21,100
Poland	347	2.89	7,711	22,700
Romania	470	3.92	8,699	79,500
Russia	2889	24.10	8,674	87,800
Serbia	327	2.73	10,400	61,500
Slovak Republic	160	1.33	8,301	21,100
Slovenia	238	1.98	18,700	75,500
Tajikistan	243	2.03	633	1,916
Turkey	778	6.49	15,700	108,000
Ukraine	703	5.86	1,040	5,100
Uzbekistan	359	2.99	4,591	16,300
Total	11,990	100.00		

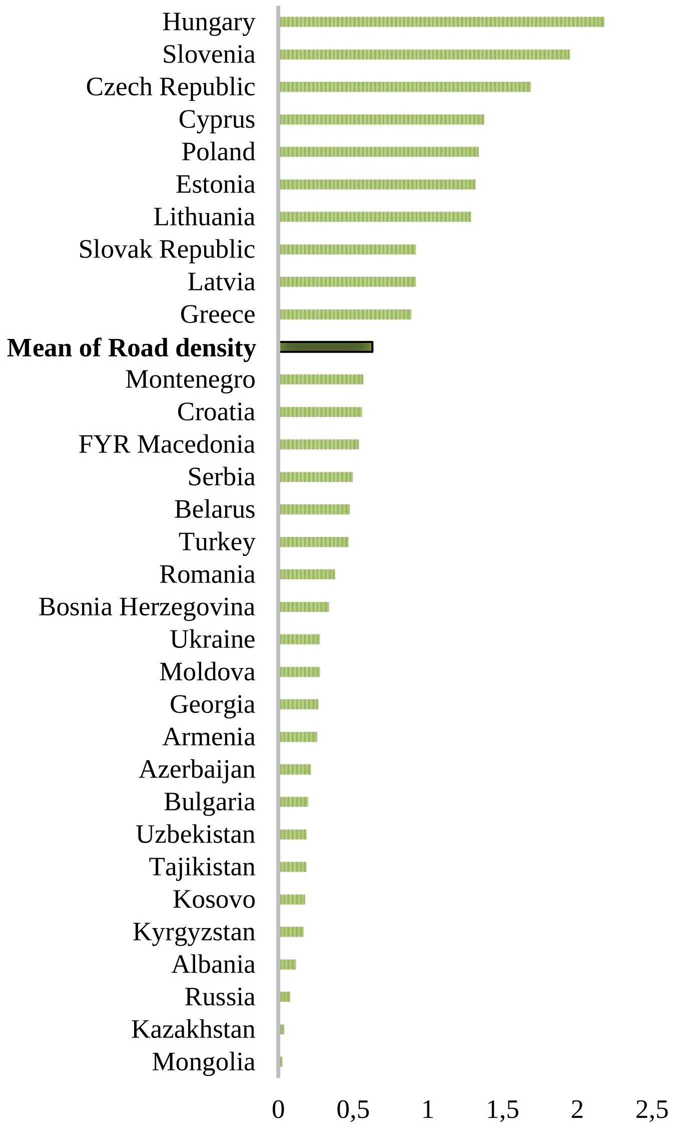
Figure 3: Transport infrastructure endowment, logistic performance index and control variable by country clusters in the sample.

(a) Rank of countries in the sample by Gap of GDP per capita.

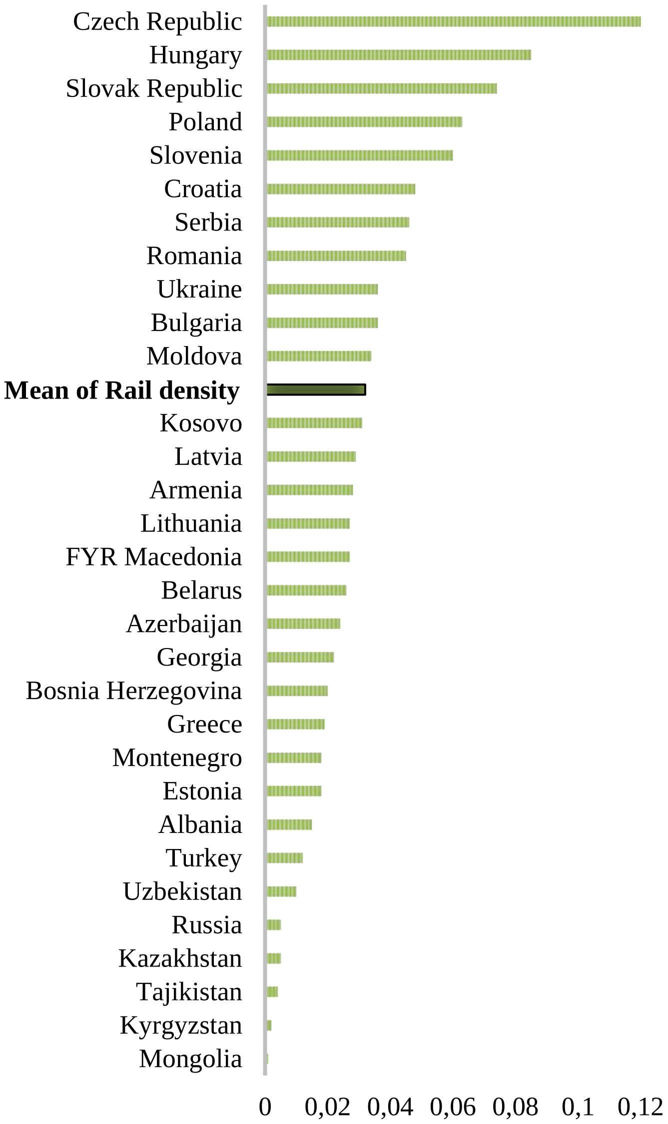


Note: Cyprus is the country with the highest GDP per capita in the sample and it is set to 1.

(b) Rank of countries in the sample by Road density.

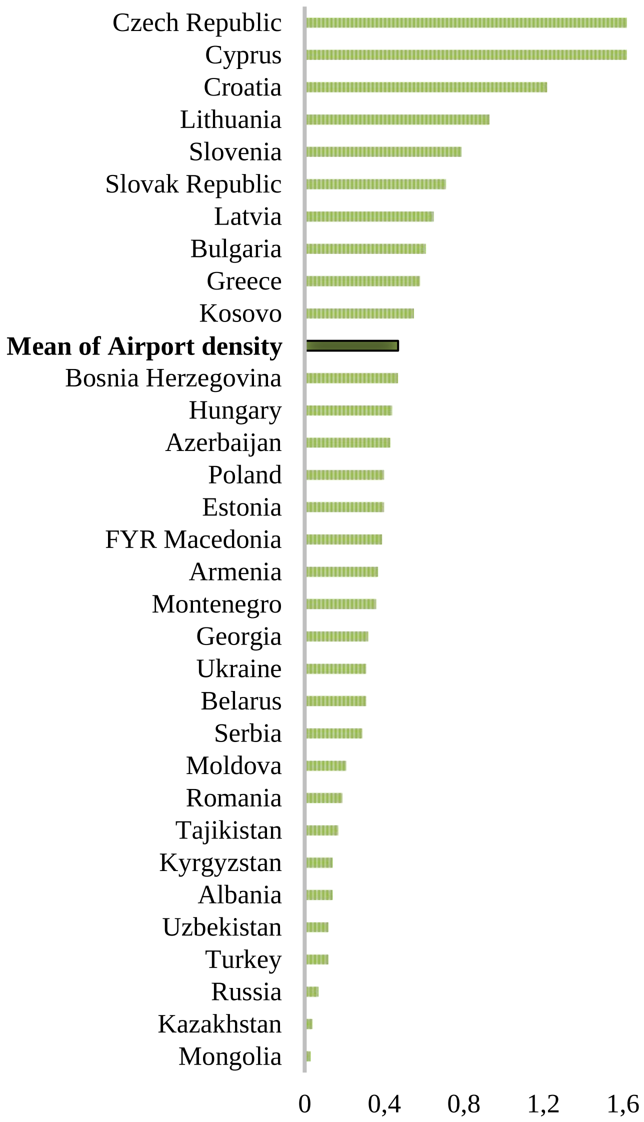


(c) Rank of countries in the sample by Rail density.



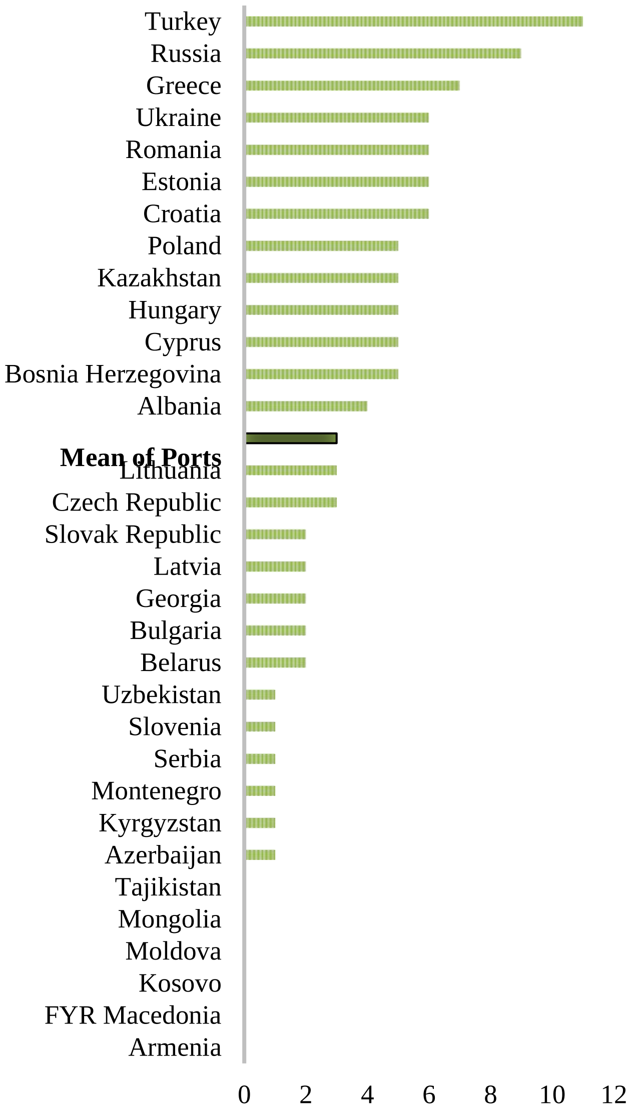
Note: Rail data for Cyprus are not available.

(d) Rank of countries in the sample by Airport density.



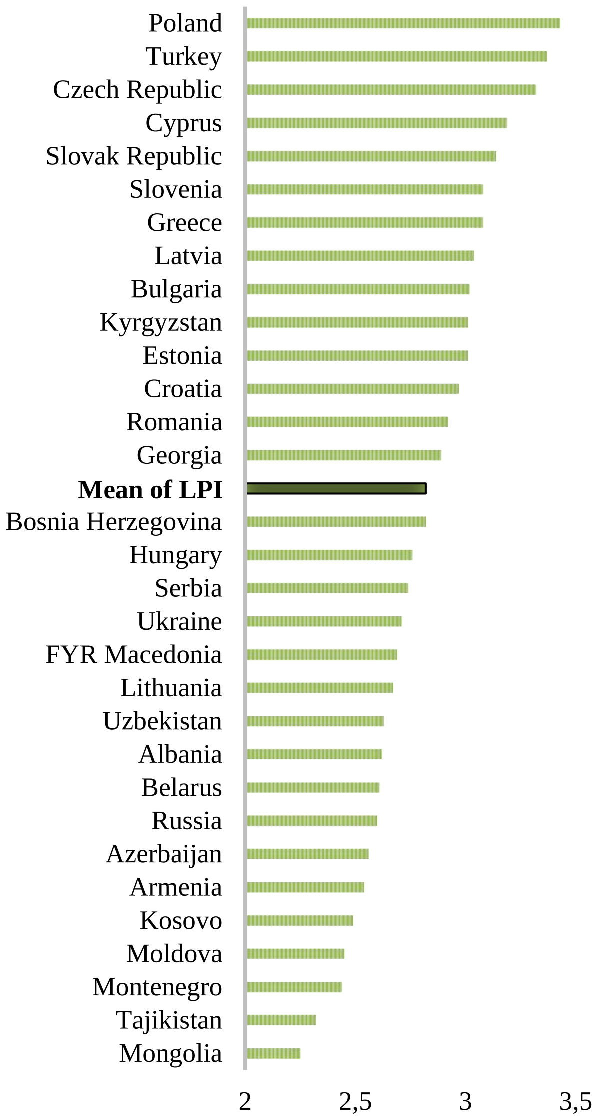
Note: Rail data for Cyprus are not available.

(e) Rank of countries in the sample by number of Ports.



Note: Six countries in the sample are landlocked.

(f) Rank of countries in the sample by Logistic Performance Index.



Note: Logistic Performance Index not available for Kazakhstan.

Table 11: Descriptive statistics of country-level variables by country.

	Gap	*Road*	*Rail*	*Airport*	*Port*	*LPI*
Albania	3.25	0.12	0.015	0.14	4	2.62
Armenia	4.73	0.26	0.028	0.37	0	2.54
Azerbaijan	2.11	0.22	0.024	0.43	1	2.56
Belarus	1.93	0.48	0.026	0.31	2	2.61
Bosnia Herzegovina	3.35	0.34	0.020	0.47	5	2.82
Bulgaria	2.12	0.2	0.036	0.61	2	3.02
Croatia	1.6	0.56	0.048	1.22	6	2.97
Cyprus	1	1.38	.	1.62	5	3.19
Czech Republic	1.15	1.69	0.120	1.62	3	3.32
Estonia	1.35	1.32	0.018	0.40	6	3.01
FYR Macedonia	2.86	0.54	0.027	0.39	0	2.69
Georgia	4.54	0.27	0.022	0.32	2	2.89
Greece	1.27	0.89	0.019	0.58	7	3.08
Hungary	1.45	2.18	0.085	0.44	5	2.76
Kazakhstan	1.56	0.04	0.005	0.04	5	.
Kosovo	4.06	0.18	0.031	0.55	0	2.49
Kyrgyzstan	11.36	0.17	0.002	0.14	1	3.01
Latvia	1.68	0.92	0.029	0.65	2	3.04
Lithuania	1.45	1.29	0.027	0.93	3	2.67
Moldova	7.94	0.28	0.034	0.21	0	2.45
Mongolia	3.74	0.03	0.001	0.03	0	2.25
Montenegro	2.29	0.57	0.018	0.36	1	2.44
Poland	1.45	1.34	0.063	0.40	5	3.43
Romania	1.83	0.38	0.045	0.19	6	2.92
Russia	1.37	0.08	0.005	0.07	9	2.6
Serbia	2.56	0.5	0.046	0.29	1	2.74
Slovak Republic	1.28	0.92	0.074	0.71	2	3.14
Slovenia	1.15	1.95	0.060	0.79	1	3.08
Tajikistan	15.01	0.19	0.004	0.17	0	2.32
Turkey	1.69	0.47	0.012	0.12	11	3.37
Ukraine	4.01	0.28	0.036	0.31	6	2.71
Uzbekistan	7.43	0.19	0.010	0.12	1	2.63
Average	**3.27**	**0.63**	**0.032**	**0.47**	**3**	**2.82**

Table 12: Correlation matrix among country-level variables.

	Gap	*Road*	*Rail*	*Airport*	*Port*	*LPI*
Gap	1					
Road	-0.45	1				
Rail	-0.43	0.71	1			
Airport	-0.41	0.57	0.70	1		
Port	-0.44	0.15	0.02	0.00	1	
LPI	-0.42	0.51	0.50	0.45	0.50	1

Table 13: Efficiency summaries - OLS model (MCMC sample size = 20,000).

	Log of Sales in USD		
	ESS	*Corr. time*	*Efficiency*
Constant	26.68	749.51	0.0013
Age	31.85	627.88	0.0016
Small	26.97	741.69	0.0013
Medium	53.18	376.09	0.0027
Large	33.99	588.40	0.0017
Exporter	44.00	454.55	0.0022
Qualification	47.28	423.02	0.0024
Foreign	28.69	697.21	0.0014
Sector dummies			
Medium-high tech	38.39	520.96	0.0019
Medium-low tech	29.32	682.05	0.0015
Low tech	57.99	344.86	0.0029
Construction retail distribution	30.94	646.49	0.0015
KIBS	37.88	528.00	0.0019
Other services	49.92	400.62	0.0025
Country dummies			
Belarus	27.82	719.01	0.0014
Georgia	26.17	764.21	0.0013
Tajikistan	28.33	705.90	0.0014
Turkey	33.87	590.44	0.0017
Ukraine	34.51	579.59	0.0017
Uzbekistan	40.37	495.43	0.002
Russia	22.59	885.49	0.0011
Poland	59.12	338.29	0.003
Romania	68.74	290.97	0.0034
Serbia	26.21	763.09	0.0013
Kazakhstan	46.81	427.23	0.0023
Moldova	22.97	870.72	0.0011
Bosnia and Herzegovina	46.51	429.98	0.0023
Azerbaijan	50.12	399.07	0.0025
FYR Macedonia	42.91	466.12	0.0021
Armenia	42.53	470.27	0.0021
Kyrgyz Republic	29.40	680.28	0.0015
Mongolia	29.86	669.69	0.0015
Estonia	29.08	687.73	0.0015
Kosovo	68.15	293.45	0.0034
Czech Republic	72.72	275.02	0.0036
Hungary	39.53	505.90	0.002
Latvia	37.61	531.84	0.0019
Lithuania	45.88	435.94	0.0023
Slovak Republic	23.62	846.79	0.0012
Slovenia	33.98	588.52	0.0017
Bulgaria	28.70	696.90	0.0014
Croatia	30.98	645.62	0.0015
Montenegro	33.66	594.12	0.0017
Cyprus	37.72	530.23	0.0019
Greece	29.88	669.41	0.0015
Sigma2	4070.80	4.91	0.2035

Table 14: Efficiency summaries - Multilevel model (MCMC sample size = 20,000).

	Log of Sales in USD		
	ESS	Corr. time	Efficiency
Fixed effects			
Constant	111.17	179.91	0.0056
Age	9597.01	2.08	0.4799
Small	13946.46	1.43	0.6973
Medium	11785.25	1.70	0.5893
Large	13191.64	1.52	0.6596
Exporter	8721.15	2.29	0.4361
Qualification	4721.63	4.24	0.2361
Foreign	18741.30	1.07	0.9371
Sector dummies			
Medium-high tech	20000.00	1.00	1
Medium-low tech	20000.00	1.00	1
Low tech	20000.00	1.00	1
Construction retail distribution	20000.00	1.00	1
KIBS	20000.00	1.00	1
Other services	20000.00	1.00	1
Random effects			
Constant	16082.67	1.24	0.8041
Sigma2	20000.00	1.00	1