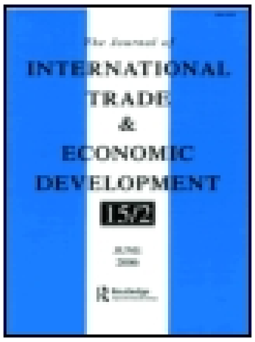

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Learning-by-importing in emerging innovation systems: evidence from Ecuador

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ABSTRACT
Using data from the population of Ecuadorian importers, we examine the extent to which the characteristics of their imports relate to their labor productivity. Results indicate that the technological intensity of imports does not explain differences in labor productivity, although the region of origin of imports explains differences in the manufacturing sector, as imported technologies from advanced regions are associated with superior labor productivity. Nevertheless, as technology intensive imports are not associated with superior performance, we argue that importers from developing countries may use foreign technology inexpertly due to the lack of absorptive capacity and the emerging nature of their national innovation system.

KEYWORDS Technology transfer; learning-by-importing; technology gap; emerging innovation systems

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1. Introduction

The balance of findings in micro-level studies that analyze the impact of imports on performance is that of a positive overall effect (Blalock and Veloso 2007; Almodóvar, Saiz-Briones, and Silverman 2014). However, there is still little evidence regarding the types of imported products that are associated with superior performance. According to the 'technology gap theory', if technology spills over across countries through trade flows (Coe and Helpman 1995), it should be expected that high-tech imports would have a greater impact on performance, since the greater the technology gap between the previous technology and the new imported one, the greater the scope for learning (Kokko 1994).

However, it is a challenging task to determine how the characteristics of imports affect performance, as data on their technological intensity are often not available. That is why the few existing studies substitute the technological content of imports with the type of market from which the imports originate, under the assumption that transferred technologies from advanced countries are relatively more up-to-date and should produce greater gains in performance through learning-by-importing (Serti and Tomasi 2008; Lööf and Andersson 2010; Castellani, Serti, and Tomasi 2010; Van den Berg and Van Marrewijk 2013). Results from these studies are consistent with the technology gap

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theory as they indicate that technology intensive imports (from advanced economies) are associated with greater levels of performance.

Despite the above, it has been suggested that in order to have an impact on performance the adoption of foreign technologies requires certain conditions to be fulfilled. First, firms need to have previously accumulated absorptive capacity, financial resources, complementary assets, knowledge and skills (Castellani, Serti, and Tomasi 2010). Second, importing countries have to be congruent with the physical, economic and social conditions that are reflected in technologies produced in other countries (Fagerberg and Godinho 2004). Finally, the international transfer of technology often requires adequate infrastructures, networks and institutions that control and facilitate such a transfer (Pérez 1986). Without these elements firms are unlikely to incorporate foreign technologies competently.

Consequently, the balance of findings, indicating that the adoption of technologies produced in industrialized countries is associated with greater performance, might be a consequence of analyzing data in developed countries where the abovementioned factors are more likely to be present. By contrast, in developing countries, the economic, social and physical conditions do not reflect those of advanced economies, nor do they have proper infrastructures, institutions and networks or firms with sufficient capabilities and resources (Kumar, Kumar, and Persaud 1999; Chaminade et al. 2009). Therefore, since the impact of imports may depend not just on their technological content, but on the characteristics of the importing innovation systems and the capabilities of importing firms (Dunning 1981; Reddy and Zhao 1990), we need to address the following research question: *Do firms that are embedded in emerging innovation systems*[1] *and that import technology-intensive products from advanced economies have the best performance?* A negative answer would imply that it is questionable whether the use of foreign technology is a feasible means of omitting some of the preliminary stages in the development process which requires both public and private active efforts to strengthen the national innovation system.

This paper analyzes the effect of different types of import shares – we can distinguish between the technological intensity of imports and the country of origin – on the labor productivity of Ecuadorian importers. Ecuador is a small low-middle income country, specializing in low value-added activities and characterized as a net importer of technology. It has relatively simple production structures, fragmented and disarticulated technological capabilities and it specializes in static comparative advantages (Cimoli et al. 2009). In Ecuador, national spending on R&D in 2011 was $269.47 million which represents 0.35% of its GDP (INEC and SENESCYT 2011). Hence Ecuador displays limited capacity either in terms of firms' technological capabilities or in terms of public investment in R&D.

The remainder of this paper is organized as follows. Section 2 reviews the literature background for our analysis. Section 3 describes the data, methods and variables. Section 4 presents and discusses the implications of the empirical results. Finally, we conclude in Section 5.

2. Literature review

2.1. The characteristics of imports and firms' performance

Imports may raise productivity through more differentiated varieties of inputs, higher quality inputs and/or learning effects (Grossman and Helpman 1991). Therefore, as there are various channels through which imports may affect performance, the characteristics of imported products should influence the effect that imports have on performance. At a theoretical level, learning effects are expected to be greater in the case of technology intensive imports produced in economies operating at the technological frontier (Lööf and Andersson 2010), because if the gap between the previous technology and the new imported one is too small, domestic firms are more likely to be equally exposed to advanced production techniques and the benefit from imported technologies may be negligible (Nyantakyi and Munemo 2014). Accordingly, the initial assumption of the existing empirical studies on this issue has been to consider that imports of leading technologies should be associated with greater performance at the level of the firm.

Since data on what types of goods are being imported are customarily not available, the strategy followed in order to analyze the influence of the characteristics of imports has been to classify imports according to the country of origin of the import. According to this approach, if it is the case that the larger the technology gap the greater the learning effects, imports from knowledge-intensive economies should be associated with higher performance as they offer more learning opportunities. In fact, this is precisely the result found in the few empirical studies on this issue. For instance, Lööf and Andersson (2010), drawing on a sample of Swedish manufacturing firms, find that imports from G7 countries, which account for about 80% of global R&D, are associated with greater productivity. Serti and Tomasi (2008) and Castellani, Serti, and Tomasi (2010) who analyze Italian firms also find that imports from advanced economies are related to higher productivity. Van den Berg and Van Marrewijk (2013), in a study of Dutch manufacturing and wholesale and retail trading firms, show that imports from advanced economies produce higher impacts on productivity. These last-mentioned authors also differentiate between different types of imported goods such as primary, natural-resource intensive, unskilled-labor intensive and technology intensive products. Their findings indicate that high-tech imports are also associated with superior productivity. Therefore, these studies provide evidence at firm level of imports as a means of international technology diffusion and of the association of technology intensive imports from industrialized economies with greater performance due to learning-by-importing effects.

Despite this evidence, it has been pointed out that the impact that the different types of imports may have on performance is also associated with the firm's ability to absorb the technological knowledge embodied in foreign equipment (Augier, Cadot, and Dovis 2013). In other words, although the technology gap determines the scope for learning, learning effects are unlikely to be apparent if firms do not have sufficient capabilities to adopt, absorb, repair and modify modern complex technologies in a productive and innovative manner (Castellani, Serti, and Tomasi 2010). This idea has been confirmed by several studies. For instance, Augier, Cadot, and Dovis (2013) find that the absorptive capacity of Spanish firms determines whether or not they benefit from imported technologies. Kokko, Zejan, and Tansini (2001) find evidence for international spillovers to Uruguayan firms with moderate technology gaps but not for firms with lower technological levels.

2.2. Technological imports in emerging innovation systems

The notion that imported technologies may improve firms' performance through the upgrading of machinery is especially relevant for developing countries as imported technological change may lead to a rapid adaptation to modern technologies (Robbins

2003; Taylor 2004). In developing countries technological change largely occurs through imports of intermediate capital goods from advanced economies which are not necessarily the most up-to-date technologies in the world, but nevertheless are more sophisticated than those traditionally adopted by local firms (Vivarelli 2014). Consequently, according to the technology gap theory, it might be expected that firms in developing countries that import technology-intensive products are the ones with the highest performance. However, as firms require absorptive capacity in order to make efficient use of foreign technologies, it is also likely that technology-intensive imports are only an effective means of international technology diffusion for firms in developed countries. The higher education systems in developed countries produce better managerial and labor skills that allow firms to have sufficient capabilities to adopt complex technologies in a productive manner (Kumar, Kumar, and Persaud 1999). Conversely, in developing countries, firms would have to emulate these capabilities before technologies can be effectively incorporated.

Besides the lack of absorptive capacity, there are other factors that may influence the suitability of imported technology which may also constitute a disadvantage for firms in developing countries. First, a proper use of leading technologies often requires additional capital investments, spare parts, designated personnel and complementary assets (Teece 1986). Since these ancillary products are not offered at a favorable price in developing countries, the invariable overpricing of these products represents a hidden cost that may reduce the impact that imported technologies have on performance (Blakeney 1987).

Second, as today's advanced technology requires the availability of sophisticated infrastructures, the existence of certain institutions and the ready accessibility of investment reserves (Pérez 1986; Kumar, Kumar, and Persaud 1999), firms in developing countries might find difficulties in incorporating such technologies. As Blakeney (1987) indicates, the demands of developing countries for access to technologies are paralleled by their demands for a restructuring of the legal environment and the modernization of infrastructures such as higher educational institutions and training facilities for science and technology.

Third, technology from advanced countries is not likely to be well suited to the needs of firms in developing countries as they reflect the physical, economic and social environments of the countries where they have been developed (Fagerberg and Godinho 2004). Thus, assimilating foreign technologies is not only a process of replacing outdated technologies, but of continually transforming technological, economic, and institutional structures (Fagerber and Verspagen 2002). In this sense, the characteristics of a country's productive structure and how its firms are integrated in global value chains may also influence how the characteristics of imports affect performance. For instance, the productive specialization in low value-added activities in developing countries may make learning effects less crucial for importers' performance than variety and quality effects. As a result, the firms with the highest performance may not be those importing high-tech products but those involved in natural resources or primary products.

Finally, firms from developed countries are closer to those in other developed countries; thus they face lower transport costs relating to advanced technologies than those faced by firms from the South. Moreover, firms in developing countries tend to face higher trade barriers for imported technology than those faced by firms from developed economies. On average, the tariffs on the industrial products imported by developing countries are three to four times higher than those faced by industrial countries (International Monetary Fund and World Bank 2001).

Therefore, although importers of technology from developing countries may have more scope for learning as the technology gap is likely to be greater than in developed countries, the abovementioned factors suggest that in developing countries the most labor productive importers might not be those importing advanced technologies from knowledge-intensive economies as they may not be able to integrate those technologies satisfactorily. Based on this notion, we shall calculate the impact of different import shares, distinguishing between the region of origin and the technological intensity of imports, on the labor productivity of Ecuadorian importers.

3. Data and methodology

3.1. Data and descriptive statistics

We were able to use data from the population of Ecuadorian importers during the period 2009–2012, which required the merging of four databases in order to construct all the variables included in the regressions that we will describe in the next section. We were able to merge the databases as in all of them firms are registered by their RUC (Registro Único de Contribuyentes) number, which is a number that identifies firms for tax purposes. First, to create the different import share variables, we used data from the Ecuadorian National Customs Service SENAE[2] (Servicio Nacional de Aduana del Ecuador) which records the annual value of each firm's imports and classifies imported goods by country of origin and type, based on the 10-digit tariff heading classification NANDINA.[3] These data are not open access and they have to be formally requested from the SENAE which provided us with data on imports for the period 2005–2013. However, our analysis only covers the period 2009–2012 as we obtained information on the number of employees in each firm from the database of the Ecuadorian Social Security IESS[4] (Instituto Ecuatoriano de Seguridad Social) which, based on the monthly registration forms of the employees, records the average number of employees covered by social security in each firm by year. Note that we were limited to 2009–2012 as the IESS only has a digitalized database for this period. This database is not open access and it has to be requested from the IESS. To distinguish between foreign and domestic firms we used data from the Register of Foreign Companies (Sistema de Sucursales de Compañías Extranjeras) of the Ecuadorian Superintendence of Companies (Superintendencia de Compañías del Ecuador). Information on foreign companies can be downloaded free from the Ecuadorian Superintendence of Companies' website.[5] Finally, we used data from the Ecuadorian Taxation Collection Service SRI[6] (Servicio de Rentas Internas) annual database for tax declarations to extract information on firms' sales, exports and economic activity. This database has detailed economic information of all firms and requires special permits for its use. From the merged database we eliminated service firms[7] and firms with sales and/or employees equal to zero. We had a total of 5,980 observations for manufacturers and 17,016 observations for wholesale and retail traders.

Table 1 displays import shares over region of origin and technological intensity[8] for manufacturers, while Table 2 does the same for wholesale and retail traders. In both sectors, the most common imported goods are manufactures based on natural resources which are goods produced with labor intensive technologies and made using natural resources. In the case of the Ecuadorian economy, these imports come from different regions of the world in similar proportions, although they mainly come from advanced countries and they are less likely to come from neighboring developing regions such as

Table 1. Distribution of imports by technological intensity, according to region of origin – manufacturing firms.

Imports' region of origin	High-tech products	Medium-tech products	Low-tech products	Manufactures based on natural resources	Primary products
North America	0.15	0.15	0.09	0.56	0.04
Advanced Asia and Oceania	0.04	0.22	0.12	0.60	0.01
Advanced Europe	0.08	0.17	0.16	0.58	0.01
Emerging Europe	0.15	0.28	0.01	0.56	0.00
Latin America and the Caribbean	0.08	0.23	0.29	0.34	0.06
Andean Community	0.04	0.39	0.20	0.35	0.02
Africa and Western Asia	0.01	0.25	0.17	0.55	0.03

Table 2. Distribution of imports by technological intensity, according to region of origin – wholesale and retail traders.

Imports' region of origin	High-tech products	Medium-tech products	Low-tech products	Manufactures based on natural resources	Primary products
North America	0.23	0.16	0.10	0.48	0.04
Advanced Asia and Oceania	0.17	0.34	0.09	0.40	0.01
Advanced Europe	0.14	0.17	0.16	0.50	0.03
Emerging Europe	0.16	0.31	0.08	0.37	0.08
Latin America and the Caribbean	0.14	0.22	0.21	0.34	0.08
Andean Community	0.08	0.45	0.13	0.25	0.09
Africa and Western Asia	0.12	0.33	0.19	0.31	0.04

the Andean Community or Latin America and the Caribbean. The high dependence on imports of manufactures based on natural resources in both sectors reveals the productive specialization of the Ecuadorian economy in oil and raw materials and the lack of a consolidated industrial sector.

Primary products are the least common type of imported goods in both sectors, which is not surprising as Ecuador is a net exporter of primary goods. This category includes products directly extracted from nature, used as basic raw materials for the manufacture of other products which do not involve any level of processing and are characterized by intensive use of labor (MCCTH 2013). The manufacturing sector mainly imports these products from Latin America and the Caribbean followed by North America, while the wholesale and retail sector mainly imports primary products from the Andean Community, Latin America and the Caribbean and Emerging Europe. Therefore, Ecuadorian imports of primary products mainly come from emerging economies which have competitive advantage in these types of goods, although North America appears as another important market of origin.

Regarding imports with technological content, in both sectors the most common imported goods are medium-tech products which are goods that require skilled labor and scale intensive technologies (MCCTH 2013). Although these imports come from different regions of the world in similar proportions, the Andean Community seems to be the most important market of origin, while North America and Advanced Europe are the least common sources. In the manufacturing sector, the least common type of imported goods are high-tech products which are advanced technology goods that experience constant innovation and they are produced with sophisticated capital intensive technologies and skilled labor (MCCTH 2013). This reveals the simple production structures and the few technological capabilities of Ecuadorian industry. In the manufacturing sector, high-tech products mainly come from North America and European countries. Additionally, the Ecuadorian manufacturing sector imports more low-tech products than high-tech products. Low-tech products, which are goods that do not require skilled labor and that are produced with capital intensive technologies (MCCTH 2013) mainly come from Latin America and the Caribbean and the Andean Community. Finally, in the whole-sale and retail trade sector, imports of high-tech products are more common than those of low-tech products and they mainly come from North America and other advanced regions. By contrast, in this sector, imports of low-tech products primarily come from Latin America and the Caribbean.

3.2. Empirical models, variables and methods

We estimate a model which examines the influence of import shares from different regions and with different technological intensity on the labor productivity of Ecuadorian importers. The estimating equation is as follows:

$$\ln\ (\text{laborProd}_{it}) = \alpha + \sum_{j=1}^{J} \beta_j \text{importshare}_{jit} + \gamma X_{it} + \tau_t + \mu_i + \varepsilon_{it}. \qquad (1)$$

Model (1) is the baseline model where *laborProd* is labor productivity measured as the natural logarithm of firms' total sales divided by the number of employees which is a performance variable commonly used in the literature (Vogel and Wagner 2010; Ortega and Marchante 2010). Note that value added per employee would be a better measure of labor productivity as it reflects the effectiveness and efficiency of labor in the production and sale of the output. However, we are forced to stay with total sales per employee due to data limitations. The variables *importshare* are our variables of interest and refer to the import shares of different types of imported products and are calculated as the value of a firm's imports of a certain type over the value of its total imports, where the sub-index j stands for the different types of import shares. We distinguish between two characteristics of imports: region of origin and technological intensity. Therefore, we estimate 3 different versions of equation (1) as we will also combine both dimensions.

Following earlier studies, in the first equation import shares reflect the region of origin of imports; thus they are measured as the value of imports from a particular region divided by the value of total imports. We distinguish between 7 regions ($J = 7$): *North America*, *Advanced Europe*, *Advanced Asia and Oceania*, *Emerging Europe*, *Latin America and the Caribbean*, *Andean Community* and *Africa and Western Asia.*[9] Since we aim at analyzing whether imports from knowledge intensive economies are associated with higher (lower) levels of labor productivity, we need regions to reflect both distance and the innovation capabilities and results of their countries. Thus, in order to construct our regional categories we employ the Global Innovation Index (GII) country ranking.[10] This classification ranks countries according to their GII in the following regions: Central and Southern Asia, Europe, Latin America and the Caribbean, Northern America, Northern Africa and Western Asia, South East Asia and Oceania and Sub-Saharan Africa. From these categories we have created our regions by employing a threshold of a GII percentage rank equal to 0.77 to differentiate between advanced and emerging regions. For example, our category *Advanced Europe* includes European countries with a GII percentage rank equal to or higher than 0.77,[11] while the category *Emerging Europe* includes European

Table 3. Mean of global innovation index percentage rank, by defined region.

Defined regions	GII Index
North America	0.93
Advanced Asia and Oceania	0.89
Advanced Europe	0.89
Emerging Europe	0.65
Latin America and the Caribbean	0.42
Andean Community	0.36
Africa and Western Asia	0.32
Ecuador	*0.16*

Notes: Corresponds to the index for the year 2015.

countries with a GII percentage rank lower than 0.77. Our category *Advanced Asia and Oceania* includes countries from South East Asia and Oceania with a GII percentage rank higher than 0.77; while the category *Africa and Western Asia* includes countries from Central and Southern Asia, Northern Africa and Western Asia and Sub-Saharan Africa which are all countries with a GII percentage rank lower than 0.77. The GII predefined region Northern America corresponds to our *North America* region and includes the United States and Canada. Finally, we distinguish between the Andean Community and the rest of Latin America and the Caribbean as the former is a free trade zone to which Ecuador belongs. Table 3 shows the average GII percentage rank of each regional category. Note that Ecuador has a GII percentage rank of 0.16 which is lower than its regional average as a reflection of its limited innovative capacity. Therefore, all regions from which Ecuadorian firms import display greater technological capabilities than Ecuador itself.

In the second estimation, import shares reflect the technological intensity of imports. Here we differentiate between 5 types of imported products ($J = 5$) according to Lall's (2000) classification of products by technological intensity: *High-tech products*, *Medium-tech products*, *Low-tech products*, *Manufactures based on natural resources* and *Primary products*. Finally, the third estimation integrates both the geographical and the technological dimensions. However, in order to make the analysis manageable, we aggregate the technological dimensions into two categories: *Technological products* which include high, medium and low-tech products and *Non-technological products* which combine manufactures based on natural resources and primary products. Note that we have carried out these aggregations as we do not find significant differences between the impacts of each category.[12] Therefore, the third estimation includes 14 import share variables ($J = 14$) as we separate out the import shares of each of the 7 regions between those with and those without technological content.

The X variable stands for the set of control variables which includes the size of the firm (*Size*) measured as the natural log of the number of employees and two dummy variables to differentiate between exporters (*Exporter*) and foreign firms (*Foreign*). The variable *Exporter* takes value 1 if the firm sells at least part of its production in international markets and the variable *Foreign* takes on 1 if the firm is listed in the Register of Foreign Companies (Sistema de Sucursales de Compañías Extranjeras) of the Ecuadorian Superintendence of Companies (Superintendencia de Compañías del Ecuador). Note that in our analysis exporters are actually two-way traders as we exclusively focus on importing firms. Furthermore, we include as an additional control a variable that accounts for firms' diversity of imports. As Castellani, Serti, and Tomasi (2010) indicate it is important to control for the diversification of imports as it is strongly associated with higher performance at the level of the firm. These variables are measured as the natural log of each firm's J in each equation. Therefore, they measure the level of diversification of firms' imports in terms of markets of origin, technological content and both markets of origin and technological content in each of the estimating equations. The variables τ and μ are respectively time and industry dummies; while ε is the error term.

Finally, we run separate regressions for manufactures and wholesale and retail traders as the differing nature of their activities will be reflected in their labor productivity. Moreover, we expect differences regarding the impact of the different import share variables between these sectors as wholesale and retail traders are less likely to experience learning-by-importing effects. This is because they do not integrate the majority of their imports into their production processes, as they are not actually involved in production itself but in the sale to end users.

We estimate these models using pooled ordinary least squares (OLS) and fixed effects (FE)[13] with robust standard errors clustered at the firm level in order to obtain adequate standard errors. The OLS coefficients can be interpreted as conditional differences across firms with different import shares relative to the reference categories which are *North America*, *Primary Products* and *North America technological products* for each of the alternative specifications. However, FE is the preferred estimation strategy as, by taking advantage of the panel structure of the data, it has the advantage of removing all time-invariant firm heterogeneity that would lead to less efficient estimates. The FE regressions estimate a correlation between changes in import shares and changes in the dependent variable, as it captures the deviations of firms from their own longer-term average. Therefore, if a time-invariant firm's characteristics are correlated with the different types of import shares, differences between the two estimation methods are expected to emerge. Note that the short time dimension and the large number of focal variables of interest make it problematic to embark on dynamic panel instrumental variable estimation techniques such as GMM (Belderbos et al. 2014).

4. Empirical results and discussion

4.1. International trade and firm performance

As our analysis focuses exclusively on importers, before analyzing how the characteristics of imports relate to labor productivity it is appropriate to confirm whether Ecuadorian importers are actually more labor productive than non-traders. In order to do that we estimate the following equation:

$$\begin{aligned} \ln\ (\text{laborProd}_{it}) = \ & \alpha + \beta_1 \text{importer}_{it} + \beta_2 \text{exporter}_{it} \\ & + \beta_3 \text{twoway}_{it} + \gamma X_{it} + \tau_t + \mu_i + \varepsilon_{it}. \end{aligned} \tag{2}$$

Again the subscript i identifies firms and t the year. The dependent variable is our measure of labor productivity, while X contains the same set of control variables used in equation (1) except for the diversity of import measures. As before, the variables τ and μ are respectively time and industry dummies and ε is the error term. The other variables define a firm's trading status, with non-trading firms as the reference category. Consequently, the variable *importer* takes value 1 for sole importers; *exporter* takes value 1 for sole exporters and *twoway* takes value 1 for firms that both import and export.

Table 4. Productivity premium of Ecuadorian firms.

	Manufacturers (OLS)	(FE)	Wholesale and retail traders (OLS)	(FE)
Trade dummies				
Non-traders	Reference	Reference	Reference	Reference
Two-way traders	1.071***	0.323***	1.260***	0.616***
	(0.067)	(0.053)	(0.057)	(0.044)
Only exports	0.385***	0.220***	0.952***	0.617***
	(0.141)	(0.070)	(0.126)	(0.092)
Only imports	0.521***	0.215***	0.755***	0.458***
	(0.042)	(0.029)	(0.031)	(0.027)
Foreign firm	1.338**		0.763***	
	(0.664)		(0.216)	
Firm size	− 0.031*	− 0.306***	0.036***	− 0.306***
	(0.018)	(0.050)	(0.011)	(0.030)
Observations	8.059	8.059	21.766	21.766
R^2	0.111	0.064	0.096	0.076

Notes: All regressions include year, sector dummies and a constant. Robust standard errors clustered at the firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 shows the results of this equation estimated with pooled OLS and FE for manufacturing and wholesale and retail sectors.

Both estimation methods, for both manufacturers and wholesale and retail traders, indicate that only importing firms, exporting firms and two-way traders are more labor productive than non-traders. In addition, results for the FE regression for manufacturers indicate that sole importers are statistically as labor productive as sole exporters, while two-way traders are the most labor productive. For the wholesale and retail sector, we find that sole exporters are as labor productive as two-way traders and that sole exporters and two-way traders are more labor productive than sole importers. Therefore, our results confirm that importers are more labor productive than non-traders as they benefit from quality, variety and learning effects. Now we shall evaluate whether the characteristics of imports, in terms of region of origin and technological content, explain labor productivity differences between importing firms.

4.2. The region of origin of imports

Table 5 shows the results of model (1) when import shares are calculated as the value of a firm's imports from a particular region divided by the value of a firm's total imports. It displays the estimations for manufacturing and wholesale and retail trade using pooled OLS and FE regressions. Note that the coefficients of import shares should be interpreted with respect to the reference category which is the import share from *North America*. Furthermore, as *North America* is the region with the highest GII percentage rank, according to the technology gap theory the coefficients of the rest of import share variables should be negative and significant. However, if the other factors discussed in Section 2 also play a role, positive or non-significant coefficients may emerge.

Results for both manufactures and wholesale and retail traders reveal differences between the two estimation methods. This indicates that the coefficients documented in the pooled OLS regressions are largely due to time invariant unobserved firm-specific effects. Consequently, we discuss results from the FE regressions as their estimated coefficients are not the result of lurking variables that are constant across time.

Table 5. Market of origin of imports, degree of diversity of markets and labor productivity.

	Manufacturers (OLS)	(FE)	Wholesale and retail traders (OLS)	(FE)
Import shares by origin market				
North America	Reference	Reference	Reference	Reference
Advanced Asia and Oceania	− 0.219***	− 0.101**	0.138***	− 0.025
	(0.066)	(0.050)	(0.039)	(0.039)
Advanced Europe	− 0.235***	− 0.068	− 0.058	0.023
	(0.068)	(0.061)	(0.051)	(0.061)
Emerging Europe	− 0.153	− 0.377***	0.813***	0.164
	(0.333)	(0.135)	(0.265)	(0.134)
Latin America and the Caribbean	0.071	− 0.102*	0.286***	− 0.030
	(0.079)	(0.059)	(0.058)	(0.064)
Andean Community	0.159**	− 0.141**	0.436***	− 0.050
	(0.075)	(0.058)	(0.053)	(0.064)
Africa and Western Asia	0.168	− 0.133	0.019	0.074
	(0.128)	(0.082)	(0.092)	(0.072)
Diversity of import's regions	0.561***	0.168***	0.521***	0.220***
	(0.038)	(0.026)	(0.021)	(0.018)
Exporter	0.410***	0.101***	0.485***	0.081***
	(0.049)	(0.033)	(0.047)	(0.027)
Foreign firms	1.397**		0.682***	
	(0.681)		(0.219)	
Firm size	− 0.169***	− 0.414***	− 0.102***	− 0.473***
	(0.022)	(0.054)	(0.012)	(0.029)
Observations	5.980	5.980	17.019	17.019
R^2	0.174	0.136	0.121	0.117

Notes: All regressions include year, sector dummies and a constant. Robust standard errors clustered at the firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In the case of manufacturers, results from the FE regression show that all the import share variables have negative coefficients which are significant except for import shares from *Advanced Europe* and *Africa and Western Asia* which are non-significant. These results are in line with the technology gap theory, as they indicate that transferred technologies from our most knowledge-intensive region are related to greater labor productivity since these technologies offer more learning opportunities. The non-significant coefficient for *Advanced Europe* may indicate that technologies from North America and those from Advanced European countries offer the same learning opportunities to Ecuadorian firms. This is not surprising as these regions have comparable innovation capabilities and results. The non-significant coefficient for *Africa and Western Asia*, our less innovative region, is surprising as it would imply that technologies produced in this region offer the same learning opportunities as those from North America. However, we should take into account that the coefficient is almost significant at the 10% level. Finally, the significant and negative coefficients for *Latin America and the Caribbean* and *Andean Community* suggest that the labor productivity premium of importing is explained not so much by geographical, cultural and linguistic distance but by the technology gap.

Although these results seem to support the technology gap theory, we should be cautious as they are based on the assumption that imports from advanced countries represent more advanced technologies which offer more learning opportunities. However, as shown in Table 1, Ecuadorian firms also import manufactures based on natural resources and primary products from advanced regions, so the technology gap theory might still be wrong if imports without technological content are associated with greater levels of labor productivity than those with technological content.

Results from the FE regression for wholesale and retail traders do not show significant differences between the reference category and the rest of the import share variables. Therefore, according to the technology gap theory, for this sector there are no learning opportunity differences between the technologies produced in the different regions. This is not surprising as wholesale and retail trading firms do not incorporate the majority of imported technologies in their production processes. Therefore, there should be little scope for learning-by-importing in this sector as imports of intermediate and capital goods[14] are expected to produce the greatest learning effects (Mayer 2000).

Concerning control variables which do not display differences between manufactures and wholesale and retail traders, results indicate that the diversity of import regions is always significant and positive, which seems to be in accordance with the theoretical argument stating that fixed costs of importing are market specific and each additional market means incurring these fixed costs again (Van den Berg and Van Marrewijk 2013). Exporters have greater labor productivity which suggests that exporters are more efficient through the effects of learning (Clerides, Lach, and Tybout 1998). Exporting allows firms in developing countries to acquire knowledge of international best practices which facilitates the adoption of new technologies and raises their performance (Yeaple 2005). Foreign firms are also more labor productive than domestic firms, which is not surprising as there is evidence to show that multinational firms are normally more innovative and productive than domestic firms (Dachs and Ebersberger 2009). Finally, we find an unexpected negative and significant effect for firm size in both samples. Firm size is normally positively correlated with labor productivity in the manufacturing industry. However, its correlation has been found to be lower in developing countries, where large public firms without foreign competitors are less productive and innovative than other firms (Ayyagari, Demirguc-Kunt, and Maksimovic 2011; Lin 2012), and this might explain our result. Moreover, there are other studies that have found negative associations between both variables. For instance Chudnovsky, López, and Pupato (2006), drawing on Argentinian data, found a negative linear relationship between firm size and labor productivity. Additionally, although large firms are more productive than small firms in the wholesale trade, this might be offset by a negative relationship in retail trade. The negative relationship between firm size and labor productivity in this sector might largely be due to an establishment-size labor productivity relationship, with many large firms having mainly small establishments (Leung, Meh, and Terajima 2008).

4.3. The technological intensity of imports

Table 6 displays the estimations of model (1) when import shares are measured as the value of imports of a particular type (*high-tech products, medium-tech products, low-tech products, manufactures based on natural resources* and *primary products*) divided by the total value of imports. Note that the reference category is *primary products*. Therefore, according to the technology gap theory, positive and significant coefficients should be expected for the import share variables which should increase with their technological intensity.

Results from the pooled OLS regression for manufactures indicate that import shares of high, medium and low-tech products are associated with lower labor productivity than those of primary products. This would imply that Ecuadorian importers do not fully

Table 6. Technological intensity of imports, degree of diversity of product markets and labor productivity.

	Manufacturers (OLS)	(FE)	Wholesale and retail traders (OLS)	(FE)
Import shares by technological intensity				
High-tech products	− 0.454***	− 0.066	− 0.515***	0.227*
	(0.142)	(0.109)	(0.110)	(0.137)
Medium-tech products	− 0.319***	− 0.095	− 0.567***	0.099
	(0.112)	(0.093)	(0.108)	(0.126)
Low-tech products	− 0.389***	− 0.107	− 0.571***	0.110
	(0.117)	(0.101)	(0.108)	(0.134)
Manufactures based on natural resources	− 0.209*	− 0.032	− 0.057	0.241*
	(0.115)	(0.103)	(0.116)	(0.128)
Primary products	Reference	Reference	Reference	Reference
Diversification of imports' types	0.421***	0.147***	0.398***	0.244***
	(0.040)	(0.028)	(0.025)	(0.020)
Exporter	0.484***	0.098***	0.506***	0.083***
	(0.052)	(0.033)	(0.048)	(0.028)
Foreign firm	1.321*		0.742***	
	(0.689)		(0.212)	
Firm size	− 0.115***	− 0.406***	− 0.040***	− 0.484***
	(0.022)	(0.054)	(0.012)	(0.029)
Observations	5.945	5.945	16.890	16.890
R^2	0.122	0.129	0.086	0.119

Notes: All regressions include year, sector dummies and a constant. Robust standard errors clustered at the firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

exploit the learning opportunities that technology intensive products offer and that the most labor productive firms are those benefiting from greater variety and quality from their imports of primary products. Nonetheless, results from the FE regression show no differences between the different import share variables. Therefore, the negative coefficients of the different import share variables found in the OLS regression are due to unobserved firm-specific effects.

For manufacturers, results from the FE regression indicate that differences in the labor productivity of Ecuadorian importers are not explained by the technological content of their imports. This suggests that learning effects do not outweigh those of quality and variety which could indicate that the characteristics of the Ecuadorian Innovation System and the capabilities of Ecuadorian firms are not well suited to an efficient adoption of foreign technologies or that the productive specialization of Ecuadorian firms and their role in global value chains make quality and variety effects as significant as the effects of learning. This result raises the question as to whether it is appropriate to assume that technology intensive imports are necessarily those related to higher firm level performance, given that quality and variety effects might improve performance as much as the effects of learning. In fact, although Van den Berg and Van Marrewijk (2013) found that imports of high-tech products were associated with higher productivity for Dutch importers, they also found that imports of primary products were associated with comparable or even greater performance. Nevertheless as we do not find differences between our high, medium and low-tech import categories it is also likely that Ecuadorian firms find difficulties in incorporating foreign advanced technologies in a productive way since high-tech products are expected to offer greater learning opportunities.

For wholesale and retail trading firms, the pooled OLS regression displays similar results to the one for manufacturers, but again differences between import shares tend to disappear with the FE methodology. To be more precise, the FE regression shows that imports of high-tech products and of manufactures based on natural resources are associated with greater labor productivity, although coefficients are only significant at the 10% level.

4.4. Import region of origin and technological content

Table 7 displays the results of model (1) when import shares are measured as the value of imports of a particular type from a particular region divided by the value of firms' total imports. Remember that we have aggregated the technological dimensions in two categories: *Technological products* and *Non-technological products*. Note that *North America technological products*, which is expected to include the most updated technologies, is the reference category. Therefore, under the common assumption that leading technologies produce greater learning effects, we should anticipate the coefficients of the rest of the import share variables to be negative and significant.

The FE regression for manufactures reveals two important outcomes. First, all import shares with technological content have negative coefficients which are significant with the exception of *Advanced Europe technological products* and *Latin America and the Caribbean technological products* which are non-significant. This suggests that imports of technologies from the most knowledge-intensive region are associated with greater labor productivity which supports the technology gap proposition. The non-significant coefficient for imports from *Advanced Europe technological products* would again reflect the notion that technologies from Advanced European countries are as up-to-date as Northern American technologies and thus offer the same learning opportunities. The non-significant coefficient for *Latin America and the Caribbean technological products* is more difficult to justify as Latin American and Caribbean technologies are less likely to be as sophisticated as Northern American ones. A possible explanation for this result might be that although Latin American and Caribbean technologies offer fewer learning opportunities than the North American ones, they do not display significant differences from each other, as the characteristics of the Ecuadorian Innovation System and the capabilities of Ecuadorian importers may be better suited to the adoption of technologies developed in countries with similar physical, economic, social and cultural conditions and comparable technological levels. Additionally, the lower import and transport costs for Latin American and Caribbean technologies might also explain this result. The second main outcome for the manufacturing sample is that all import shares without technological content present non-significant coefficients with the exception of *Emerging Europe non-technological products* which is negative and significant. This again could be a consequence of variety and quality effects being as important as learning effects, or that the capabilities of Ecuadorian importers and the characteristics of the Ecuadorian Innovation System are not sufficiently developed to integrate advanced technologies such that it clearly improves their performance.

Results from the FE regression for wholesale and retail traders do not show significant differences between the reference category and the rest of the import share variables. We only find significant and positive coefficients for *Emerging Europe technological products* and *Africa and Western Asia non-technological products.*

Table 7. Market of origin, technological intensity of imports, degree of diversity of product markets and labor productivity.

	Manufacturers (OLS)	(FE)	Wholesale and retail traders (OLS)	(FE)
Import shares by market of origin and product type				
North America				
Technological products	Reference	Reference	Reference	Reference
Non-technological products	0.228	0.027	0.240**	0.032
	(0.143)	(0.099)	(0.113)	(0.113)
Advanced Asia and Oceania				
Technological products	− 0.188***	− 0.117**	0.135***	− 0.022
	(0.073)	(0.057)	(0.042)	(0.040)
Non-technological products	− 0.130	0.039	0.492***	0.033
	(0.121)	(0.095)	(0.092)	(0.103)
Advanced Europe				
Technological products	− 0.152**	− 0.050	− 0.033	0.035
	(0.075)	(0.069)	(0.056)	(0.065)
Non-technological products	− 0.405***	− 0.120	0.047	0.063
	(0.128)	(0.073)	(0.118)	(0.119)
Emerging Europe				
Technological products	− 0.271	− 0.276***	0.865***	0.274*
	(0.359)	(0.100)	(0.241)	(0.145)
Non-technological products	0.144	− 0.737**	0.435	− 0.037
	(0.371)	(0.357)	(0.820)	(0.162)
Latin America and the Caribbean				
Technological products	0.102	− 0.105	0.171***	− 0.069
	(0.102)	(0.069)	(0.065)	(0.069)
Non-technological products	0.141	− 0.053	0.735***	0.209
	(0.107)	(0.094)	(0.103)	(0.151)
Andean Community				
Technological products	0.160*	− 0.136**	0.305***	− 0.062
	(0.091)	(0.061)	(0.058)	(0.072)
Non-technological products	0.251**	− 0.125	0.948***	0.047
	(0.104)	(0.080)	(0.100)	(0.128)
Africa and Western Asia				
Technological products	0.371**	− 0.203***	0.078	0.067
	(0.156)	(0.077)	(0.106)	(0.086)
Non-technological products	− 0.027	0.087	0.274	0.232**
	(0.186)	(0.216)	(0.173)	(0.110)
Diversification of imports' type	0.136***	0.050***	0.136***	0.064***
	(0.009)	(0.007)	(0.006)	(0.005)
Exporter	0.351***	0.099***	0.435***	0.081***
	(0.049)	(0.033)	(0.046)	(0.028)
Foreign firm	1.328**		0.742***	
	(0.650)		(0.208)	
Firms size	− 0.203***	− 0.412***	− 0.119***	− 0.482***
	(0.023)	(0.054)	(0.013)	(0.029)
Observations	5.945	5.945	16.890	16.890
R^2	0.188	0.139	0.136	0.116

Notes: All regressions include year, sector dummies and a constant. Robust standard errors clustered at the firm level in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

5. Conclusions

Drawing on data from the population of Ecuadorian manufacturing and wholesale and retail trade importers during the period 2009–2012, this paper contributes to the literature on the performance effects of imports by examining how the characteristics of imports relate to different levels of labor productivity. We are able to determine both the region of origin and the technological intensity of imports in order to examine to what extent Ecuadorian firms benefit from foreign embodied technology.

The paper argues that differential labor productivity effects are to be expected of specific import shares, as imports may affect labor productivity through quality, variety and learning effects (Grossman and Helpman 1991). Moreover, it is argued that, although technology intensive imports from advanced economies are expected to be associated with greater labor productivity, since they offer more learning opportunities, in the Ecuadorian context (which is characterized by an emerging innovation system with firms with limited technological capabilities specializing in low value added activities) the most labor productive firms are not necessarily those importing the most advanced technologies as the technology gap theory predicts.

Results from FE regressions indicate: (1) the region of origin of imports explains labor productivity differences in the manufacturing sector, but not in the wholesale and retail trade sector. This is not surprising as manufacturers use most of their imported inputs in their production processes, while wholesale and retail traders sell the majority of their imports to end users without any productive transformation, thus they are less likely to experience quality, variety and learning effects. (2) The labor productivity premium of manufacturers' imports seems to increase with the level of development of the economy of origin: the strongest associations are calculated for the import share of *North America* and *Advanced Europe*. (3) The technological content of imports does not explain labor productivity differences in any sector. (4) For manufacturers, the technological imports that are related to higher labor productivity are those from *North America*, *Advanced Europe* and *Latin America and the Caribbean*. (5) In the manufacturing sector, there are no labor productivity differences between imports from North America with technological content and those without technological content from any region except for emerging European countries. (6) In general the differences in wholesale and retail traders' labor productivity are not explained by import shares with or without technological content from different regions, although it seems that imports without technological content from *Africa and Western Asia* and those from *Emerging Europe* with technological content are associated with higher labor productivity.

Our findings are not consistent with the predictions of the technology gap theory as they reveal that, even in the manufacturing sector, the technological content of imports does not explain labor productivity differences. Note that we do not find that technology intensive imports are associated with greater labor productivity than those without technological content, nor that high-tech imports are related to greater performance than less intensive technology imports. These results seem to indicate that the emerging nature of the Ecuadorian Innovation System and the limited capabilities of Ecuadorian firms make importers of technology unable to fully exploit the learning opportunities that new technologies offer and that the subsequent productive specialization in low value-added activities of Ecuadorian firms and their role in global value chains make variety and quality effects as important as learning effects. However, for manufacturing firms we do find that imported technologies from advanced economies are associated with greater labor productivity than imports with technological content from emerging or less advanced regions. This suggests that Ecuadorian importers experience greater learning effects with the more up-to-date technologies. Nevertheless, given that the technological content of imports does not explain labor productivity differences, it is also likely that Ecuadorian importers do not have sufficient capabilities to take full advantage of the opportunities associated with the most advanced technologies as a consequence of the emerging nature of their national innovation system.

The key implication of this research is that for imports to be a means of technology diffusion, firms require certain capabilities, a sufficiently mature innovation system and imported technologies to be congruent with the physical, economic and social conditions of the importing economy. Technology is not a public good available free to everyone, so there are large technological differences between rich and poor countries. As a result, imports of advanced technologies are unlikely to significantly increase the competitiveness of firms in developing countries unless Governments implement the necessary policies to upgrade the national innovation system and, thus, the capabilities of importing firms. These policies are not only technological but also institutional (Gerschenkron 1962) and include the restructuring of the legal environment, making the economy congruent with the most competitive technologies, the establishment of technology policies that solve systemic problems and upgrade firms' technological capabilities, the building of R&D infrastructures and institutions and the promotion of networking (Georghiou and Metcalfe 1998).

Consequently, our findings suggest that it is questionable whether it is feasible to use foreign technology as a means of omitting some of the preliminary stages in the development process. As Kumar, Kumar, and Persaud (1999) indicate, firms in developing countries need technology to develop technological capability but they are limited in their ability to acquire the technology because of their low level of absorptive capacity. Anyway, technological catch-up is not a question of replacing an outdated technological set up with a modern one, but of continually transforming technological, economic and institutional structures (Fagerberg and Verspagen 2002). In this sense, as indicated by Fagerberg (1987), the rate at which a country exploits the possibilities offered by the technological gap depends on its ability to mobilize resources for the transformation of social, institutional and economic structures.

The relevant implications of this paper suggest further research on how the characteristics of imports affect firm-level performance in different contexts, as we should be cautious regarding the extent to which we can consider Ecuador as representative of an emerging innovation system or to what extent we can generalize our results to other developing countries. As shown in Table 2 Ecuador displays very limited technological capabilities according to its GII percentage rank which might explain our results. Therefore, it is appropriate to examine whether the same patterns emerge in other countries with similar or more or less mature innovation systems. Finally, in order to indicate directions for further research, it is worth mentioning an important limitation of this research as we were unable to distinguish between capital, intermediate and final goods. Differentiating between these categories is important as quality, variety and learning effects are likely to differ between them, especially when making a distinction between the manufacturing and the wholesale and retail trading sectors. This could be done by using the BEC-classification of the United Nations.[15]

Notes

1. The concept of innovation system stresses that the flow of technology and information among people, firms and institutions is key for the innovation process. In an *emerging* innovation system we should expect weak inter-sectoral linkages, the absence of interface units and universities specialized mainly in the supply of manpower (Galli and Teubal 1997).
2. http://www.aduana.gob.ec/index.action.
3. For the national import duty for countries of the Andean Community, based on the Harmonized Commodity Description and Coding System of the Customs Cooperation Council.
4. https://www.iess.gob.ec/.

5. http://www.supercias.gob.ec/portal/.
6. http://www.sri.gob.ec/web/guest/home.
7. We decided to eliminate services as we only have data on trade goods.
8. Section 3.2 explains the criteria that we followed to construct our regional and technology intensity categories.
9. Appendix 1 shows the countries included in each regional category.
10. The Global Innovation Index is a composite indicator that ranks countries in terms of their environment to innovation and innovation outputs. https://www.globalinnovationindex.org/content/page/data-analysis/.
11. Note that although Israel belongs to the Northern Africa and Western Asia group, we have included it in the *Advanced Europe* category as it is the only country of its region with a GII percentage rank higher than 0.77.
12. Results from these tests can be requested from the corresponding author.
13. Fixed effect was selected by the Hausman test which implies there is a correlation between unobserved effects and regressors. Thus, time-invariant variables (e.g., *Foreign*) were eliminated.
14. Note that our data do not enable us to distinguish between intermediate and finished goods.
15. http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=10.

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Appendix 1. List of countries by region.

Region defined	*Countries in each region defined*
North America	*Canada, United States*
Advanced Asia and Oceania	*Japan, Hong Kong, China, Cook Islands, Macao, Korea, Singapore, Brunei, Australia, New Zealand, Taiwan*
Advanced Europe	*Czech Republic, Slovenia, Belgium, Germany, The Netherlands, Luxembourg, Austria, Monaco, Iceland, Finland, Norway, Malta, San Marino, Estonia, United Kingdom Of Great Britain, Portugal, Sweden, Vatican City, France, Ireland, Spain, Switzerland, Denmark, Italy, Israel.*
Emerging Europe	*Turkmenistan, Latvia, Guadeloupe, Cyprus, Greece, Bulgaria, Liechtenstein, Serbia, Belarus, Lithuania, Bosnia and Herzegovina, Ukraine, Russia, Andorra, Moldova, Former Yugoslav Republic of Macedonia, Romania, Slovakia, Albania, Croatia, Poland, Hungary, Montenegro*
Latin America and the Caribbean	*Bahamas, El Salvador, Jamaica, Trinidad and Tobago, Barbuda, Antigua and Barbuda, Dominican Republic, Brazil, Curacao, Honduras, British Virgin Islands, Argentina, Falkland Islands, Costa Rica, Turks and Caicos, Guyana, Paraguay, Saint Kitts and Nevis, Panama, Montserrat, Puerto Rico, Saint Vincent and the Grenadines, Netherlands Antilles, St. Lucia, Cuba, Cayman Islands, Nicaragua, Venezuela, Uruguay, Chile, Belize, Dominica, Aruba, Virgin Islands, Mexico, Anguilla, Barbados, Haiti, French Guiana, Suriname, Guatemala*
Andean Community	*Bolivia, Colombia, Peru, (Ecuador)*
Africa and Western Asia	*Mozambique, Ivory Coast, Lao People's Democratic Republic, Wallis and Futuna, United Arab Emirates, Christmas Island, Samoa, Benin, Somalia, Tajikistan, Fiji, Gabon, Ethiopia, Mayotte, Bahrain, Saudi Arabia, Syrian Arab Republic, Senegal, Azerbaijan, Uzbekistan, Djibouti, Algeria, Liberia, Botswana, United republic of Tanzania, Namibia, Iran, Zambia, Seychelles, Niger, Yemen, Eritrea, Swaziland, Ghana, Zimbabwe, Guinea, Malaysia, Pakistan, Uganda, Comoros, North Korea, Gambia, Georgia, Togo, Cambodia, Qatar, Gibraltar, Turkey, Rwanda, Burkina Faso, Kyrgyzstan, Bangladesh, Oman, Nepal, India, Kuwait, Cameroon, Kazakhstan, Northern Mariana Islands, Indonesia, South Vietnam, Tunisia, Cape Verde, Federated States of Micronesia, Solomon Islands, Guinea-Bissau, Egypt, Thailand, American Samoa, Western Sahara, Maldives, Marshall Islands, Madagascar, Myanmar, Guam, Malawi, Mali, Kiribati, Iraq, Congo, South Africa, Central African Republic, Afghanistan, Equatorial Guinea, Sudan, Chad, Lesotho, Libya, Keeling Islands, Angola, Sao Tome and Principe, Mauritania, Sierra Leone, Jordan, Congo, Bhutan, Tuvalu, Armenia, Kenya, Sri Lanka, Mauritius, Nigeria, Lebanon, Vietnam, Morocco*