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The Effect of Robotization in OECD Countries on Latin American Exports

In the past decades we have observed rising use of industrial robots, which has been especially pronounced in high-income countries. According to the International Federation of Robotics (IFR), more than 3 million industrial robots were operating in factories around the world in 2020 (IFR 2021); the stock of industrial robots rose by a factor of 5 between 1993 and 2015 in North America, Europe, and Asia (Dauth et al. 2021). Automation has primarily taken place in manufacturing, but also in other sectors, such as agriculture or services. These trends have had disruptive effects on domestic markets, which spurred research on the economic effects of automation. In particular, scholars have focused on the impact of robots on productivity and labor market outcomes.

However, the impact of robotization is not constrained to the domestic market and can spill over globally through supply chains and affect firms in developing countries through different mechanisms. There are two main channels through which automation might affect trade flows. The first channel focuses on the shift in relative production costs. Automation might reduce production costs in high-income countries, such that low-income, labor-abundant countries may lose their relative cost advantage in producing formerly labor-intensive goods. This could lead to the reallocation of production sites back from the global South to the global North (i.e., reshoring). In this case, products from developing countries might face a decline in global demand, adversely impacting local economic development (Rodrik 2018).The second channel operates through the increase in efficiency of robot-adopting firms in the North, such that these firms expand their production. In this case, their demand for intermediates might increase, which could benefit developing countries (Artuc et al. 2020).

KEY MESSAGES

- **The effects of automation in high-income countries are not limited to domestic economies, but might spill over via global supply chains**
- **We evaluate the effects of robot adoption in OECD countries on exports from Latin America to the OECD along the value chain**
- **We combine detailed firm-level data for four Latin American countries with data on robot adoption and input-output linkages**
- **In response to robot adoption, exports in the same industry decrease, but exports increase for products along the value chain**
- **Our results indicate the importance of evaluating supply chain linkages when drawing policy conclusions about the effects of robotization**

This policy brief investigates the effect of robotization in the global North on firm-level exports from Latin America across sectors. Importantly, we evaluate the impact of robotization in the North on firm-level North-South trade along the entire supply chain. This allows us to take into account inter-country input-output linkages that channel the effects of automation in the global North to firms in the global South. The results from our empirical analysis indicate

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TAKING STOCK OF THE ACADEMIC LITERATURE

Robotization is often discussed as the third big economic transformation in modern times.[1] The adoption of robots has caused a reorganization of production in many industries, spurring academic research on the economic impact of automation.

Firms have in general profited from technological advances in robotics. Adoption of robots has reduced production and operational costs for firms, which has led to sizable productivity gains (Koch et al. 2021). Multiple studies have shown both at the aggregate and at the firm level how automation augments labor productivity (Graetz and Michaels 2018), increases value-added (Acemoglu and Restrepo 2020), and boosts competitiveness (Bonfiglioli et al. 2020). While the literature agrees on the overall gains of robotization for firms, the impact on the workforce is still disputed.

In a recent literature survey, Aghion et al. (2022) show two contrary views on the impact of robots on labor demand. The optimistic view posits that through increases in productivity and competitiveness firms can expand their market shares, lower the price of goods, and increase the overall size of the market. This potentially leads to an increase in both employment and wages. The pessimistic view highlights that the increase in labor demand as a result of productivity gains only applies to the labor force that performs complementary tasks. At the same time, automation might lead to a displacement of workers from labor-intensive tasks, which are then performed by robots. Acemoglu and Restrepo (2020) provide evidence for the US labor market that the latter effect dominates. They find that automation leads on aggregate to a decline in employment and wages in local US labor markets. Based on Spanish firm-level data, however, Koch et al. (2021) found evidence for positive employment effects in robot-adopting firms and negative employment effects for firms which do not adopt robots. For the German labor market, Dauth et al. (2021) show a nuanced picture. Here, the displacement effect of automation in manufacturing is fully offset by re-allocation effects towards service industries.

Taking stock of these findings, the jury seems still to be out on the question whether automation leads on aggregate to positive or negative employment effects at home. However, in the age of global value chains (GVCs), automation also has an impact on the (international) sourcing decision of firms and can thereby affect the economies of trading partners abroad. Echoing the views on the domestic employment effects of automation, two different channels for the effect of automation on international trade are conceivable. First, automation might put low-skilled and replaceable jobs at risk not only at home, but also abroad due to a change in relative production costs. This could especially affect trade flows between the global North and South. If robots can take over tasks at lower costs which were originally performed by low-skilled workers in the South, the current pattern of relative cost advantages might change and production sites might increasingly be relocated to the North (i.e., production reshoring). On the other hand, productivity gains for robot-adopting firms in the North might also translate into increasing demand for intermediate goods coming from the South, with positive implications for trade and growth.

The empirical findings on the impact of automation in the global North on trading partners in the global South are relatively scarce and to some extent inconclusive. There is limited evidence for automation-induced reshoring from South to North. Krenz et al. (2021) show, based on a cross-country framework, a strong association between automation and reshoring at the macro-level. For the case of Spain, Stapleton and Webb (2021) find that robot adoption had no impact on the offshoring activity of firms in the case that they were already offshoring to low-income countries, but robot adoption increased offshoring activities of firms that had not yet offshored to such countries. In total, they cannot detect a clear effect on the value of imports from developing countries. Taking the perspective of a country from the global South, Faber (2020) finds evidence that robot adoption in the US had a negative effect on local employment and exports in Mexico. Similar findings are reported by Stemmler (2019) for Brazil and Kugler et al. (2020) for Colombia. On the other hand, Artuc et al. (2022) provide support for a strong efficiency channel of automation and argue that in the long run, developing countries will profit from robot adoption in the Global North through an increase in global demand for intermediate and final goods.

EFFECT OF ROBOT ADOPTION ON FIRM EXPORTS ALONG THE SUPPLY CHAIN

The objective of our analysis is to provide empirical evidence on the effect of robot adoption in high-income countries on firm-level exports of Latin American countries.[2] For this purpose, we use detailed firm-level data for four Latin American countries (Mexico, Brazil, Peru, and Uruguay), which accounted for 68.5% of Latin American exports in the year 2019.[3] The data covers the universe of exports by firm, HS

[1] The first transformation being industrialization in the 18th century and the second being the service transformation during the middle of the last century.

[2] The results presented in this article are based on Baur et al. (2022).

[3] Numbers are based on Inter-American Development Bank data on goods exports of Latin American countries, which in turn are based on official data from national sources.

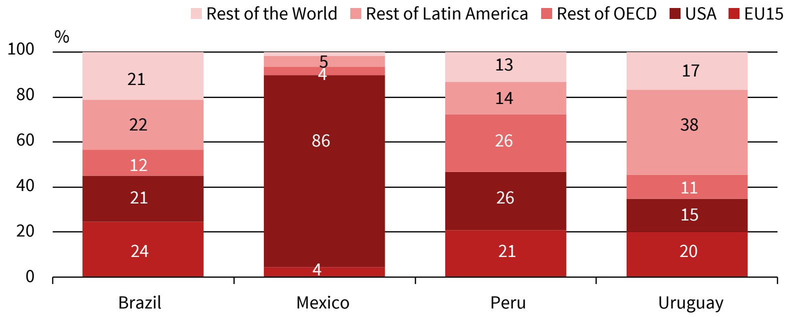
6-digit product, destination country of exports, and year over the period 2001–2007.[4] From Figure 1 we can observe that the OECD is an important destination region for Latin America, with an export share of 60% for the countries covered in our analysis. This provides support for our assumption that changes in the robot stock of the selected destination countries will impact exports. Interestingly, the share of exports to other Latin American (neighbor) countries[5] is low in comparison to exports to other world regions. This is quite surprising, as gravity trade theory predicts high trade shares with neighbors, but it reinforces the importance of shocks outside Latin America on exports.

We combine our firm-level data with data on industrial robot adoption from the International Federation of Robotics (IFR), which are available for most OECD countries by industry and year of robot adoption. One challenge for our project is to account for the proper automation shock that exporters face in the destination country of exports. To our knowledge, the literature accounts for robot adoption in the same industry, meaning that textile exporters are affected by robot adoption in the textile industry.[6] However, this analysis disregards value-chain linkages, which account for a great part of the shock faced by developing countries. For instance, a textile producer is not only affected by automation in the textile industry in the North (due to an increase in competition), but also by shocks in all other industries that use textile products as inputs. Hence, we construct a novel dataset using input-output linkages from the Bureau of Economic Analysis (BEA-US) to map exported products to all industries in which they are used as inputs. In this way, automation shocks in the destination are mapped to trade flows using same-industry linkages as well as value-chain linkages.

In terms of our empirical strategy, we estimate the effect using long differences between 2001 and 2007 to account for lagged effects in the adoption of robots.[7] Table 1 shows our main results. Columns 1 and 2 provide evidence on same-industry effects, whereas columns 3 and 4 show the effects along the value chain. Robot adoption in OECD countries is associated with a reduction in exports of Latin American countries, when solely considering effects in the same industry (see columns 1 and 2). However, once we account for input-output linkages and trade along the value chain, the opposite holds: we find a positive effect of robot adoption on firm-level exports to OECD countries (see columns 3 to 5). This positive export effect also remains significant when accounting

Figure 1

Exports from Latin America by Destination Regions



ᵃ The graph depicts the distribution of exports from Brazil, Mexico, Peru and Uruguay across different destination regions in 2001. OECD countries are the main destinations of exports for products from Brazil, Mexico, Peru and Uruguay.

Quelle: World Bank Exporter Dynamics Database; SECEX; authors' calculations. © ifo Institute

[4] Firm-level data for Mexico, Peru, and Uruguay come from the World Bank Exporter Dynamics Database. Firm-level data for Brazilian firms come from SECEX (Brazilian Foreign Trade Secretariat).

[5] Latin American Members of the OECD (Chile, Costa Rica, Colombia, and Mexico) are categorized as Rest of Latin America and are excluded from the OECD group for this analysis.

[6] One exception is Stemmler (2019), who distinguishes between final product and intermediate exports based on the World Input Output Database (WIOD).

[7] To account for selection effect due to entry and exit of firms, we estimate the effect of robot adoption on trade using a Pseudo-Maximum-Likelihood estimator.

Table 1

Effect of Robotization in OECD Countries on Latin American Exports: Same-industry Effects vs. Effect along the Value Chain

Outcome variable:	Direct linkages		Indirect linkages		
Firm-level exports to OECD	(1)	(2)	(3)	(4)	(5)
Robots stock	-0.0135* (0.00763)	-0.0126** (0.00496)	0.252* (0.129)	0.0770 (0.0600)	0.313*** (0.0574)
Total imp of destination	0.0621*** (0.0178)	0.0581*** (0.0173)	0.754*** (0.0965)	0.810*** (0.0884)	0.850*** (0.101)
Observations	100,142	100,140	86,332	86,332	86,272
Firm-product-destination	Yes	Yes	Yes	Yes	Yes
Origin-destination-time	Yes	Yes	Yes	Yes	Yes
Product-time	Yes	Yes	Yes	Yes	Yes
Sector-origin-time		Yes		Yes	Yes
Sector-destination-time					Yes

Note: All results include interacted firm (in the origin country), HS 6-digit product, and destination-fixed effects to account for unobserved heterogeneity of firm-product pairs by destination. As we want to rule out the effect of changes in trade policy and country-specific policies, we also include importer-exporter-time fixed effects to absorb any time-varying changes by country pair. In addition, we include product-time fixed effects, which help mitigate endogeneity concerns related to changes in demand for specific products, such as commodities over this period. Note that we also include imports from the rest of the world as a control variable to account for changes in demand by product in the destination country. Standard errors are clustered two-way by importer-product and year.

Source: Authors' own calculation.

for unobserved shocks specific to an industry in the destination country.[8]

POLICY CONCLUSIONS

Our empirical analysis shows that robot adoption in the global North does not necessarily pose a threat to export-led growth in developing countries. On the contrary, advanced economies might increase their demand for goods and services from developing countries thanks to productivity gains related to automation. This could open new opportunities for firms in the global South to benefit from participation in global value chains. Domestic government policies can play an important role in facilitating integration of developing countries into GVCs (World Bank 2020).

A central policy priority in this context should be the lowering of trade costs and better access to trade infrastructure. Lowering tariffs and other nontariff barriers gives firms better access to foreign intermediate inputs, which improves their GVC integration. Additionally, the adoption of new trade agreements makes serving foreign markets less costly for domestic firms and, as a result, it might increase integration into international production networks. For the same reason, policy measures to streamline border procedures and to improve domestic infrastructure are essential to reap the benefits of exporting and of participating in GVCs.

Another set of policies relates to foreign direct investment (FDI). By attracting multinational corporations (MNCs), domestic firms can more easily enter global production networks and benefit from knowledge and technology spillovers. Not only firms acquired through FDI, but also domestic firms that become a supplier to an MNC might observe substantial productivity growth.[9] To make FDI more attractive, governments should focus on improving domestic institutions and engage in proactive investment policies. For example, investment promotion agencies (IPA) can successfully reduce information asymmetries that often impede the first investment of MNCs in a foreign country (Carballo et al. 2021). Moreover, government programs targeted at increasing linkages between MNCs and domestic suppliers can also play an important role in sharing the benefits of GVC participation more broadly and enhancing the transfer of foreign knowledge and technology.

It is also important that policymakers take into account that the positive effects of automation on North-South trade might come with important distributional consequences within developing countries, which could lead to disruptions in local labor markets. For this reason, investments in the training of workers and sound distributive policies are crucial to mitigate the adverse effects of both domestic and foreign automation and to share the gains from trade more equally.

Finally, the functioning of complex GVCs crucially depends on the rule-based multilateral trade order, especially when it comes to the GVC participation of firms in developing countries (World Bank 2020). A revival of multilateral trade cooperation and an ambitious reform of the WTO should therefore figure prominently on the priority list of policymakers around the world.

[8] This is an important advantage of exploiting input-output linkages in comparison to same-industry linkages. In the second case, we cannot account for shocks that are specific to an industry-country pair, whereas in the case of input-output linkages we control for all shocks that affect an industry-country pair over the period.

[9] Using data for Indonesian firms, Arnold and Javorcik (2009) provide evidence of productivity increases from being acquired by an MNC. Alfaro-Urena et al (2022) show positive productivity effects of becoming a supplier to an MNC using firm-to-firm data for Costa Rica.

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