Trade, robots, and industrial development

Evidence and policy options

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Background

Preparing the recovery from the pandemic recession

Renewed interest in industrial policy with some degree of protection (supporting national champions); e.g., Buy American; Made in China 2025

Physical distancing accelerated automation and digitalization
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Preparing the recovery from the pandemic recession

Renewed interest in industrial policy with some degree of protection (supporting national champions); e.g., Buy American; Made in China 2025

Physical distancing accelerated automation and digitalization

Concerns about prospects for trade-led growth and industrial development in low and middle-income countries
This talk

1. Evidence on drivers of firm-level upgrading and industrial development

2. Evidence on the implications of robotization for trade between developed and developing countries

3. Policy options for promoting industrial development and trade-led growth
Evidence of trade-led growth, 1945-2014

Recent literature pointing to sizable causal effects of trade on growth (Feyrer, 2019 AEJ Applied; Buera and Oberfield, 2020 ECTA)
Richer countries have more (and larger) exporters

Evidence from many firm-level studies reveals that exporting firms are typically:

- Larger
- More productive
- More likely to pay higher wages
- More skill and capital intensive
- More likely to innovate

Source: based on Exporter Dynamics Database version 2.0. following Fernandes, Freund and Pierola (2016 JDE)
Growth of manufacturing firms over the life-cycle

Source: Hsieh and Klenow (2014 QJE)

99% of percent of the firms in many low-income countries have 10 workers or less (McKenzie, 2017 AER)
Firm-level upgrading in developing countries

Drivers of firm capabilities

Objectives of entrepreneurs
Entrepreneurial ability
Agency / ownership issues
Learning (within firms, from other firms, from trainers and consultants)

Output-based drivers
Exports
Demand from local buyers (foreign and domestic)
Competition in output markets
Reputation in output markets

Input-based drivers
Imported inputs
Domestic inputs

Learning about production techniques
Quality upgrading
Technology adoption
Product scope

Source: based on Verhoogen (2020)
This talk covers recent evidence on

### Drivers of firm capabilities

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### Output-based drivers

- Exports
- Demand from local buyers (foreign and domestic)
- Competition in output markets
- Reputation in output markets

### Input-based drivers

- Imported inputs
- Domestic inputs

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Source: based on Verhoogen (2020)
The role of entrepreneurial human capital

Bastos and Silva (2021): The origins of high-growth firms

Data: panel on formal firms-employees-managers, Brazil, 1994-2014

Focus on 2000-2001 cohort (allows us to track founders and examine subsequent firm growth)

Look at differential founding attributes of firms that became HGF or exporters

Results hold for other cohorts and are qualitatively similar for HGF and exporters
Richer states in Brazil generate more high-growth firms per capita
Employees and managers of HGF have greater human capital endowments

a. Education, wages, and the probability of high-growth firms
Employees and managers of HGF have greater human capital endowments

Human capital of founders matters for becoming HGF/exporter

But has low explanatory power:
Adj. R2 < 0.04 for HGF
Adj. R2 < 0.10 for Exporters

Hard to predict winners based on ex-ante observables

Consistent with evidence from business plan competition in Nigeria (McKenzie and Sansone, 2019 JDE)
Exporting to richer countries leads firms to upgrade outputs and inputs

Bastos, Silva and Verhoogen (2018 AER): Export destinations and input prices

**Theory:** firms have heterogeneous capabilities; consumers in rich countries demand higher-quality products; upgrading outputs requires upgrading inputs

**Data:** panel data on firms, export transactions, product-level inputs and outputs

**Identification:** Used firm-specific exchange rate movements to generate exogenous variation in the composition of export destinations within firms

**Main takeaways:**

1. Firms induced to export more to richer destinations charged higher prices for outputs and purchased more expensive inputs

2. Effect on input prices stronger in sectors with greater scope for vertical differentiation
Magnification and learning effects of exporting to high-income countries

- Exporting more to rich countries
- Expand higher-quality production for export markets
- Use higher-quality inputs (imported and domestic)

Upgrading of all outputs
Upgrading of domestic input suppliers

Mechanisms (separately) identified in:


Ongoing work on the role of firm leverage in mediating effects of export shocks on firm upgrading and growth in Vietnam (Artuc, Bastos and Rijkers, 2021)
Exporting leads to worker upgrading via training

Bastos, Silva and Proença (2016 RIE): Exports and job training

Panel data on firms, workers and worker-level training activity from main provider in Brazil (SENAI)
Exporting leads to worker upgrading via training

SENAI is a network of vocational schools managed by National Confederation of Industry. Largest training provider in LAC and 5th largest in the World.

Technical upgrading courses provided by SENAI:

1. Update, deepen or complement professional skills acquired in a specific occupation

2. Focus on skills needs from technological innovations and new production processes (e.g., for industrial electricians, SENAI offers an 80-hour course on electrical controls)

SENAI is financed by a tax on firms (1% of wage bill)

Firms self-select into training courses
Exporting leads to worker upgrading via training

Theory: exporting leads to quality upgrading and/or technology adoption => skill upgrading of existing workforce via training

Data: employer-employee + worker-level training activity from SENAI, 2009-2012

Identification: Industry-specific exchange rate movements to generate exogenous variation in export participation at the firm-level

Main takeaways:

1. Exporting rises the share of workers completing technical upgrading courses (especially workers performing low-skill occupations)

2. Workers completing technical upgrading within exporting firms recorded wage gains of about 3%
Learning through FDI: Multinationals tend to be well managed, consistent with selection and most trade models

Source: CEP World Management Survey (Bloom and Van Reenen)
German acquisitions led to productivity gains in Poland following EU accession

Bastos, Lovo and Varela and Hagemeyer (2021): Economic integration, industrial structure, and catch-up growth: Firm-level evidence from Poland

**Data:** firm panel 1997-2013

**Identification:** Event studies and DiD

**Results:** Differential increases in TFP in sectors in which Germany was specialized in 2004
German acquisitions led to productivity gains in Poland following EU accession

Data: firm panel 1997-2013

Identification: Event studies and DiD-PSM estimator

Results: German acquisitions led to increases in firm growth, productivity and turnover

Consistent with Bastos, Monteiro and Straume (2018 JIE) and the broader literature on impacts of foreign acquisitions on firm performance
Prospects for export-led industrial development

Leading economists raised concerns: Rodrik (2018), Acemoglu (2020)
Robot adoption driven by changes in relative prices
Robotization greater in high-wage countries and in sectors with more automatable tasks

Source: Artuc, Bastos and Rijkers (2018): Robots, tasks, and trade

Common robot applications include: assembling, dispensing, handling, processing, welding
Robotization accelerated by COVID-19 pandemic

US imports of robots buck the trend
Jan-Aug, annual % change

Japan's production of industrial robots grew during the pandemic
Sale value, rolling 12-month sum, rebased
Machinery
Industrial robots

Top import sectors excluding precious metals and including industrial robots
Source: US International Trade Commission
© FT
Robot adoption impacted productivity and wages in the OECD

Robots were a contributing factor

Graetz and Michaels (2018 REStat), Acemoglu, Lelarge and Restrepo (2020) find positive impacts of industrial robots on productivity

Acemoglu and Restrepo (2020 JPE) find adverse impacts on jobs and wages of production workers in U.S. local labor markets
Is robot adoption in the OECD replacing imports from developing countries?

Map 6.3 A substantial share of exports from developing countries is in goods that can be produced by robots


Note: The map shows exports (by quintile) as a percentage of total exports to high-income OECD (Organisation for Economic Co-operation and Development) countries, weighted by the share of jobs in sectors that produce the exported goods that are potentially replaceable by robots based on their task makeup. See Artuc, Bastos, and Rijkers (2018) for a detailed explanation of how replaceability is measured.
Is robot adoption in the OECD replacing imports from developing countries?

Artuc, Bastos and Rijkers (2018): Robots, tasks, and trade

Theory: Ricardian trade model with input-output linkages; robots can replace labor in a subset of tasks in some sectors

Effect of lower robot prices on North-South trade within broad sectors:

Lower robot prices

**Robotization of tasks** in
- high-wage countries
- sectors where automation is more feasible

**Substitution effect**
(reduces imports from developing countries)

**Scale effect**
(increases imports of from complementary inputs from developing countries)
Is robot adoption in the OECD replacing imports from developing countries?

**Data:** country-industry panel data on robots and trade between OECD and developing countries, 1995-2015

**Identification:** Theory-based IV strategy to account for endogeneity of robot adoption

An increase in robots per hour in the OECD promoted imports from developing countries in the same broad sector, especially of parts and components.

Firm-level evidence from Spain supports this conclusion (Stapleton and Webb, 2021)
The path for trade-led development is open

Some important considerations:

1. Distributional implications of automation and trade in high income countries can fuel protectionism (taxation and labor policies)
The path for trade-led development is open

Some important considerations:

1. Distributional implications of automation and trade in high-income countries can fuel protectionism (taxation and labor policies)

2. Industrial robots have a comparative advantage in repetitive tasks and will continue improving

3. Sustained industrial development will require an even greater focus on upgrading firms and workers – policy has an important role to play

4. Manufacturing may generate less jobs than before – greater attention to trade and FDI in services
FDI/Offshoring in export-oriented (tech) services is likely to become more important.

Raises many important regulatory issues (e.g., data localization, privacy, labor laws, taxation). Research will require substantial data collection efforts.
Learning by working differs across sectors

Artuc and Bastos (2021): Learning by working in high-skill sectors

**Hypothesis:** different sectors offer different opportunities for learning by working, which are reflected in wage profiles

**Data:** employer-employee panel data, manufacturing and services, Brazil, 2003-2015

**Empirical strategy:**

Exploit worker mobility across sectors (accounting for worker and firm observables, worker fixed-effects, microregion fixed-effects)

Allow wage profiles associated with experience in the sector to vary depending on whether worker is currently employed there or not
Learning by working differs across sectors, cities and firms

Artuc and Bastos (2021): Learning by working in high-skill sectors

Related evidence for big cities (De la Roca and Puga, 2017 REStud) and globally-engaged firms (Mion, Opromolla and Ottaviano, 2020).
Summary

1. **Human capital of entrepreneurs** matters for firm growth and export participation, but success is difficult to predict.

2. Magnification and learning effects of exporting to rich countries (quality upgrading, input-output linkages and training).

3. Firm-level upgrading through foreign acquisitions (related evidence on spillovers to input suppliers).

4. **Robotization** is unlikely to close the path for export-led growth, but makes the upgrading of firms and workers in developing countries even more important.

5. Evidence on (transferable) learning by working in high-skill services sectors, globally-engaged firms and big cities.
Implications for industrial development policy

Promoting industrial development and openness-led growth requires **coherent policies in several domains:**

- International trade and investment
- Transport and logistics
- Education
- Labor markets
- Competition and regulation
- Regional development
- Innovation
## Discussion of policy options

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<th>Subsidies + temporary protection</th>
<th>Trade liberalization/facilitation + export and investment promotion</th>
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<td>May promote industrial development (Juhasz, 2018 AER; Bartelme et al., 2019)</td>
<td>Reduce input costs and improve their quality (imported technologies, materials, components)</td>
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**Can governments pick winners?**
- government generally not better informed than firms
- government may be captured by the firms/industries they are supposed to regulate

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<th>Inefficiency/misallocation</th>
<th>Benefits of exports and FDI for firm and industry performance</th>
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<td>More expensive inputs and outputs</td>
<td>Can leverage existing government structures (e.g., diplomatic services) and NGOs to reduce information frictions and facilitate buyer/seller matches</td>
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<tr>
<td>Protection is often not temporary</td>
<td>Can benefit from (and magnify effects of) quasi-horizontal policies (education, training, innovation, finance, infrastructure)</td>
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Export promotion

1. Prioritize high-income markets

2. Avoid picking winners: export success difficult to predict; assistance subject to capture; misallocation in domestic market

3. Involve key industry players in program design. But be aware of international best practices

4. Let firms self-select into information-based programs

5. Create transparent mechanisms for assisting firms: leverage ICT and big data in real time for impact evaluation + RCTs

6. Quasi-horizontal policies: be mindful of input-output linkages, localized spillovers and potential for amplification and learning externalities in specific sectors and regions
Foreign investment promotion

1. Targeting multinationals may be feasible and optimal

2. Be mindful of input-output linkages, localized spillovers and potential for amplification and learning externalities in specific sectors, firms and regions

3. Develop highly-professional Investment Promotion Agencies with long time horizon (Harding and Javorcik, EJ 2011, 2013, 2019)

4. Create transparent mechanisms for attracting foreign firms: ICT and big data in real time for impact evaluations + RCTs to study mechanisms

5. Sustainable, fair and transparent tax policies
Thank you!

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Additional slides
Robot adoption is growing rapidly in China

Robots per million workers in manufacturing

Likely drivers of growing robot adoption in China:

- Rising wages
- Aging population
- Changing specialization
- Subsidies

Source: International Federation of Robotics
Robotization in China need not hinder exports of BRI economies

Bastos (2020 JDE): Exposure of Belt and Road Economies to China trade shocks

Data: Bilateral trade data for 1995-2015

Takeaways:

1. Rise in China’s overall imports (driven by openness and productivity growth) significantly boosted the exports of BRI economies

2. Effects of China’s demand shocks was stronger in more upstream industries

(The BRI will reduce trade costs)
Success in export markets requires learning about foreign demand.

Bastos, Dias and Timoshenko (2018 CJE): Learning, prices, and firm dynamics

**Theory:** Heterogeneous capabilities; Bayesian learning about demand; endogenous quality choice

**Data:** panel on firms, export transactions, wages, product-level inputs
Positive demand realizations lead to quality upgrading

Exporters tend to use higher-price inputs (imported and domestic) as they age and grow (Bastos, Dias and Timoshenko, 2018 CJE)
Foreign acquisitions led to reorganization and technology adoption

Bastos, Straume and Monteiro (2018 JIE): Foreign acquisition and internal organization

**Data:** employer-employee + ICT survey panel data, Portugal, 1992-2009

**Identification:** DiD-PSM estimator

**Results:** Foreign acquisitions (mostly from richer countries) led to improved performance, internal reorganization, ICT adoption, increased within-firm wage inequality
Sectoral distribution of high-growth firms in Brazil (1-digit)

Source: Bastos and Silva (2021)
Sectoral distribution of high-growth firms in Brazil (2-digit, top 20)

Source: Bastos and Silva (2021)
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