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# Automation, Global Value Chains and Development: What do we know so far?

Background Paper

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Katherine Stapleton

Katherine Stapleton  
Department of Economics,  
University of Oxford

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## Abstract

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The rise of global value chains (GVCs) in the 1990s and 2000s was accompanied by an unprecedented reduction in poverty for a handful of developing countries. Since the global financial crisis, the growth of GVCs has stagnated. The changing nature of global trade, and recent advances in robotics and artificial intelligence, have led to concerns over whether manufacturing-led development will remain a viable path for countries that have yet to industrialise. It has often been assumed that automation in advanced or emerging economies will reduce the incentive for further offshoring to developing countries or lead to a wave of reshoring. Yet, there is very little empirical evidence so far on whether that is the case. This paper explores the changes in GVCs before and after the financial crisis, the rise of automation and the evidence to date on the relationship between automation and GVCs.

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# 1. Introduction

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The rise of global value chains (GVCs)<sup>1</sup> in the 1990s and 2000s was accompanied by an unprecedented reduction in poverty for a handful of developing countries. Advances in ICT, coupled with the continued dismantling of trade barriers and a favourable political climate, allowed advanced economies to relocate certain production stages to developing countries. This provided employment opportunities and scope for productivity growth.

Since the financial crisis, the growth of GVCs has stagnated and the nature of global trade has changed. Trade is becoming more concentrated within regions, rather than across them, and the share of trade between high- and low-income countries has declined. At the same time, the scope for automation in both manufacturing and the service sector has increased substantially.

These trends have some concerning implications for developing countries. It has often been assumed that, as emerging economies mature, low-skilled labour-intensive activities will relocate to lower-income countries. This 'flying geese' pattern has most prominently been observed in East Asia. In policy circles, there has been talk of the '85 million jobs' that will be imminently moving out of China<sup>2</sup> and relocating to a new wave of developing countries in South-East Asia and Africa. The slowing growth in GVC trade, the regionalisation of goods value chains, and the rapid pace of automation have all resulted in this assumption being questioned. In terms of the scope for further manufacturing-led development, there are two key concerns for developing countries:

- Firms headquartered in developed countries are 'reshoring' production that was initially offshored, as opposed to relocating to, or sourcing from, a new wave of low-income countries and generating further development gains.
- Some typically labour-intensive manufacturing activities remain concentrated in emerging economies, such as China, where they have been automated rather than relocated.

In the years since the financial crisis, trade in services has been growing faster than trade in goods. While technologies such as robotics and artificial intelligence (AI) threaten to substitute for the offshoring of low-skilled tasks, such emerging technologies can also make it easier for firms to offshore or fragment economic activities across borders. AI-powered translation services, online 'gig economy' platforms, and the further rollout of the internet in developing countries, are all making it easier for firms in developed countries to employ workers in developing countries.

Technologies that improve communication are enabling the offshoring of activities that are not yet automatable or are still performed at a lower cost by humans. Technological advances therefore have counteracting implications for GVCs. The key question may be how these contrasting impacts net out.

The sections below will explore the recent changes in global trade, and the relationship between automation and GVCs. We also consider the evidence behind these two development concerns and the new technologies that are enabling trade and GVCs.

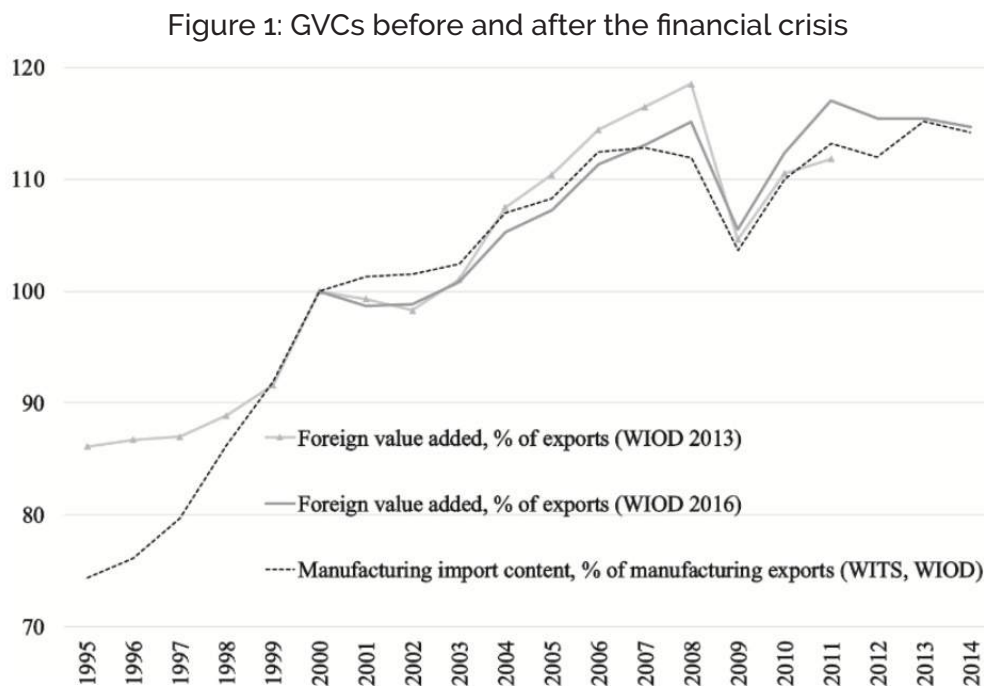
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<sup>1</sup> Global value chains (GVCs) are defined by the Cambridge Dictionary (2019) as "the different processes in different parts of the world that each add value to the goods or services being produced".

<sup>2</sup> See for example: Lin, J. 'How to Seize the 85 million Jobs Bonanza' (blog), The World Bank, 27 July 2011. <http://blogs.worldbank.org/developmenttalk/how-to-seize-the-85-million-jobs-bonanza>

## 2. The GVC 'revolution'

In the 1990s and 2000s, we witnessed a period of exceptional growth in GVCs. This was marked by China's integration into the global economy and advances in ICT. Dramatic improvements in the speed and cost of communication, combined with falling trade barriers, allowed firms to coordinate production stages at a distance and 'slice up' their value chains across borders. Back and forth trade in intermediate parts began around 1985. Initially, this was between the major manufacturing giants of the US, Germany and Japan and nearby developing countries such as Mexico, Poland and Association of Southeast Asian Nations (ASEAN) countries, respectively. It soon accelerated globally. Figure 1 shows how measures of world vertical specialisation, such as the global share of foreign value added in gross exports of goods and services,<sup>3</sup> rose rapidly in the 1990s and early 2000s, and GVC trade grew to become quantitatively important. Between 1995 and 2009, trade in intermediates accounted for around two thirds of all global trade when measured in value-added terms (Timmer *et al.*, 2015).



Source: Constantinescu *et al.* (2018)

<sup>3</sup> World vertical specialisation refers to the extent to which firms purchase intermediate inputs from foreign countries. The share of foreign value added in exports for a given country measures the value added of foreign goods and services that are used as intermediates to produce exports in that country. The global share of foreign value added in gross exports of goods and services aggregates this measure over all countries and reflects how fragmented production is.

## GVCs and development

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During this period, we also saw an unprecedented decline in global poverty. Between 1990 and 2015, 1.2 billion people were lifted out of poverty, based on the World Bank's US\$1.9-a-day poverty line. Of this decline in poverty, 93% came from a select group of countries that became heavily integrated in GVCs over this period – China, India, Korea, Mexico, Poland, Indonesia and Thailand. China alone accounted for 64% of the poverty reduction (World Bank PovcalNet, 2019). While this poverty reduction story is inevitably about more than just trade, the GVCs that emerged in the 1990s and 2000s allowed advanced countries to relocate labour-intensive production stages to these developing countries. This provided employment opportunities and the scope for productivity growth and technology transfer. Given the development success of these few recipient countries, huge policy efforts have since been channelled into trying to attract manufacturing investment and integrate developing countries into GVCs. For example, between 1990 and 2009, the global number of national export promotion agencies tripled (Lederman *et al.*, 2009).

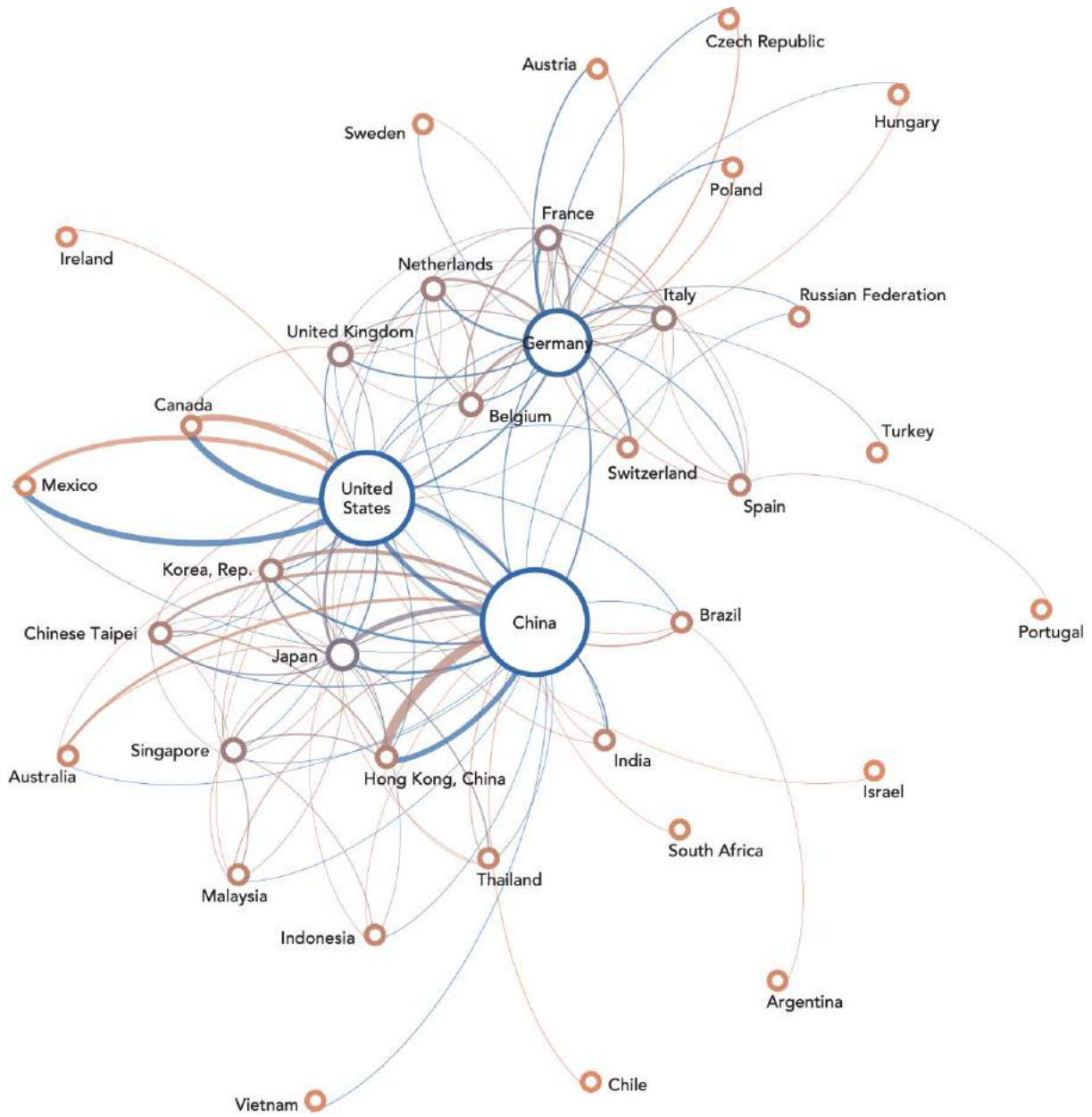
## Explaining the participation of developing countries in GVCs

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A substantial literature has been dedicated to studying the geography of GVCs. Much of this work in economics has been at the intersection of industrial organization and international trade (see Antras and Yeaple (2014) for a summary). This work suggests that the enforceability of contracts has been an important factor for the geography and structure of GVC trade. Likewise, there is a wealth of evidence on the importance of macroeconomic stability, business environment and risk in impacting on GVC decisions.

Interestingly, there is a debate over whether labour costs matter. It has generally been concluded that developing countries involved in GVCs typically have low unit labour costs (ratio of average wages to GDP per capita) but not necessarily low wages. Unit labour costs reflect productivity as well as wages, demonstrating that labour productivity is an important determinant of GVC participation. Despite falling trade and communication costs, geography remains of great importance. All of the countries that were major offshoring destinations were initially relatively close to one of the manufacturing giants. Even now, regional networks are key. For example, the manufacturing activities relocating out of China tend to remain strongly linked with supply chains within China. Figure 2 illustrates the importance of these regional networks.

Figure 2: Global trade in parts and components



Source: Dollar (2017) Global Value Chains Development Report

Notes: The colour of the nodes and lines represents the degree of centrality, with blue representing the highest degree. This diagram includes the 61 economies in the OECD-WTO Trade in Value-Added database and their most important bilateral gross trade flows.



### 3. Changes in trade after the financial crisis

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World trade took a big hit during the financial crisis and has since been shrinking relative to GDP. This, along with the stagnating of other measures of globalisation, such as cross-border investment and bank loans, has led to the recent coining of the term 'slowbalisation' (*The Economist*, 2019). A big part of this story has been the role of growth in GVC trade, which fell sharply in 2008 and has since levelled out (Timmer *et al.*, 2015). This has caused some debate over whether the process of deeper GVC integration has stalled or started to reverse. Constantinescu *et al.* (2018) explained that some of this slowdown in the growth of GVC trade reflects changes in the Chinese economy; Chinese exporters are now using more domestically produced inputs than imported inputs. This means that the foreign value-added content of Chinese exports has been declining – a pattern that has been well documented by Kee and Tang (2016).

Another explanation for the stagnation of GVC trade is that there has been a rise in protectionism since the financial crisis. Bown (2018) looks at the trade policy of G20 countries after the financial crisis: there has been an increase in the prevalence of temporary trade barriers, and these increasingly cover imports of intermediate inputs. An additional suggestion put forward by Harms *et al.* (2012) and Baldwin and Venables (2013) is that the slowing growth of GVC trade simply reflects the readjustment after firms were too zealous in offshoring in the 1990s and 2000s.

There have been several other changes in GVCs over the past decade. Goods producing value chains are becoming more regionally concentrated. For example, the share of global trade in goods between countries within the same region declined between 2000 and 2012. However, this trend has started to reverse, with the within-region share of global goods trade increasing by 2.7 percentage points since 2013 (Bughin *et al.*, 2019).<sup>4</sup> Likewise, the share of global trade between high- and low-income countries has been declining and GVCs are also becoming more reliant on high-skilled labour. These trends can be partially explained by the rising consumer power of emerging markets in Asia. They could also be caused by business models involving shorter lead times, the growth of just-in-time manufacturing, or growth in automation, reducing the incentive for firms to offshore production to distant, low-cost locations. Yet, trade in services is growing faster than goods trade. Bughin *et al.*, (2019) show that, over the past decade, trade in services has grown more than 60% faster than trade in goods.

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<sup>4</sup> Africa as a continent is an exception to this trend: the share of intra-regional trade has been stagnant over the past decade.

## 4. The relationship between automation and GVCs

### Automation in manufacturing

Automation is an ongoing process that has been chipping away at the labour intensity of manufacturing in advanced economies for nearly a century. However, the past two decades have seen some striking improvements in the capabilities of machines. Robots can now autonomously perform a relatively wide range of tasks – including welding, painting and packaging – many of which were not possible in the 1990s. These capabilities set the current scope for automation in the manufacturing sector apart from earlier waves of automation and the rise of ICT.

There is evidence that growth rates in industrial automation have accelerated in the years after the financial crisis. For example, global sales of industrial robots doubled between 2012 and 2016, while they grew relatively slowly between 1990 and 2009 (International Federation of Robotics (IFR), 2017). Additionally, prices have fallen over the past two decades, while quality has improved. The price of a typical spot-welding robot in 2015 was around one-quarter of its 1993 price in real terms (Ark Invest, 2018). Sales of other technologies, such as computer numerically controlled (CNC) machines,<sup>5</sup> have also been increasing, albeit not as dramatically.

Figure 3: Sales and cost of industrial robots



Source: IFR (2017) for industrial robot sales, Ark Invest (2018) for the price.

<sup>5</sup> CNC machines use computers to store, calculate and execute operations that are usually performed by hand – for example, milling or metal work.

A substantial part of this growth can be explained by rising Chinese demand. Between 2009 and 2016, the operational stock of industrial robots in China increased tenfold, and one in three robots globally are now installed in China (IFR, 2017). Another reason for this growth is that technological advances in other fields, such as improvements in sensors, computing power and open source software, have all fed into the robotics industry, increasing competition and pushing down prices.

However, despite growing very quickly in recent years, the existing scope for industrial automation is still limited. The use of industrial robots is concentrated in a narrow range of industries and tasks, and industrial robots remain very inflexible. Once a firm has installed an industrial robot, it is typically very hard to then change production processes, products or tasks. Installing industrial robots is generally conducted by a specialist robotics integration company, meaning that adoption tends to be geographically concentrated and limited to very large, productive firms producing high volumes (Leigh and Kraft, 2017). Fort *et al.* (2018) also revealed that firms starting to use industrial robots tend to open a new plant to do so, rather than upgrading their existing facilities. This suggests that the decision to automate involves substantial upfront capital and long planning time horizons.

A new wave of robotics in the form of 'cobots' and mobile robots is making it more feasible for smaller firms to automate. Cobots are flexible, can work alongside humans, involve less stringent health and safety regulations, and can be bought for relatively low prices. Alongside applications of AI in robotics, cobots are expanding the scope of activities that are feasible to automate. However, their adoption is still in its infancy.

## Automation in services

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It has taken huge engineering accomplishments to even come close to developing robots with some of the basic perception and mobility skills of a toddler. Yet machine learning has already made it feasible for computers to exhibit superior performance to adults in numerous cognitive tasks. This is Moravec's paradox: the idea that, contrary to what most people assume, high-level reasoning requires very little computation, but basic manual dexterity and handling skills require enormous computational resources (Moravec, 1988).

Advances in AI have received a huge amount of media attention. However, empirical evidence on the spread of AI is actually very limited. This makes it hard for policymakers to track how widely it is being used. The evidence that does exist suggests that the growth in AI adoption has taken off rapidly over the past decade. Furman and Seamans (2019) found evidence of a large increase in AI-related activity, as reflected by the number of AI startups and patent counts. Many service sector activities are already being automated using AI, including customer support services and back office data processing work. These are activities that were offshored to countries such as India and the Philippines in the 1990s and 2000s, and so there is a very real possibility that offshoring this type of service sector could be negatively affected.

## Automation and GVCs

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To date, there has been little research on the relationship between automation and GVCs, either theoretical or empirical. From a theoretical perspective, the growing scope for automation would be expected to reduce the incentive for firms to take advantage of labour cost differentials. In sectors where automation is already feasible – and cheaper than even the lowest-cost human labour – we would expect to see firms choosing to automate rather than seeking out new low-cost production locations. However, whether firms choose automation over offshoring should depend on a number of factors beyond the cost of the technologies themselves: labour supply and demography; health and safety regulations; access to credit; trade and communication costs; but also factors such as the diffusion of information, the availability of skills and even culture towards automation.

Although automation generally displaces labour in the tasks that are replaced, it can also increase productivity. Through this channel, it can contribute to the demand for labour. So, while automation could directly reduce the offshoring of labour-intensive manufacturing work, through raising productivity, it might lead to additional employment or trade. Acemoglu and Restrepo (2019) argue that automation is also counterbalanced by the creation of new tasks in which labour has a comparative advantage. They point to a range of historical examples of the creation of new tasks for labour in times of technological change. In the era of GVCs, this could also imply new trade in tasks, or offshoring of activities that didn't exist before.

There are further reasons to believe that the relationship between automation and GVCs is likely to be quite complex. It's plausible that offshoring itself could also lead to automation in other segments of the value chain. Bernard *et al.* (2018) recently used Danish data to show that offshoring from Denmark tends to be associated with: the domestic reorganisation of production; investment in research and development; and technology upgrading within Denmark. Offshoring itself might raise productivity, leading firms to expand and so invest in new technologies. Automation could also be a side product of reshoring, even if this was initially conducted for other reasons, such as proximity to market.

What we do know from studying GVCs is that global trade tends to be dominated by a few very large, productive firms. In 2000, for instance, the top 1% of US exporters accounted for 81% of US exports (Bernard *et al.*, 2009). Automation has also been seen to follow a similar pattern. Firms that automate are larger, more productive, and more likely to import, export and be involved in GVC trade. Large multinationals tend to have complex supply chains and invest in advanced technology. This means they are likely to combine the frontier of automation with a global network of affiliates and suppliers, taking advantage of cost and quality differentials where they exist.

A recent paper by Artuc *et al.* (2019a) has used country-industry panel data on trade and industrial robot use to study the relationship between robot adoption and North-South trade. They find that increased robot use in Northern countries is associated with an increase in their imports from less developed countries. It is also associated with a larger increase in exports to these countries, meaning that net imports from less developed countries decline. The positive impact of Northern robotisation on imports from the South is mainly driven by exchanges of parts and components. Therefore, this paper suggests that the productivity or counterbalancing effects of automation are at work, with automation increasing developing country imports.

In a separate paper using Mexican export data, Artuc *et al.* (2019b) explore how automation in the US affects employment in Mexico. They develop a theoretical model where automation in the US can affect the demand for Mexican goods through different channels. Automation could improve the comparative advantage of the US in certain sectors, reducing demand for Mexican products. However, the increased efficiency of US firms could foster demand for complementary goods in Mexico. The results indicate a strong negative relationship between exposure to US automation and exports from Mexico to the US. This suggests that the displacement effect of automation seems to be stronger than the productivity and counterbalancing channels. This existing evidence on the relationship between automation and GVCs is therefore somewhat mixed.

## 5. Exploring the two main development concerns

### a) Reshoring – what's the evidence?

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In the current political climate, there has been a strong push for firms in developed countries, particularly the US, to reshore production. Reshoring occurs when firms reverse their previous offshoring decisions and relocate parts of their value chain back to their original location. There have been a number of high-profile cases of reshoring that are often used to illustrate the notion that reshoring is taking off. One example is Adidas. After years where the production of sports shoes had been offshored mainly to China, Indonesia, and Vietnam, the firm built two new highly automated factories for trainers – one in Germany and one in the US. However, what is less often reported is that these two factories account for less than 1% of overall production. Beyond such reports on high-visibility cases, there has been limited evidence or consensus on the aggregate extent of reshoring. Firms are also more likely to publicise their reshoring decisions than their offshoring decisions, making the media skewed to reporting on these cases.

A common definition of reshoring has not yet been adopted, and reshoring is often described, and measured, in different ways. Krenz *et al.* (2018) measure reshoring as the change in the ratio of domestic to foreign inputs. They use data from the World Input-Output Database to show that globally<sup>6</sup> this measure has been steadily rising over time. Measured in this way, the turning point from net offshoring to net reshoring occurred around 2009. De Backer *et al.* (2016) looked at a similar measure of the share of domestic demand that is served by imports for a wide range of countries. They show that, for most countries, the growth in the imports' share of domestic demand has slowed down in recent years, but there isn't much sign of a true reversal. In some countries – for example, the US, France and Italy – the share of domestic demand served by imports is still increasing. In others, the share has decreased in recent years – this is the case for Japan, Germany and the UK.

In the last four years, AT Kearney (2018) have developed a 'Reshoring Index' for the US. Their index is based on the year-on-year change in the manufacturing import ratio. This is the ratio of imports of manufactured goods from 14 low-cost countries (traditionally offshore trading partners), to the US domestic gross output of manufactured goods. The index shows that relative growth of imports from the low-cost country trading partners has outpaced relative growth of US manufacturing gross output in four of the past five years and eight of the past 10 years. This shows evidence *against* reshoring (as measured in this way) for the US.

However, the problem with these measures is that they do not make the distinction between inputs and final goods. This means that export growth of final goods in developing countries could be mistaken for reshoring. A leading definition of offshoring in the trade literature is that offered by Hummels *et al.* (2014): 'The import of intermediate inputs (or tasks) *that could have been produced internally within the same firm*'. The second part of this is key and has not been considered in these measures. We therefore need more detailed work using firm-level data with more accurate measurement before we can make better conclusions about reshoring.

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<sup>6</sup> The 2016 release of data from the World Input Output Database includes 43 countries.

It is not clear what the causal factors are behind the reshoring observed to date. While it has often been assumed that automation is a driving factor, there is no current evidence that this is the case. Some preliminary work has suggested that there is a negative relationship between measures of automation and offshoring across countries and industries (OECD, 2015; Krenz *et al.*, 2018). However, causation could run both ways. Firms that choose to reshore for other reasons may then automate as a consequence of reshoring, because labour costs are higher in developed countries. Some anecdotal evidence suggests that the primary reasons for reshoring are flexibility, proximity to main market, access to skills and reducing supply chain risk (WMG, 2018). The political environment and fiscal incentives offered to firms to reshore production could also increasingly factor in. The US, the UK and a number of other OECD countries have now started offering tax breaks and other advantages to firms that reshore production.<sup>7</sup>

## b) Manufacturing in China – should we be worried?

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Over the past decade, China has witnessed a large increase in production costs. For example, average hourly wages in China's manufacturing sector trebled between 2005 and 2016 (Euromonitor, 2017). In addition to rising wages, in the years since the financial crisis, manufacturing firms on China's east coast have faced low-skilled labour supply shortages and increased costs of complying with labour and environmental regulations. In light of these rising costs, it has been assumed that labour-intensive manufacturing activities will inevitably relocate to lower-cost destinations. Yet, it appears that China has been maintaining and expanding its production and exports of labour-intensive products, while also entering higher value-added manufacturing sectors (Hallward-Driemeier & Nayyar, 2017). In 2016, manufacturing employment in China was also still rising (China National Bureau of Statistics, 2017).

Given that the most recent data is not yet available, it could be that more manufacturing has started to relocate in the past couple of years and has not yet shown up in the statistics. The current trade war with the US may also act as a catalyst and spur firms to relocate production outside of China to avoid tariffs. In light of China's size and heterogeneity, it might also take a lot longer for manufacturing activities to relocate to new locations. There is evidence that the 'geese' have first 'flown' domestically within China: Hou *et al.* (2017) show a recent westward shift in manufacturing employment within China to economically less developed provinces with lower labour costs. If this is the case, there is no reason to worry and perhaps manufacturing production is relocating to developing countries, and will continue to do so, just at a slower pace than might have been expected.

However, a real concern is that the bulk of manufacturing production will never move to a further wave of developing countries the way it has done over the past few decades. There are a few reasons why this could be the case. The Chinese manufacturing sector is characterised by dense

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<sup>7</sup> See, for example: McIntyre, S. '8 Tax Incentives OEMs Reshoring to the US Should Pursue' (blog), Syscom Tech, 13 April 2017. [www.syscomtechusa.com/tax-incentives-oems-reshoring-u-s-should-pursue/](http://www.syscomtechusa.com/tax-incentives-oems-reshoring-u-s-should-pursue/)

agglomeration and economies of scale, along with highly developed transport and logistics networks. This means that there are many benefits to producing in China beyond labour costs. Additionally, labour productivity has also risen rapidly, and education policies have facilitated the growth of a technical workforce with skills that may not be available elsewhere. These factors all act as a gravitational pull, providing the incentive for firms to keep production in, or close to China, irrespective of labour costs. The growing consumer power of the Chinese middle class, along with expectations for rapid delivery and customised products, also provide reasons for GVCs to remain concentrated in China.

The staggering rise of automation in China in the past few years and government-led efforts to promote high-tech sectors does seem like it could be an explanation for why manufacturing production is remaining in China despite rising costs. Beginning with the Chinese government's 'Made in China 2025' plan, launched in 2013, there has been an increased effort to promote the use of advanced technologies in manufacturing. This plan aims to automate key sectors of the economy, including car manufacturing, electronics, home appliances, logistics, and food production. One of the key focus industries is robotics, with Xi Jinping calling for a 'robot revolution'. The plan has been accompanied by a range of policies under the '*jiqi huanren*' – 'machines replace workers' directive, such as subsidies, low-interest loans and tax-waivers for companies that purchase robotics and advanced equipment.

In industries where automation is already technically feasible, these policies have increased the incentive for firms to automate and reduced the attractiveness of destinations with lower-cost labour. Growing Chinese production of low-cost alternatives for products such as industrial robots, is also pushing down global prices and expanding the technical scope of automation. There have been a number of high-profile examples of Chinese firms or original equipment manufacturers (OEMs) producing in China switching to automation. One that caught the attention of the media was Foxconn, the world's largest OEM and the main assembler of iPhones. In 2016, Foxconn replaced 60,000 workers in its Kunshan factory in South China with a new automated production system. However, beyond these case studies, there is not yet much empirical evidence investigating these trends on an aggregate level.

Two studies offer some evidence that firms may be choosing to automate or upgrade production, as opposed to relocating to, or sourcing from, other countries. Gelb *et al.* (2017) conducted a survey of Chinese firms, asking about their response to rising wages. They found that the firms surveyed tended to choose to upgrade production processes instead of relocating. Li *et al.* (2019) also conducted a survey of light manufacturing firms on their response to rising labour costs. They found that the most common strategy has been technological upgrading. But the drawback of these surveys is that surveying firms that have not relocated causes a sample selection issue, given that firms more likely to choose relocation might have already exited the market. Beyond these studies, we don't have any clear evidence that automation is causing firms to remain in China rather than relocate.



## 6. The speed of technology adoption

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Even if technological advances in automation generally provide the incentive for firms to reshore production – or maintain production in China, or other emerging economies – there is plenty of evidence that the spread of technological progress is slow and uneven.

Despite its economic viability, advanced automation is still currently only conducted by a small minority of firms, with substantial heterogeneity of adoption across firms, industries and countries. History suggests that new technologies take a long time to diffuse and be widely adopted. McKinsey (2017) looked at the historical adoption rates of 25 technologies and found that the time between the commercial availability of these technologies and their eventual maximum level of adoption generally took at least nearly a decade – in some cases, multiple decades – with the time range between eight and 28 years.

This suggests that large-scale adjustments of GVCs to automation will take time. So, there is still scope for current developing countries to tap into the opportunities for low-skilled labour-intensive offshoring, at least for some time. There is a growing body of evidence suggesting that automation is counter-cyclical. For example, Jaimovich and Siu (2018) demonstrated that 88% of employment loss in middle-skill occupations in the US occurred in economic downturns. Hershbein and Kahn (2018) also established that US regions harder hit by the financial crisis invested more in technology and started requiring higher-skilled workers. This research shows that adjustments to technology happen with a substantial lag, and so we may not experience big changes in the geography of GVCs until long after automation technologies have become commercially viable.

## 7. Emerging technologies that enable trade

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As well as replacing tasks conducted by humans, AI also has the potential to enable the growth of GVCs. Countries that share a common language typically trade far more than countries that do not. AI-enabled translation services can therefore enable trade and make it easier for firms in developed countries to subcontract activities to workers in developing countries. Brynjolfsson *et al.* (2018) provided evidence that machine translation is already having an impact on trade. They analyse the effect of the introduction of eBay Machine Translation (eMT) on eBay's international trade, showing that the introduction of English-Spanish machine translation increased eBay's US exports to Spanish-speaking Latin American countries by 17.5%–20.9%.

Online labour platforms are also making it possible to connect companies with individuals around the world. This is allowing them to outsource services as diverse as software development, graphic design, writing, data entry and accounting. Lehdonvirta *et al.* (2018) have documented the growth of this type of employment in India, the Philippines and sub-Saharan Africa. AI-powered logistics platforms could also reduce trade costs, improving the efficiency of GVCs, streamlining logistics and optimising supply chains. This itself could enable further offshoring of goods production. However, so far, we generally have very little empirical evidence on how these technological developments are impacting on trade and GVCs.

## 8. Concluding remarks

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GVCs and manufacturing-led development have been unprecedented forces for poverty alleviation. From a development perspective, there are good reasons to fear a slowdown of offshoring to low-income countries. Although concrete evidence has not yet emerged, there are some signs that goods value chains are changing in a way that is less conducive to development; trade is becoming more regional and more skill intensive and labour costs are becoming less important.

There is not yet much sign of a large-scale reshoring trend, while there is more evidence that GVCs are proving slow to relocate away from emerging markets, particularly China. Early evidence suggests that the expanded scope and falling cost of automation in manufacturing are having an impact on GVCs. Rapid technological advances in robotics and AI are predicted to continue, and financial incentives for industrial automation offered by the US and China will artificially speed up adoption. Yet emerging technologies and online labour platforms are also playing an enabling role for GVCs, and facilitating the offshore outsourcing of service sector activities.

To date, our knowledge on all of these topics remains very limited. A future research agenda should aim to better understand: the changes in GVCs post-financial crisis; the adjustment happening within the manufacturing sector in China; and the aggregate evidence on the relocation (or lack thereof) of manufacturing GVC activities to a new wave of developing countries. We also need detailed work exploring whether there is a causal relationship between automation and GVCs. This should focus on displacement, and on the productivity and counterbalancing effects of automation. The growth of service sector trade offers great potential but is under-researched. We need to evaluate whether emerging new service sector activities that are not yet feasible to automate might offer the potential for employment growth to developing countries.

New technologies will always act as a double-edged sword, substituting for certain tasks but generating new demand for others. Although the well-trodden path of manufacturing-led development may not be available for developing countries for much longer, a new wave of offshoring for service sector activities could occur. The key will be to understand these changes and know how to harness them for the benefit of developing countries.

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