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Development strategies for middle-income countries in a digital world – impacts from trade costs, data and innovation policies

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Abstract

The digitalization of economic activities, combined with a secular slowdown in the growth of global output and trade, reduces the potential of traditional export-oriented manufacturing as a development strategy. This paper takes a trade economics perspective to outline a possible response to the changed nature of industrialization. The outlined response currently applies mainly to middle-income countries but deserves attention also in longer-term development strategies of low-income countries. The paper argues that digital technologies affect trade costs through various mechanisms, which apply differently to manufactures and services and determine decisions of multiproduct firms on what to produce for what market. Emphasizing big data analysis of customer preferences as an input to manufacturing, the paper finds that (i) industrialization and services-oriented development strategies are complements, rather than substitutes; (ii) data on customer preferences are an asset for developing countries; and (iii) data governance, which harnesses the increasing dependence of manufacturing on data, and innovation policies, which give greater importance to indigenous innovation, crucially augment the potential of industrialization as a development strategy in a digital era.

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1. Introduction

New digital technologies are rapidly transforming how and what goods and services are produced and traded. Robotization allows for automation and increased productivity of a growing part of manufacturing, while information and telecommunication technologies (ICTs) improve the tradability and productivity of services. Several authors have argued that these features disable traditional export-led manufacturing as a development strategy but enable a services-led development strategy (e.g. Ghani and O'Connell 2014; Pathways Commission for Inclusive Development 2018; Baldwin and Forslid 2020).

The COVID-19 crisis sharpens this debate. First, an accelerated reshoring of production to developed countries combined with automation would reduce opportunities for export-oriented manufacturing. Second, supply-chain disruptions could cause assessments of the risks associated with global sourcing to revalue resilience relative to just-in-time delivery and cost effectiveness. Ensuing resilience building could result from shorter supply chains or real-time transparency, based on a digitalization of supply-chain management with opportunities for inclusion reduced to those developing countries whose levels of digitalization ensure such transparency. Decisions to reshore or move supply channels are time-consuming and require long-term planning and commitment, especially as producers adjust to an economic downturn and committed fixed investment and organizational capital persist as long as business partners do not go bankrupt. But even if the COVID-19 crisis were to be less severe than commonly feared it will, nonetheless, make the global economy suffer further prolonged slow growth and lower demand for manufactured exports of developing countries. In essence, COVID-19 increases the urgency for debate on development strategies.

The main objective of this paper is to contribute to this debate and examine how developing countries could continue to industrialize despite likely reduced opportunities for manufactured exports and further potential threats to industrialization coming from new digital technologies. It starts from the perspective that not thinking about possible industrialization alternatives to traditional export-oriented manufacturing implies accepting reduced growth and development potentials.

The main contribution of the paper is to add a trade economics perspective to the debate on digitalization and development strategies. Digital technologies (industrial robots, additive manufacturing, computer-aided design (CAD) and manufacturing (CAM), and big data) have various impacts on trade costs that apply differently to manufactures and services. Differential impacts on trade costs affect the interlinkages of goods and services in the various stages of the manufacturing process and determine decisions by firms on how and what to produce and supply to what markets. Emphasizing the role of data on customer preferences in this context, the paper finds that (i) industrialization and services-oriented development strategies may well be complements, rather than substitutes; (ii) data on customer preferences[1] are an

[1] The issues discussed in this paper regard product-specific data and databases that may be collected through marketing and customer intelligence. One example is the Nielson HomeScan database, which relies on barcode analysis to provide price and sales information for millions of products sold in the United States. It can be accessed at https://www.chicagobooth.edu/research/kilts/datasets/nielsen, as used in Hottman, Redding and Weinstein 2016. While such product-specific data may not always be separable from personal data, the issues discussed here do not pertain to narrow personal data shared through social networks, search engines or electronic payments

asset for developing countries; and (iii) data governance that harnesses the increasing dependence of manufacturing on data, and innovation policies that give greater importance to indigenous innovation, crucially augment the potential of industrialization as a development strategy in a digital era.

The main argument of the paper is that the new digital technologies, and especially big data, affect the trade costs of developed and developing countries asymmetrically. Big data technologies[2] can provide firms with low-cost information on customer preferences, enabling them to supply the heterogenous demand patterns in their target markets. This opportunity exists for firms from developed and developing countries alike. However, existing digital divides (e.g. UNCTAD 2019; OECD 2019) cause firms in developing countries to be less ready or able to access and process data on customer preferences and imply that data-related productivity growth and other gains accrue asymmetrically to the benefit of firms from developed countries. Accordingly, in addition to measures that bridge digital divides, a crucial element of development strategies in a digital era is data governance that regulates the use of data on customer preferences in a way that maximizes developmental impacts.

The approach followed here mainly applies to middle-income countries that emphasize manufacturing in their development strategies with a view to continuing structural transformation and transiting towards high-income status. These countries generally aim at rebalancing their export-oriented development strategies towards a larger role of both domestic markets and indigenous innovation, including in order to escape the so-called middle-income trap.[3] The larger countries among them may follow this strategy on their own, while others may rely on regional solutions or South-South integration. The approach applies less to the current situation of low-income economies, many of which are in Africa, where industrialization has never taken off and where traditional export-oriented manufacturing combined with resource-based industrialization and digitized services development currently promises greater development potential. Nevertheless, these countries' data on customer preferences also are valuable assets, even if they may provide tangible benefits only once these countries attain middle-income status.

The paper expands on the simple approach based on Ricardian trade theory that was recently proposed by Baldwin and Forslid (2020) – henceforth BF. Naturally, this approach is an abstraction and does not capture the complexities of international production sharing and trade.[4] However, it takes technological

systems, that have dominated public debate on privacy and cross-border data flows. On the other hand, measures designed to protect privacy of personal data could be used as a basis for measures that govern the use of product-specific data.

[2] Big data technologies allow voluminous amounts of machine-readable data to be rapidly generated, processed and analysed. These processes often employ cloud computing that substantially increases the availability and affordability of computing services by using data servers, storage and software analytics over the Internet. Machine learning can use these data to identify current and potential future customer preferences.

[3] This strategy generally relies on domestic per capita income and purchasing power to be sufficiently high and provide enough scale and earnings to compensate declining revenues from manufactured exports. It also relies on growth of domestic income generation to remain high to ensure that households and businesses finance increased spending from increased income, rather than debt. Data that would allow assessing whether COVID-19 has damaged the potential of this strategy more than that of export-oriented manufacturing are currently not available.

[4] For similar approaches but that include issues related to production sharing, see, for example, Bernard et al. 2018, 2020, and, with an emphasis on robots, Artuc, Bastos and Rijkers, 2020. Including these issues would complicate the analysis without qualitatively changing the findings.

differences as the driving force behind trade and can accommodate shifts in trade costs relatively easily. It provides a natural framework to highlight systematic relationships and the main impacts of the new digital technologies on the international division of labour and trade in a way that allows policymakers to decide what policies may be needed to attain their development objectives.

In addition to the articles mentioned above, this paper relates to three lines in the literature. First, one emphasis of the recent trade economics literature on heterogenous firms is on the sunk costs which firms need to incur to start exporting and which trigger changes in the number and variety of products sold by multi-product firms. A firm's decision on what product to offer in what market depends on combinations of firm, product and market characteristics: firms may locate production close to their customers to avoid trade costs or supply their markets from a distance, whereby only the firm with the lowest market-specific component of the fixed cost related to market entry and/or with the highest market-specific component of demand can sustain its entry into a market (e.g. Melitz and Redding 2014). This paper adds a development perspective to this literature by considering access to data on customer preferences on developing country markets as a form of trade costs to highlight the ensuing implications for industrialization in developing countries.

Second, the paper relates to the business-school literature on innovation for markets characterized by heterogeneous demand patterns determined by differences in per capita income (e.g. Brandt and Thun 2016; Thun 2018). It argues that the top (bottom) segments in developing country markets are served by foreign (domestic) firms and that an emerging middle class has created a middle segment with distinctive demand patterns. To serve this emerging segment, foreign firms face a marketing gap because they lack appropriate knowledge on these demand patterns, while domestic firms face a technology gap because they lack appropriate technological capabilities. The paper's contribution is to show that access to data on consumer preferences is a crucial asset for serving this middle market segment.

Three, to examine implications for data governance, the paper relates to a nascent literature (e.g. Bauer, Ferracane and van der Marel 2016; Casalini and Lopez Gonzales 2019) emphasizing anti-trust conduct, market power, privacy, data security and surveillance, i.e. issues concerning a "free Internet". More important for economic development, however, are regulatory issues. These relate to industrial, trade and investment policies designed to foster investment, fuel innovation and exploit comparative advantages for domestic companies based on, for example, data on sales and related product characteristics (e.g. Aaronson 2018, 2020; Chen et al. 2019). This paper links these latter issues to a small literature on big data for development, which currently emphasizes experiences in developed countries or humanitarian issues in developing countries (e.g. Hilbert 2016). Examining, instead, how big data can contribute to industrialization as a development strategy, and the related argument that differential access to specific data sets and their use through big data technology causes big data to have unequal development benefits, contributes to the conceptualization of the value of big data for development.

Finally, the paper contributes to the literature on indigenous innovation by incorporating middle-market segments into a literature on frugal innovation that has mostly focussed on the poor or the social contexts of innovation (e.g. Bhatti et al. 2018; Ernst el al. 2015; and Pisoni, Michelini and Martignoni 2018).

The rest of the paper proceeds as follows. The next section evaluates the debate on industry-led versus services-led development strategies. It concludes that manufacturing remains an integral part of development strategies and that the increased use of services as inputs to manufacturing makes the development of services and manufacturing complements, rather than substitutes. Section three introduces the approach of BF, which draws on the Ricardian model with a continuum of goods of Dornbusch, Fischer and Samuelson (1977). Section four uses this framework to explore the differential impact of new digital technologies on trade costs in manufactures and services in two steps: first considering manufactures and services separately and, then focusing on data as a services input and the ensuing implications for manufacturing. The section expands on BF by shifting the perspective from homogenous to heterogeneous demand preferences[5] and by considering effects on manufacturing from new digital technologies beyond industrial robots, including additive manufacturing, CAD/CAM, and especially big data. The section draws on insights from the recent theoretical and empirical trade literature on multi-product firms. Section five explores implications for data and innovation policies. Section six concludes.

2. Industry-led and services-led development strategies

Manufacturing has traditionally been considered as the engine of growth and development. This view relates to the observation that poor countries typically have large differences in output per worker across sectors, and that shifts of output and labour, first from agriculture to industry and later from industry to services, played a major role in the development of today's advanced economies (e.g. Lewis 1954; Kuznets 1955; Chenery 1986), as well as of the developing economies in East Asia that have transited from low- to high-income status (e.g. Herrendorf, Rogerson and Valentinyi 2014).

The special role of manufacturing was initially explained from data on high-income economies in the 1960s. These are reflected in Kaldor's three growth laws, which describe positive associations between (i) growth of manufacturing output and average GDP growth, in part explained by the shift of labour from agriculture to industry; (ii) growth of manufacturing output and manufacturing productivity, which is associated with increasing returns to scale in manufacturing, resulting from (a) its large scope for mechanisation and spatial agglomeration, and (b) cumulative production experience over time and large sector size, which thanks to the tradability of manufactures even economies without large domestic markets can achieve through export-oriented industrialization; and (iii) growth of manufacturing output and overall productivity of the economy, resulting from technological spillovers from manufacturing to other sectors and from stronger backward and forward linkages in manufacturing than in other economic sectors (e.g. Hauge and Chang 2019).

[5] Heterogeneous demand structures describe variation in demand patterns depending on both levels of per capita incomes – with related issues, such as the prevalence of North-North trade, examined with non-homothetic preferences that are identical across countries and give rise to Engel-curve features in, for example, Matsuyama 2000; Fajgelbaum, Grossman and Helpman 2011 – and country-specific features, such as preferences for specific product functionalities, e.g. fuel efficiency of cars, that also play an important role in home market advantages, as in Coşar et al. 2018.

More recently, data on low- and middle-income countries confirm that growth of manufacturing output and overall GDP growth are positively related (Szirmai and Verspagen 2015); that productivity growth in manufacturing explains about half of the catch-up in relative aggregate productivity across countries (Duarte and Restuccia 2010); and that productivity in manufacturing exhibits unconditional convergence across countries (Rodrik 2013). This last finding implies that the productivity of manufacturing in low- and middle-income economies rises over time and converges to the global technological frontier regardless of policies and circumstances. Related evidence suggests that productivity growth within manufacturing becomes increasingly important as economic development advances and the scope for shifting labour away from low-productivity agriculture declines (Diao, McMillan and Rodrik 2019). Taken together, these findings point to the unique role of manufacturing as a catalyst for productivity growth and economic catch-up, and as a provider of well-paid jobs especially for less-skilled workers.

Mainly two observations have called into question the continued validity of this uniqueness. First, over the past two decades, the peak shares of manufacturing in value added and employment across a range of developing economies were both lower and occurred at lower levels of per capita income than in earlier industrializers, i.e. a development indicating premature de-industrialization. However, much of this decline is a statistical illusion that results from a re-distribution of manufacturing activities at the global level (Haraguchi, Cheng and Smeets 2017; Wood 2019). A significant part of this decline reflects the relocation of manufacturing jobs from more to less productive but more populous countries, especially China. It also reflects a decline in global prices of manufactures relative to those of services, which is partly related to the increased number of developing countries competing for exports to developed country markets. A recalculation of the share of manufacturing in total value added in constant prices indicates no decline in manufacturing at the global level or for many individual countries. The decline of manufacturing in total employment partly reflects a faster drop in the labour intensity of manufacturing than in services, which indicates the superior productivity potential of manufacturing (Tregenna 2009) and therefore illustrates the unique role of manufacturing, rather than its irrelevance.

A second observation calling into question the unique role of manufacturing in development emphasizes the heterogeneity of services and that some services have come to share some of the pro-development characteristics traditionally associated only with manufacturing. The superiority of productivity growth experienced in manufacturing relative to services has declined since 2000 across most developed and developing economies (IMF 2018). This catch-up has been driven by ICT-intensive sectors such as telecommunications, finance and distribution, which have recorded higher rates of productivity growth than manufacturing (Jorgenson and Timmer 2011) and for which unconditional convergence exceeds that for manufacturing as a whole (IMF 2018). An important reason for this improved productivity-enhancing potential is that these services use digital technologies and/or are highly digitized. This allows them to enjoy significant economies of scale both because the provision of an additional unit of such services occurs at virtually zero marginal cost and because they are more tradable than traditional face-to-face services. The increased tradability of business services – processing insurance claims, audits, tax statements and medical records; desktop publishing; remote management and maintenance of IT-networks; and financial research and analysis – has played a crucial role in the services-led development trajectories of developing countries such as India, the Philippines and Rwanda and has led global trade in

services to grow faster than trade in goods since the 1980s, though from a low basis. Underlining the heterogeneity of services and emphasizing the pro-development characteristics of certain services have become a hallmark in the recent literature on services-led development strategies (e.g. Ghani and O'Connell 2014; Hallward-Driemeier and Nayyar 2017; Gollin 2018).

On the other hand, services that exhibit productivity-enhancing characteristics are less likely to create large-scale employment opportunities for unskilled labour. Much of the services employment expansion across developing countries over the past few decades occurred in wholesale and retail trade, tourism, and construction, which are less likely to provide productivity gains (IMF 2018). Therefore, the limited availability of highly skilled computer-literate labour and related high-tech infrastructure in developing countries constrains the expansion of productivity-enhancing services even with an enhanced tradability of such services. Moreover, backward linkages tend to be highest in the low-productivity segments of the services sector. Perhaps most importantly, the tendency of manufacturing and services activity to co-locate appears to be uncorrelated with the ability of countries to develop high-productivity services tied to the presence of manufacturing.[6] Given that this tendency appears to have intensified since the Global Financial Crisis (GFC) in 2008, it is unlikely that some countries can specialize in manufacturing and others focus on exporting high-productivity intermediate services to them (Kuan 2016). Hence, developing countries will enjoy greater aggregate benefits if their highly skilled computer-literate workers in the services sector concentrate on activities that provide significant forward linkages to manufacturing. Focusing on financial and business services, Liu et al. (2019) find that domestic services development reduces the revealed comparative advantage (RCA) of manufacturing sectors with low embodied services, while it fosters the RCA of manufacturing sectors with a high degree of embodied services. This suggests that the developmental potential of productivity-enhancing services might be best considered a complement, rather than a substitute, to manufacturing.

That the importance of services for manufacturing has increased is often described as the "servicification of manufacturing" (e.g. Miroudot and Cadestin 2017). This phenomenon manifests itself in several ways: (i) manufacturing is becoming more intensive in services as reflected by the number of services that are used as intermediate inputs; (ii) manufacturing jobs are becoming more services oriented – the number of workers performing service-related activities within manufacturing firms has grown; and (iii) services are increasingly embedded into or bundled with manufactured goods (e.g. after-sales services and financing schemes), a phenomenon known as "servitization".[7]

The servicification of manufacturing is closely related to digital technologies, which facilitate integration of the various stages of business processes. The easier digitization of services in the pre-production stage enables closer interaction between R&D, product design and production, creating a dynamic industrial

[6] Input-output data showing that this tendency is weaker for developing countries will be influenced by varying vertical organization of production, with manufacturing firms in developing countries, including subsidiaries of MNEs, issuing more in-house services than those in developed countries.

[7] Manufactures also seem to drive the complementarity between services and manufactures in exporting. For example, Ariu, Mayneris and Parenti (2020: 2) show that for exporters that export both manufactures and services "the goods are the main activity of the firms, while services only sometimes complement goods provision" and that "bi-exporters almost never export services in destinations in which they do not offer goods".

environment where firms benefit from knowledge spillovers (Pisano and Shih 2012). The easier digitization of post-production stages, i.e. branding, advertising and retail, has reduced the cost of customization and enabled firms to use data on customer preferences for a low-cost alignment of product design, production and sales where offerings are tailored to customer preferences. The resulting business model of mass customization does not only serve customer demand better but also allows a firm to better respond to concerns of customers regarding its responsibility to contribute to environmental and social well-being. Indeed, one of the reasons for servicification is that it allows a manufacturing firm "to use services such as market research and R&D services in preparation for export-entry and marketing and design services for continued presence in the export market" (Lodefalk 2014: 61).[8]

But even though there is no evidence that the global economy is running out of opportunities for manufacturing, industrialization as a development strategy may be more complex going forward, mainly for three reasons. First, the opportunities for developing countries to export manufactures to developed countries have declined. Part of this decline results from the sluggish growth performance of developed countries and the sharp decline in the trade intensity of global output growth, which have been important characteristics of the global economy since the GFC and are likely to intensify with the COVID-19 crisis. Another part of the decline relates to a backlash to globalization in developed countries caused by concerns that increased imports from developing countries have contributed to increased income inequality (Autor, Dorn and Hanson 2013).

Meanwhile, export-oriented manufacturing may become more complex due to concerns about the robustness and resilience of geographically widely spread supply networks. The COVID-19 crisis has intensified such concerns and related reassessments of the optimal balance between efficient and undisrupted production. A shortening of supply chains to increase their resilience might deprive many developing countries of opportunities for export-oriented manufacturing. However, developing countries can also enhance supply-chain resilience by adopting digital technologies that increase transparency along the supply chain and allow developed country firms to monitor and respond to potential disruptions before these endanger their survival.

Second, the digital revolution can make production more efficient especially in developed countries that are adopting digital technologies more rapidly than developing countries. Much of this debate has focused on robotization and the potential reshoring of manufacturing to developed countries. Robotization may be labour saving and transform production processes by reducing the importance of wage costs. But closer inspection suggests that robots are not yet suitable for low-wage, labour-intensive industries, leaving the door open to enter industrialization along traditional lines for some time to come. Nevertheless, the window of opportunity in labour-intensive industries will eventually close as the cost of robots declines further, making them spread to lower-wage manufacturing sectors and eventually to lower-income countries (Mayer 2018a).

[8] Many existing studies discuss servicification in the context global value chains (GVCs) (e.g. Miroudot and Cadestin 2017), including because empirical evidence for servicification usually relies on input-output data that have become a mainstay of GVC-analysis. But servicification is a broader phenomenon, as further discussed, e.g. by Lodefalk 2014.

Third, as discussed above, digital technologies affect how services and manufacturing interconnect, with the international aspects of this dimension determined by how the use of the various digital technologies change trade costs and productivity. These mechanisms have so far been discussed for robotics and services as end products (e.g. BF). How they relate to other digital technologies and issues associated with manufacturing based on the input of data are the focus of the remainder of this paper.

3. Production cost differences and trade costs: a simple Ricardian approach

This section examines how digital technologies affect the cost incentives for trade in goods and services and their impact on productivity in manufacturing. It expands on the basic Ricardian setting in BF. The approach starts from the proposition that goods and services are traded when international differences in production costs exceed trade costs, where the latter include policy-induced trade barriers (i.e. tariffs and non-tariff barriers), transportation costs and the costs of transmitting information and data.

The cost of production of a given good or service is the combination of unit labour costs and the unit cost of all other inputs. The unit labour cost *c* in sector *i* in a typical country is defined to comprise a unit labour input coefficient, a_i, and the wage, so that the unit labour cost is wa_i. The cost of all other inputs, r_i, includes capital costs (e.g. machinery), intermediate inputs, taxes and the like. Labour is assumed to be perfectly mobile across sectors but perfectly immobile across countries, while all non-labour factors are perfectly mobile across countries and freely traded, so that they represent the same cost in all countries. BF therefore express the unit production cost of a good or a service *i* in a country as depending on its labour costs relative to other countries and the importance of labour costs in its total production costs:

$$c_i^n = w^n a_i^n + r_i$$

where *n* denotes the nation under consideration (the North, i.e. developed countries, in this case).

The proportional difference between the production cost in *i* in the two nations (denoted by *n* and *s*) is:

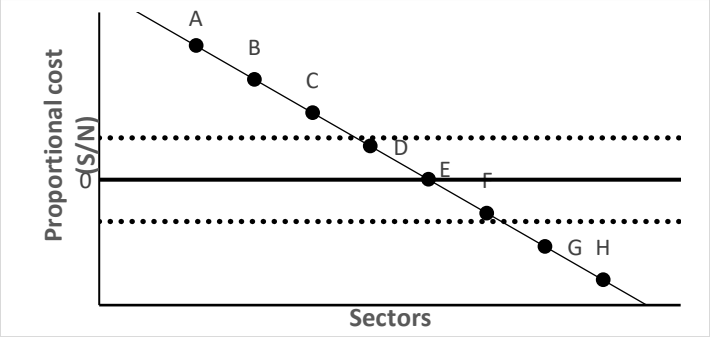
$$\frac{c_i^n - c_i^s}{c_i^n} = \theta_L(1 - \frac{w^s a_i^s}{w^n a_i^n})$$

where θ_L is the labour cost share in the North.

To examine the implications of this setting for the sectoral structure of the international division of labour between developed and developing countries, BF use a modified version of Dornbusch, Fischer and Samuelson (1977) whose specific characteristic is the assumption of a continuum of goods. Further assuming workers in the North to be more productive than workers in the South, but to different degrees in different sectors, wages in the North exceed those in the South (measured in terms of the numeraire). As a result, the North has a comparative advantage in those sectors where productivity differences are largest, while the South has a comparative advantage in those sectors where these differences are smallest, i.e. where its relative wage is lower than its relative productivity. Figure 1 plots the proportional production cost difference between developing and developed countries for each sector, i.e. $(c_i^s - c_i^n)/c_i^s$,

on the vertical axis and the various sectors on the horizontal axis. The sectors are labelled such that A is the sector where the cost advantage of developed countries is highest (such as high-tech machinery), and H is the sector where the cost advantage of developed countries is smallest (such as apparel).[9]

Figure 1: Production cost differences and trade costs in a Ricardian approach



Source: Adapted from Baldwin and Forslid, 2020.

Developed countries export the goods and services where their technological edge outweighs their higher wage level, i.e. in sectors where production costs are higher in developing than in developed countries. This means that only developed countries export from sectors A to D, while only developing countries export from sectors F to H. Neither developed nor developing countries export from sector E, where the difference in production costs is zero.

For simplicity, BF assume trade costs to be the same for all goods and across all countries.[10] Figure 1 represents trade costs by the dashed horizontal lines that for both developed and developing countries are at the same distance from the good for which the difference in production costs is zero. Under these assumptions and looking at sector D, proportional production costs in the South are higher than in the North, but the gap is less that the per-unit trade cost, i.e. sector D is below the upper horizontal dashed line. In this case, Northern goods will not be cost-competitive in the South, given that they must bear the trade costs, while Southern goods from sectors D to H are uncompetitive in the North. As a result, each nation supplies its own consumption in sector D (as well as goods in sector F where Southern goods are not cost-competitive in the North), i.e. these goods are not traded but their production is fully localized.

Given that this simple set-up emphasises entire sectors, it cannot accommodate production sharing within economic sectors and ensuing intra-industry trade, whereby developed countries offshore labour-intensive production stages to and import ensuing products from low-wage countries, while they maintain

[9] In a Heckscher-Ohlin setting, the continuum of goods would be determined by relative factor endowments, with unit production costs lowest in goods that make extensive use of a relatively abundant factor of production, as e.g. in Feenstra and Hanson, 1996.

[10] In the real world, trade costs differ across products and countries, e.g. because of differences in trade policies and distance-related transportation costs, as well because of differences in the composition of countries' import and export baskets. However, including these features would unnecessarily complicate the graphic representation of the approach, without changing its main features.

higher-wage production stages in their economies. The following discussion of the impact of digitalization on this basic setting will account separately for issues related to production sharing.

4. The differential impact of new digital technologies on trade costs in manufactures and services

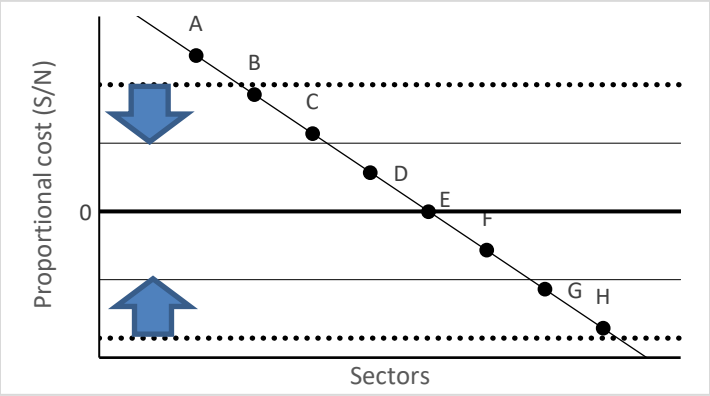
The simple set-up in the previous section allows for an examination of how digital technologies affect the international division of labour regarding sectors A to H. Similar to BF, the examination assumes that new digital technologies lower trade costs and the share of labour cost in total production costs, but not to the same extent. For services, the main impact of digitalization is the reduction in trade costs associated with reduced costs of transmitting information and data. For manufactures, by contrast, the main impact of digitalization observed so far is the reduction of the share of labour in total production costs. According to BF, this is because robot use has so far been concentrated in goods production and because the main reduction in trade costs of goods already occurred with containerization and air cargo.

The examination proceeds in two steps. First, it looks at services and manufactures separately. This part expands on BF, first, by including both short-term and long-term dimensions of robot deployment and by adding some considerations regarding 3D-printing and CAD/CAM-technologies. The section, then, goes beyond BF by focusing on data as a services input and examining ensuing implications for manufacturing. This step starts by applying the main logic of BF to the setting introduced in the previous section. It, then, moves to a setting concentrating on developing country markets with three different varieties of a specific manufacturing sector. This setting focusses on potential impacts of big data technologies on the reduction of trade costs for foreign firms and related variables that determine relative market shares of foreign and domestic firms regarding the middle segment in this sector.

4.1. *The digitalization of services*

Regarding services, BF assume that digitalization affects labour cost shares only marginally but drastically reduces trade costs. Figure 2 reflects this by a narrowing of the space between the two horizontal line and a resulting increase in the number of services sectors that are traded. This implies, for example, that developing countries acquire a comparative advantage in services sectors G and H, while they will start importing from developed countries services in sectors B and C.

Figure 2: Digital technologies and comparative advantage in services sectors



Source: Adapted from Baldwin and Forslid, 2020.

Sectors B and C could be services that serve as inputs to manufacturing, so that increased tradability of services would foster industrialization in developing countries. For example, such sectors could include software and blueprints required for design with CAD/CAM technologies or cloud computing services that would enable developing countries to use algorithms and artificial intelligence for their manufacturing processes more easily.

Meanwhile, acquiring a comparative advantage in sectors G and H could allow developing countries to initiate export-oriented services-led development strategies. However, these sectors largely rely on low unit labour costs and are likely to include activities with little potential for productivity growth, such as wholesale and retailing, or tourism. Therefore, it is unlikely that they would provide a developmental potential similar to manufacturing.

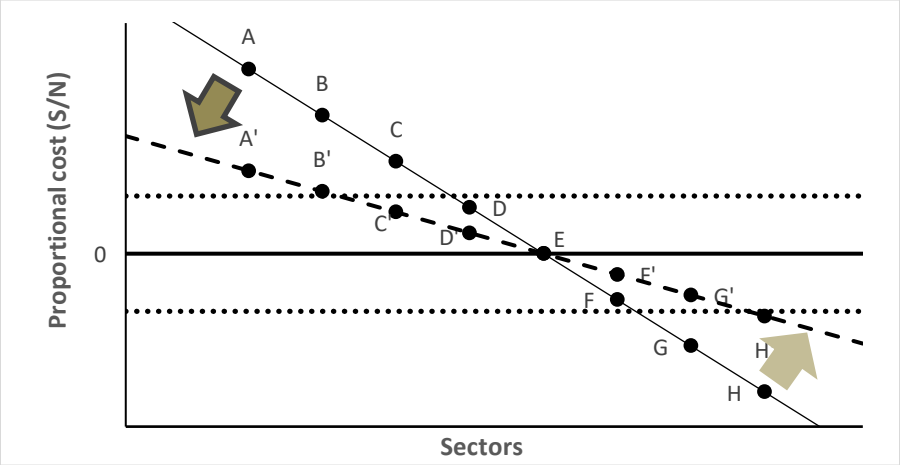
Moreover, the quality of employment created in these sectors is likely to be low. For example, evidence suggests that labour compensation in the industrial sector is somewhat higher than in services for comparable workers (IMF 2018). Manufacturing jobs also tend to be characterized by valuable non-wage attributes, including formal employment arrangements with associated benefits for workers, such as access to minimum wages, labour codes, retirement plans, paid holidays and sick leave, and health and life insurance. They also tend to provide relatively stable arrangements, relying less on part-time or temporary contracts than other sectors, and may offer collective bargaining via unions (Jaumotte and Osorio Buitron 2015).

4.2. *Manufacturing and industrial robots*

BF apply the above setting to industrial robots assuming no change in trade costs but a sizable decline in the labour-cost share in production. Figure 3 reflects this decline in the importance of labour-cost differentials for international competitiveness by a rotation of the line that align the various sectors according to proportional cost differences towards the zero line. Given that industrial robots have been adopted mainly in developed countries, this rotation occurs only for the upper part of this line in the short

run (indicated by the dark grey arrow in figure 3). It will eventually also occur in the lower part of the line, when the price of robots will have become sufficiently low for robotization to spread widely also into developing countries (indicated by the light grey arrow in figure 3). In terms of sector-specific effects, the displacement of workers by robots reduce comparative advantage based on international differences in unit labour costs. Accordingly, Northern producers lose their comparative advantage in sector C, where production becomes non-traded.

Figure 3: Robot use and comparative advantage in manufacturing



Source: Author's elaboration on Baldwin and Forslid, 2020.

However, robots do not only reduce the share of labour in total production costs but also improve labour productivity. If developed countries apply robots in all sectors, the zero line shifts downward. This may imply that Northern producers maintain their comparative advantage in goods from sector C and that they acquire a comparative advantage in sector D. It may also imply that Southern producers lose their comparative advantage in sector G, which may be interpreted as reshoring. Evidence indeed indicates that the productivity effect dominates the labour displacement effect (e.g. Frey 2019) and that, in terms of sectoral effects, robot adoption, for example in the automotive sector of Germany, is accompanied by only marginal employment effects but substantial export growth (Mayer 2018a).

Once robots become widely used also in developing countries, the zero line will move upwards, and the sector-specific effects may reverse towards the initial pattern of comparative advantage. By contrast, the rotation of the proportional cost curve persists, with the entire curve eventually entering the space delineated by the horizontal lines reflecting transport costs. In the very long run, this development implies a virtual cessation of international trade in manufactures and a virtual cessation of the potential of export-oriented manufacturing as a development strategy.

A decline in the cost and an improvement of the functionality of 3D-printers, with an ensuing adoption of additive manufacturing at an industrial scale, will accelerate these effects. Additive manufacturing already

allows for rapid prototyping and physical testing of components and functional properties of products.[11] This implies significantly lower cost and shorter time periods for product development. Additive manufacturing will eventually increase the flexibility of the entire manufacturing process and enable the production of small series at low cost (i.e. similarly to the cost of mass production). Higher personalization of products and better responsiveness to customers' requirements can be achieved with orders automatically passing through the production planning process to machine control, which reconfigures the machine to process individual orders.

In a model that is also based on a Ricardian setting with a given level of trade costs, but which includes the production of intermediates in addition to final goods, Artuc, Bastos and Rijkers (2020) show that robotization in developed countries increases developed country exports of final goods to developing countries and decreases (increases) developing country exports of final goods (intermediate inputs) to developed countries, with an overall reduction in net exports of developing countries. This decline in net exports mirrors the above finding that robotization will tend to reduce exports from developing countries.

4.3. *Manufacturing and data as a services input*

This section examines the effects of reduced trade costs for services that serve as inputs to manufacturing on comparative advantage in manufacturing. It focuses on data on customer preferences.

4.3.1. *Insights from the recent trade literature on multi-product firms*

The Ricardian setting discussed so far reflects the 'old trade theory' view that countries export a homogenous product in one sector and import another one in a different sector and that international trade involves only many small firms. However, recent empirical evidence shows that a few large firms dominate a country's exports and that they supply many product varieties (Bernard et al. 2007; Freund and Pierola 2015). The related theoretical literature on heterogeneous firms and the determinants of firm size (e.g. Melitz and Redding 2014; Hottman, Redding and Weinstein 2016; Bernard et al. 2018) initially focused on productivity, including productivity growth from firms' self-selection into export markets (e.g. Melitz 2003). It has increasingly considered also demand-side factors, notably in the form of "appeal", i.e. vertical quality differentiation or subjective differences in consumer taste (e.g. Hallak and Schott 2011; Feenstra and Romalis 2014; Aw and Lee 2017), and the ability to supply multiple products (Arkolakis 2010; Bernard, Redding and Schott 2010, 2011; Eckel and Neary 2010; Mayer, Melitz and Ottaviano 2014; Eckel

[11] Mayer, 2018b, reviews existing literature on how intellectual property rights and patents may limit the industrial use of additive manufacturing, concluding that such constraints are probably significantly lower than sometimes hypothesized (e.g. Andreoni and Anzolin 2019).

et al. 2015; Hottman, Redding and Weinstein 2016). These empirically motivated studies have put productivity issues related to multiproduct firms at the centre of recent trade theory.[12]

One emphasis of this literature is that the fixed costs that firms face in serving a market and in supplying each product to each market determines the product scope of multiproduct firms.[13] Assuming (i) a market structure of monopolistic competition that emphasizes product differentiation and increasing returns to scale at the firm level, and (ii) market behaviour where firms maximize profits by varying quantities, firm-level decisions on market entry need to balance variable profits against the fixed costs of exporting and of broadening the product scope supplied to a specific market. An important conclusion of this literature is that decisions on what products a firm supplies to what market depends on combinations of firm, product and market characteristics: only the firm with the lowest market-specific component of the fixed cost related to market entry and/or with the highest market-specific component of demand can sustain entry into a market and expansion of product scope in that market (e.g. Melitz and Redding 2014).

One line of this literature on multiproduct firms focuses on uncertainty. Firm-specific uncertainty about export profitability and about persistent demand components in a potential export market require new exporters to incur search costs and, therefore, to start by exporting varieties that they have previously been selling on their domestic market (e.g. Iavocone and Javorcik 2010). Uncertainty and the related fixed cost of market entry tend to be lower for homogenous goods, for which global reference prices and quality standards are available. By contrast, attempts by producers of heterogenous goods to reduce such uncertainty and reach more, and different, customers incur substantial costs of market intelligence and marketing (Arkolakis 2010). Firms adjust the intensity of market intelligence by using acquired information to update their beliefs on the profitability of their exports.

Local firms are presumed to have better knowledge about local circumstances and customer preferences. Accordingly, the heterogeneity of demand across countries may be a demand-side explanation for the frequently observed positive correlation between an economy's production and consumption structure, i.e. what has been called "home bias" (e.g. Markusen 2013; Coşar et al. 2018). However, foreign firms could offset this advantage of local firms. Controlling foreign market data reduces their uncertainty, and related fixed costs of market entry, as to whether they can reach customers in foreign markets that demand product features and functionalities that differ from those on their traditional markets (see also Diez, Mora and Spearot 2018).

Another line of the literature on multiproduct firms relates to firm differences on the supply side. It sees adjustments in the product scope of a multiproduct firm to be based on its core competence and average productivity. Assuming that (i) a multiproduct firm’s costs of production differ across products, (ii) these

[12] In most of this literature, consumer preferences take the form of constant elasticity of substitution (CES), which implies love of variety: utility is increasing in the measure of varieties consumed, while consumption of any given variety provides diminishing marginal utility but approaches infinity as its consumption approaches zero. The bulk of this literature follows a Ricardian setting with a market structure of monopolistic competition: production of any variety involves a fixed production cost in terms of units of labour and a variable cost that depends on a firm’s productivity. For a Heckscher-Ohlin approach to firm heterogeneity, see Melitz and Redding (2014: section 7).

[13] The scope of this fixed cost goes beyond the framework of BF who emphasize trade costs related to distance and trade policy.

differences apply to the firm rather than being specific to particular markets, and (iii) all of a firm's products are differentiated from its rivals' products as well as from each other, this approach shows that products closer to a firm's core competence have lower costs and that multi-product firms adjust to shocks that increase both the size of the potential market and the extent of competition by dropping some of their marginal products while trying to expand sales of their core products (Eckel and Neary 2010).[14] In doing so, the firm increases its average productivity and avoids product cannibalization, i.e. that rising demand for its marginal product varieties displaces demand for its core variety. One source of such a shock to a developed-country multi-product firm might be an increase in developing countries' purchasing power sufficiently strong to provide a potential new market for one of the firm's marginal varieties, combined with increased competition from local firms whose core competence technology is more efficient in producing the variety of that product whose functionalities and price matches best the potential new customers' desires.

Eckel at al. (2015) combine demand and cost aspects by extending the core-competence model to allow for investment in advertising and marketing (such as in Arkolakis 2010) to enhance the perceived quality of their products. They show that quality-based competence is higher for firms in heterogenous goods sectors than in homogenous goods sectors, in both domestic and export markets. In a similar vein, Mayer, Melitz and Ottaviano (2014) show that firms focus on their best performing products in markets with the toughest competition. Similar research suggests that firms producing different varieties of goods, such as similar goods but of different quality, experience diseconomies of scope in producing many varieties, and that the extent of these diseconomies increases with growing distance from the firm's core variety (Arkolakis, Ganapati and Muendler 2016). One element of such diseconomies is higher market-access cost for an exporter's minor varieties, for example because of additional cost in access to data on consumer preferences regarding additional products further away from a firm's core competency.

Common to these lines of recent trade literature is the insight that firm-level productivity in a given product or a given product variety is determined by two parameters: a firm-level measure of ability, where products or product varieties closer to a firm's core competence are produced more efficiently, and firm-product specific expertise, which is determined by knowledge of consumer preferences. Both parameters affect trade and under certain conditions may be correlated across products or product varieties. This will be the case when higher productivity from producing closer to core competence and with better knowledge of consumer preferences allows a firm to earn higher variable profits to offset fixed market entry costs. Empirical evidence (Aw-Roberts, Lee and Vandenbussche 2018; Fontagné, Secchi and Tomasi 2018; Macedoni and Xu 2020) suggests that these two parameters intimately interact – with closeness to customer preferences playing a crucial role, because the selection of products that a firm exports differs across markets, whereas it would be the same if the firm's product scope was determined by its core competency alone.

[14] Bernard, Redding and Schott (2011) also show that only the most productive firms manufacture a wide range of products, as it is only them that can cover the fixed costs associated with multiple products. A multi-product firm decides to drop or add products depending on interactions of shocks to its overall profitability coming from changes in its productivity and the attractiveness of its products to consumers vis-à-vis other producers of the same product.

This interaction between firm-level productivity parameters and customer preferences also highlights the close relationship between demand-side approaches and more traditional supply-side models. The choice of a specific product mix that a firm supplies to a specific market increases the firm's productivity (Bernard, Redding and Schott 2010, 2011) as do product-specific technology adoption and innovation (e.g. Aw, Roberts and Xu 2011; Sampson 2019) in more traditional settings. A firm can offset the fixed cost of market entry and increase productivity by exporting a broad range of products if its product mix matches the required quality and revealed consumer preferences of its target market. In addition, productivity measures are mostly based on revenue relative to factor inputs and thus go beyond simple measures of technical efficiency to include management and organisational efficiency, as well as demand factors such as consumer preferences for price/quality combinations of specific product varieties. Moreover, since higher quality products are more expensive to produce, the inclusion of product quality straddles the demand and cost sides of firms. In this sense, the approach outlined in section 3 may be nested in a broader one, where productivity is most important in markets with low degrees of product differentiation and where quality improvements are expensive, while demand factors become more important in markets with increasing degrees of product differentiation and decreasing costs of quality improvements (see also Aw and Lee 2017).

These findings have important implications for North-South trade relationships. Demand patterns in developed countries differ from those in developing countries because of both higher requirements for quality and functional sophistication, associated with higher per capita incomes, and national demand idiosyncrasies unrelated to income. Understanding these differences requires information about prevailing customer preferences and their evolution. In this respect, a local firm whose embeddedness in local markets provides low-cost knowledge about local customer preferences and whose core-competence product matches domestic demand patterns has an advantage[15] over foreign firms, for which acquiring knowledge about demand in the domestic market requires a systematic and costly efforts. Hence, control over market-related data becomes a key determinant of what firm supplies what market, as discussed in the following section.

4.3.2. Firm heterogeneity and multiproduct firms in a development perspective

This section integrates the insights from the recent trade literature on multi-product firms into the Ricardian approach presented in section 3. It deviates from BF and assumes customer preferences to be heterogenous and dependent on per capita income, which implies demand structures to differ between developed and developing countries. The focus on multiproduct firms implies that adjustment to exogenous changes in trade costs occurs through changes in product scope, with firms adding (dropping)

[15] Big data technologies can enhance this natural comparative advantage of domestic firms. These technologies replace random sampling and can easily merge different sources, whereby local knowledge facilitates data interpretation and augment the benefits of big data technologies that detect patterns and correlations but do not provide any guidance for interpretation.

products produced at gradually declining (increasing) technical efficiency.[16] With a given exogenous change, a firm's adjustment depends on its profitability and ensuing endogenous decisions regarding product scope and innovation and technology adoption that, in turn, determine its future productivity.

The section distinguishes two cases. The first case focusses on existing goods and emphasizes the fixed trade cost involved in gaining knowledge about consumer preferences in a new market. It argues that effective use of big data technologies can reduce this fixed cost in international trade and enables both Northern and Southern firms to broaden the product scope of their exports, but that existing digital divides mean that this decline in trade costs is limited to Northern firms.

The second case focuses on the emerging market of a new product variety in the South whose price/quality mix caters to the emerging middle class and is located between a variety supplied by a Northern firm to quality-conscious affluent customers and a variety supplied by a Southern firm to price-conscious poor customers. It argues that, to serve this value-for-money middle market segment, the Northern firm incurs a fixed trade cost as in the first case, while a Southern firm incurs a fixed cost regarding innovation and technology adoption required to broaden its product scope by including a higher quality variety. In addition to the size of these different fixed costs, the distance of the value-for-money segment from the firms' core competence and the size of this market segment also determine whether Northern or Southern firms serve value-for-money customers.

The section takes a development perspective and examines how the mechanisms discussed in the previous section can help firms from developing countries to expand their product scope such that the firm's overall productivity increases. While the first case may be interpreted as highlighting the support of big data technologies to export-oriented manufacturing, the second case is akin to expanding production beyond traditional low-productivity to modern high-productivity sectors, which defines structural transformation and can be considered the essence of economic development.

(i) Data on customer preferences and declining trade costs for existing products

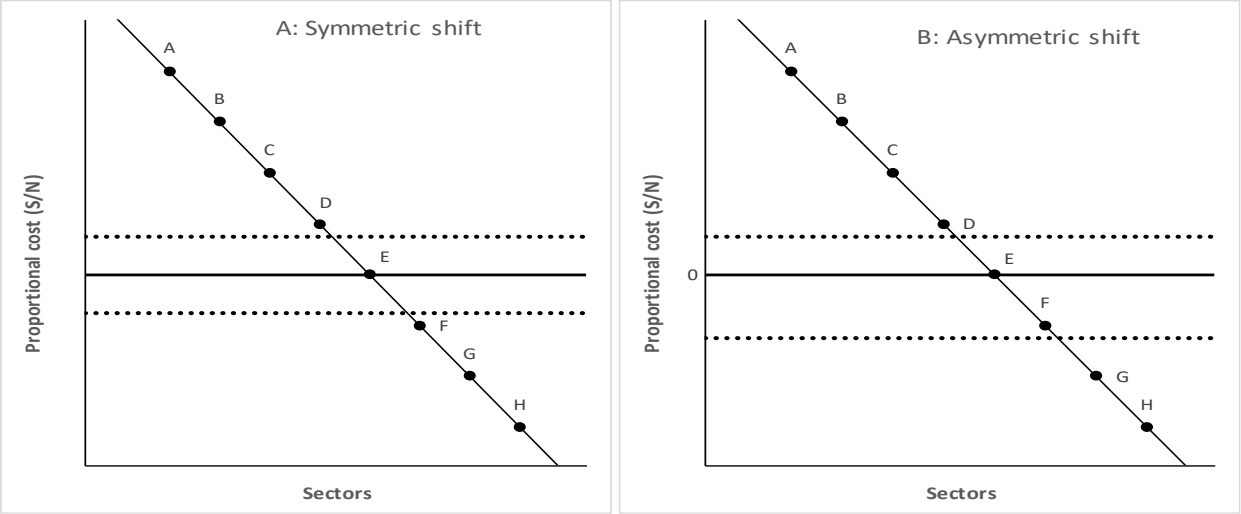
The first case regarding the impact of big data on firms' product scope assumes data on customer preferences to become ubiquitously available and that using big data technologies for their analysis leads to a general decline in trade costs. Figure 4A reflects this assumption in a symmetric shift of the horizontal lines towards the zero line. As a result, Northern firms can now include product D in their export product scope, while product F moves into the export product scope of Southern firms.[17] The extent to which these firms engage in exporting products D and F depends on the distance of the two products from the

[16] An exogeneous decline in trade costs can occur on the supply through product harmonization or improved port infrastructure that reduce costs of importers to service a market, and on the demand side through data availability and demand learning. The focus here is on demand-side causes.

[17] The inclusion of production sharing reinforces this mechanism as firms incur a fixed cost in decisions from which country to source inputs, e.g. to gain knowledge on the reliability of the supplier, similarly to the fixed cost in deciding which country to supply through exports (e.g. Bernard et al. 2018).

respective firm's core competence, the firms' respective market shares, and the implications of these two parameters on cannibalization effects, as discussed above.

Figure 4: Data and shifts in trade costs with a North-South digital divide



Source: Author's elaboration.

More importantly, the extent to which ubiquitous data availability reduces a firm's trade cost depends on its ability to use big data technologies. The extensive evidence on digital divides suggests that the hardware and software and the skilled labour required to make effective economic use of big data technologies are concentrated in developed economies, with China standing out among the developing countries that have narrowed the digital divide (UNCTAD 2019). This digital divide is reflected in figure 4B by an asymmetric move of the horizontal lines, with the trade cost of a Northern firm declining and that of a Southern firm remaining unchanged. This implies that, given current digital divides, the ubiquitous availability of data on customer preferences tends to benefit Northern firms, but not Southern firms.

A range of studies provide evidence showing that knowledge of demand-related data on destination markets is an important factor for sustained export activities. Regarding developed countries, Martin and Mejean (2014) show that tougher competition from low-wage countries has triggered an increase in the quality of French exports. Regarding developing countries, Artopoulos, Friel and Hallak (2013) emphasize product-specific fixed costs, pointing to informational barriers (Rauch 1999) and the need to pay fixed and sunk costs (Roberts and Tybout, 1997) that emerging exporters incur. They indicate that successful new exporters adapt their products to foreign demand and establish information channels to keep up-to-date about its evolving patterns (such adjustment also involves adapting production processes to adjust quality, comply with requirements of foreign distributers, and seek long-term relationships with them to secure up-to-date information about foreign markets). Artopoulos, Friel and Hallak (2013) examine case study evidence for Argentina[18] finding that the trigger for sustained export success was a pioneer exporter who had social ties with the business community of the target export market and could glean tacit knowledge

[18] Artopoulos, Friel and Hallak (2013) also discuss similar evidence for other countries, including in Africa.

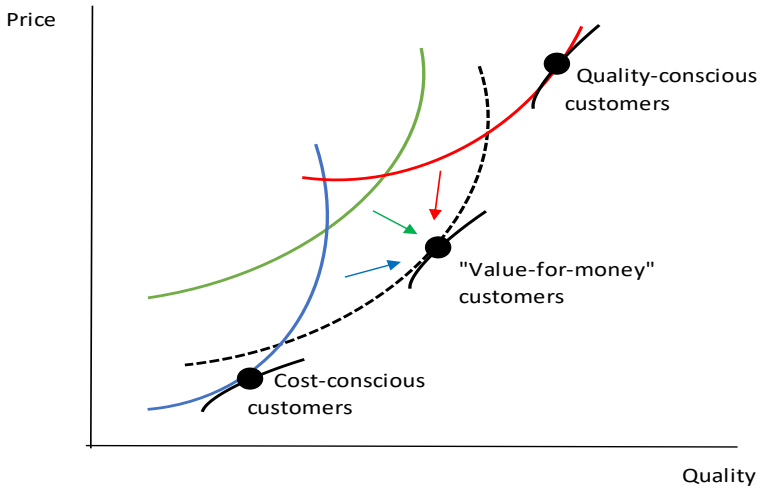
about viable ways pf establishing an export business based on the adoption of a new set of business practices. Manova and Yu (2017) provide similar evidence for China.

(ii) Big data, multiproduct firms and emerging product varieties

To discuss the second case, it is useful to shift from an economy-wide perspective with different sectors to a sectoral perspective with vertically differentiated varieties of a specific good. This shift allows for an incorporation of reduced export opportunities for developing countries and a rebalancing of their industrialization strategy towards a greater importance of domestic markets.

Similar to the model in Bernard, Redding and Schott (2010, 2011), figure 5 combines high, medium and low price-quality varieties of a product, i.e. quality-price production frontiers of firms that differ in innate productivity and whose product varieties vary in their attractiveness to different customers, and the indifference curves of customers with different preferences regarding the price/quality mix of a product variety. A quality-conscious customer will have a relatively steep curve, which touches the technological frontier of a high-productivity producer serving top customers (i.e. the red line). Northern firms will be placed best to serve quality-conscious customers because well-off customers in the South tend to aspire to the same tastes, habits and quality as consumers in the North. Price-conscious customers will have a relatively flat curve in the quality-price space, which touches the technological frontier of a low-productivity producer that serves base customers (i.e. the blue line). Southern firms will service price-conscious customers, given that their preferences are too far away from a Northern firm's core product for it to serve these customers in a profitable way. Value-for-money customers and producers with medium-productivity levels occupy intermediate positions (i.e. the green line). Figure 5 places this market segment halfway between quality- and price-conscious customers but its actual placement will differ across countries depending on the differences in the per capita of the three groups of customers.

Figure 5: Price-quality combinations of product varieties for three groups of customers



Source: Adapted from Fujimoto 2014 and Thun 2018.

The development question is under what conditions Southern firms can expand their product scope and supply value-for-money customers. These customers will orient their demand towards the firm that has the highest general appeal, where home bias will favour a Southern firm and brand consciousness a Northern firm, and that offers the product whose functionalities and price/quality mix matches best their preferences. A Southern firm incurs a fixed cost of product innovation to upgrade the price/quality mix of its products, while a Northern firm incurs a fixed trade cost to identify the preferences of value-for-money customers.

The profitability of these investments depends on the increase in variable profits that firms earn from increased sales relative to their additional fixed cost. It is determined by the interplay of several variables: (i) a larger distance of the value-for-money variety from a Southern firm's core competence product requires larger investment in product innovation, where the size of this investment depends on the cost elasticity of change in the price/quality mix and a low elasticity implies the need for greater investment in innovation to achieve a given change in the price/quality mix (Aw and Lee, 2017); (ii) a larger distance of the value-for-money variety from a Northern firm's core competence implies a larger decline in its average productivity and therefore greater difficulty in offsetting the additional fixed trade cost – the size of this effect is also determined by the degree of competition (Martin and Mejean 2014; Manova and Yu 2017); (iii) greater differentiation of the added variety from a firm's existing varieties implies smaller cannibalization effects and, hence, relatively larger sales of the new variety and larger increases in variable profits, with greater differentiation from the products of rivals having similar effects; (iv) a larger market for the new variety will allow each firm to sell more; and (v) firms with a large market share covering all existing varieties will tend to experience larger cannibalization effects and have less of an incentive to introduce new varieties, while firms with smaller market shares face smaller cannibalization effects so that introducing a new variety tends to increase their combined market share (e.g. Hottman, Redding and Weinstein, 2016).

The relative importance of these variables differs both across countries and across products and their impact depends on the general level of a firm's productivity. While a firm faces a general trade-off between cannibalization effects and increases in profitability from enlarging its product scope, how the discussed variables affect decisions of a firm to enlarge its product scope will be crucially affected by the size of required additional fixed costs – for a Southern firm regarding investment in product innovation and for a Northern firm regarding knowledge of customer preferences. These costs are outcomes of government policies that determine the cost which (i) a Northern firm incurs to access data on Southern customer preferences, and (ii) a Southern firm incurs to broaden its product scope and include a higher-quality variety. These policies are the focus of the following section.

5. Implications for data regulation and innovation policy

The previous section highlighted that data on customer preferences in developing countries are an asset. It also argued that harnessing these data for firm-level decisions on product scope and target markets affect firm productivity and relative shares of foreign and domestic firms in specific market segments. This

section focusses on data governance and innovation. These are among the major areas where developing countries may need policy adaptation to benefit from digitalization in pursuing industrialization as a development strategy.[19]

The section starts by discussing what form of data governance – norms, principles and rules that govern the treatment of data (Aaronson 2020) – might help developing countries to delineate the use of data and what role international rules on cross-border data flows and data localization might play in this context. It will then examine the impact on innovation policy resulting from an increased importance of data in development strategies and from a rebalancing of market orientation from a concentration on foreign markets towards emerging domestic market segments. This examination is based on the perspective that a prolonged sluggishness of developed country import growth, combined with a potential shortening of GVCs, makes servicing domestic value-for-money market segments increasingly important for continued industrialization and that developing countries without data processing and analysis expertise risk not being able to extend structural transformation beyond low-skilled, low-productivity activities. The provision of related new income opportunities will also help workers to meet their demand preferences without incurring debt and without causing rapid import growth, which with reduced export opportunities could eventually trigger balance-of-payments crises.

5.1. Data governance

Digitalization enables new business models that use data in ways for which existing rules and regulations are either inappropriate or uneven across countries. This situation has allowed a few very large digital firms, mainly from the United States and China, to assume dominant positions on world markets in certain areas. It has also led digital connectivity to advance much faster in some countries, causing significant digital divides between developed and developing countries (UNCTAD 2019).

Partly as a reaction to these uneven developments, debates on how to govern the data economy are intensifying. The COVID-19 crisis is likely to further accelerate shifts towards data-intensive business models and has added momentum to the debate. Urgency to finding consensus on data governance issues considered as amenable to rules and regulations at the World Trade Organization (WTO) has been related to proving continued ability of WTO-processes to attain binding agreement (e.g. Hufbauer and Lu 2019). This has resulted in a broadening of ongoing plurilateral e-commerce talks to include digital trade issues that go beyond narrowly defined areas concerning the electronic exchange of goods and services.

The rationales that guide the debates on regulating the data economy may be divided into four broad types (e.g. Casalini and Lopez Gonzales 2019). There is general agreement on the need for regulation in three of these rationales, i.e. to safeguard the privacy and prevent misuse of personal data; guarantee ready access to data for medical, fiscal, auditing or similar purposes; and protect access to sensitive data for national security reasons. Nevertheless, no agreed regulation in these areas has materialized (e.g. Hufbauer and Lu 2019), including because of (i) diverging national attitudes towards data privacy (e.g.

[19] For other challenges related to broader industrial and competition policy issues, see Mayer 2018b.

Aaronson 2020); (ii) significant difficulty in separating personal and personally identifiable data from other data, as well as in defining digital trade (Aaronson 2018); and (ii) difficulties in defining what kind of data are in the purview of national security interests, as exposed, for example, by the trade tensions between the United States and China. Part of these difficulties also relates to their overlap with the fourth rationale – enabling digital industrial policy. Perspectives on the soundness of this rationale diverge strongly, independently of whether digital industrial policy is defined narrowly as using targeted policy (i.e. industrial policy) to build domestic digital firms and bridge digital divides by building domestic digital and data infrastructure (e.g. Foster and Azmeh 2019), or broadly as using targeted policy to benefit from digitalization in industrialization strategies (e.g. Ciuriak 2018; Mayer 2018b; Andreoni and Anzolin 2019). Linking data governance to the broader definition of digital industrial policy has a direct bearing on development strategies because the growing importance of the data economy implies that emerging rules and regulation in this area shape the future directions of structural transformation in developing countries.

The mechanisms that determine the extent to which domestic and foreign firms can access data on customer preferences, emphasized in the previous section, mainly concern governance of cross-border data flows and data localization requirements. Regulation on cross-border data flows may refer to ex-post accountability for the data exporter if the data sent abroad are mis-used; demand determination of general adequacy rules, e.g. concerning standards in receiving countries guaranteeing privacy and preventing misuse; or require case-by-case review and discretionary decisions, e.g. relating to data deemed important for national security or economic reasons.[20] Closely related to regulation on cross-border data flows are data localization requirements, whereby all equipment to collect, analyse and transfer data internationally must be located in a defined country. These may relate to rapid and easy access to specific data, e.g. for medical, fiscal or auditing purposes, and not be accompanied by flow or processing restrictions, or be combined with such restrictions to guarantee national sovereignty over the protected data.

One argument of proponents of free cross-border data flows and the absence of localization requirements is that an efficient functioning of GVCs and free access to global services require moving data across national borders with minimal impediment. Findings that such impediments inhibit imports of data-intensive services and reduce productivity of local firms in sectors more reliant on data (e.g. Ferracane, Kren and van der Marel 2019) may be taken to support this argument. However, these findings currently concern services-led development strategies, as low-productivity services activities (such as retail, publishing, and real estate) are the most intensive users of data-intensive services. The findings would pertain to the use of data on domestic consumer preferences only if such data were transferred abroad for storage, processing or analysis and subsequently re-imported, i.e. a process that these measures are meant to inhibit. Perhaps most importantly, to the extent that digital divides allow only developed country

[20] For an overview of countries with domestic policies to regulate data or the data-driven economy, see Aaronson, 2018. See also the database of the Digital Trade Restrictiveness Index (DTRI), accessible at https://ecipe.org/dte/database/, where data policies represent one of three parts that constitute the cluster on restrictions on data, which combined with three other clusters compose the DTRI.

firms to process and analyse data on domestic consumer preferences, removing impediments to cross-border data flows will benefit these firms, but not firms from developing countries.

A second argument[21] is that impediments to cross-border data flows would prevent domestic consumers from accessing services of global digital firms, as well as small domestic enterprises from trading digitally and exporting to markets that so far are accessible only to large firms and MNEs. These arguments point to benefits from e-commerce and digital services exports, where these benefits may be measured by the value of goods and services subject to digital trading. Such activities are largely unrelated to data on domestic consumer preferences, where related benefits would be measured by the income that this use of data generates and the impetus to industrialization and structural change it provides.

Opponents of free cross-border data flows and advocates of data localization requirements point to cybersecurity, data privacy and public policy objectives, such as regulatory oversight of the financial or other sectors and national security, whose benefits are hard to quantify. They also argue that the data economy continues to evolve rapidly and that governments need time to adapt institutions and policy frameworks to these changes; and that digital divides will need to be narrowed to level the playing field before adopting binding rules and regulation (e.g. Foster and Azmeh 2019). From this perspective and given existing digital divides, binding agreements on free cross-border data flows would not only lock-in a status quo where already established digital firms and frontrunning countries continue to benefit disproportionally from the value that data processing and analytics generate, but any rules and regulations based on current circumstance may prove inappropriate as perceptions about what constitutes legitimate regulation may continue to evolve.

Part of these arguments relates to experience from the multilateral Uruguay Round agreements and especially the many bilateral and regional free trade agreements that have constrained the space of developing countries to use policies that they consider appropriate to support industrialization and that the now-developed countries used during their industrialization processes. Developing countries accepted these constraints in exchange for improved access to developed country markets and potential enhanced inclusion into GVCs, expecting significant progress on their industrialization agenda. As discussed in section 2, sluggish growth in developed country import demand and a likely shortening of GVCs, combined with already low access barriers in most areas of developed-country markets, reduce the incentives for developing countries to make a similar bargain on data governance.[22]

Policymakers confronting data governance may thus face two trade-offs. A first trade-off implies the need to balance the potential costs of governance of cross-border data flows and data localization for e-commerce and services exports against the benefits in terms of data privacy, cybersecurity and national security. The second trade-off regards industrialization strategies. A focus on inclusion in GVCs and export-oriented industrialization may require free cross-border data flows and no localization requirements to

[21] Digital rights groups oppose restrictions on cross-border data flows and data localization requirements for non-economic reasons, fearing their use by governments to restrict freedom of expression and pointing to the concept of net neutrality and the principle that the Internet should be open access and non-discriminatory.

[22] Nonetheless, removing remaining market access barriers on agricultural and "sensitive" industrial items could provide sizable additional export opportunities largely in low-skilled intensive manufacturing and agriculture.

allow for real-time information on potential bottlenecks and disruptions along the supply chain. By contrast, more domestically oriented industrialization calls for reinforced governance of data that tracks customer preferences. Hence, this second trade-off is only apparent: the two strategies rely on different types of data and therefore are not mutually exclusive.

Focusing on the implications for data governance of the domestically oriented part of industrialization, broadly defined digital industrial policy would demand that data on domestic customer preferences be used only by domestic firms. Accordingly, such data would be classified "important" and allowed to be stored and processed abroad, e.g. by providers of cloud and online processing services, only upon discretionary decision[23] by a competent authority, where the risk of such data leaking to unauthorized users would be a major determinant.[24] Data localization requirements play an important role for digital industrial policy in its narrow definition as they are intended to spur the building of a national digital and data infrastructure. The availability of such an infrastructure will facilitate exclusive access of domestic firms to data on domestic customer preferences if storage in the cloud and processing through specialized software providers is considered as having too high a risk of data leakages. Building domestic digital and data infrastructure is costly and its rationale will need to be assessed against the benefits from using much cheaper cloud services and the associated risks of data leakages. On the other hand, the high energy consumption of data centres may give developing countries with access to cheap, and possibly renewable, energy a comparative advantage and provide an incentive for providers of cloud services to locate their data centres in developing countries.[25] Depending on legal arrangements regarding such data centres, developing country hosts could use part of them under their national jurisdiction.

The relative importance of the export-oriented and the more domestically oriented parts in such a re-balanced industrialization strategy will depend on country-specific circumstances. Following such a strategy nonetheless implies significant uncertainty, including because of the dearth of knowledge on the benefits from big data for industrialization. Virtually all existing evidence on the benefits of big data for development relates to humanitarian areas, such as health, education or food security issues, or the optimal provision of utilities (e.g. energy) and public transport (e.g. UN Global Pulse, 2020; Hilbert 2016). Narrowing this knowledge gap is an important research agenda.

Another source of uncertainty concerns the implications of such a strategy for innovation policies that developing countries have pursued with a focus on export-oriented industrialization and that may need adaptation for a more balanced strategy. This is the focus of the following section.

[23] Such and similar decision-making authority by national policymakers could be reflected in law as "legitimate public policy exceptions" from free flow of data. This would extend the potential range of such exceptions beyond more traditional issues related to consumer protection, privacy and protection of personally identifiable information.
[24] See Aaronson, 2020, for a discussion of attempts to ensure that Canadian and German laws apply to Canadian and German personal or government data when it is stored on the cloud.
[25] Mayer and Banga, 2020, provide data and further elaboration on this issue.

5.2. Innovation policy

Innovation policy in developing countries has traditionally targeted improved access to international sources of technology and knowledge, combined with improved local capabilities required to identify appropriate technology transfer mechanisms and facilitate the absorption and adaptation of imported technology to local conditions (Fu 2015). Only more recently have these policies given greater attention to indigenous strengths and independent local sources of product and marketing innovation. These efforts have departed from only mixed evidence of technology transfer and knowledge spillovers from MNE-subsidiaries (Fu and Gong 2011; De Marchi, Giuliani and Rabellotti 2017) and built on progress on certain innovation variables (e.g. Cornell University, INSEAD, and WIPO 2019).

There is also increasing awareness that traditional innovation lacks inclusiveness.[26] Large swaths of the population have not benefitted from innovation either as consumers of affordable products whose functionalities respond to their needs, or as producers that create value through product innovation and improve their income and standards of living. Concerns about insufficient inclusiveness have given rise to the concept of "frugal innovation", which spans a wide range of social, environmental, and economic considerations of how to advance local innovation in developing countries. The definitions of frugal innovation are as diverse as its delineation from cost, reverse, or good-enough innovations. While the various definitions often emphasize social aspects (Bhatti et al 2018), their economic dimensions share the perspective of effective innovation leading to outcomes that combine cost effectiveness and affordability with functionality and performance features that meet the expectations of resource-constrained customers. The attributes of these outcomes strongly depend on specific customer needs and market characteristics.[27] But their application beyond initial bottom-of-the-pyramid orientations, including for some market segments in developed countries[28], indicate common success factors, especially in relation to institutions that alter the capabilities and incentives for effective innovation targeted at specific new market segments. Accordingly, these institutional factors may serve as reference points for the emergence of a middle-class market segment in developing countries, emphasized here.

Targeting specific new market segments primarily means approaching innovation from a customer demand perspective and optimizing design in terms of functionality and performance characteristics. This

[26] One prominent efforts towards more inclusive innovation is China's indigenous innovation policy, which was officially announced in 2006 in the 2006-2020 Medium and Long-Term National Science and Technology Development Plan. The plan includes geopolitical considerations and targets high-technology areas through mega-projects that are supported through R&D tax incentives, government procurement, and strategies for intellectual property rights and technology standardization. Given its sectoral focus and link to geopolitics, China's indigenous innovation policy only loosely relates to the emphasis on specific market segments in this paper and, therefore, is not further discussed.

[27] Evidence on frugal innovation is mainly anecdotal, but see Pisoni, Michelini and Martignoni 2018, and Ernst el al. 2015, for more general findings.

[28] Part of frugal innovation in developed countries relates to environmentally conscious citizens who choose frugality and voluntarily follow resource-saving production and consumption patterns that, if generalized, may facilitate reaching multilaterally agreed climate and energy targets (Pisoni, Michelini and Martignoni 2018). Another part relates to precarious work and income situations of a growing share of these countries' populations that might further increase with the COVID-19 crisis and could eventually provide opportunities for reverse innovation, i.e. an export market for outcomes of frugal innovation in developing countries.

implies an innovation process that relates to the entire gamut of product, process, managerial and organizational, and marketing innovation; emphasizes the interlinkages between design, production and marketing stages that digital technologies and the increased role of data in innovation enable; develops collaborations with local suppliers starting from the design stage to take account of informal institutional elements, which encompass local social and cultural practices; and gives start-ups and small firms a larger role in innovation processes than in settings that target exports to developed countries. As emphasized by Edler (2016), such inclusive innovation goes beyond innovations for the poor. Instead, it represents a major change in innovation policy, which goes beyond the traditional focus on supply-side conditions and capabilities and emphasizes demand-side instruments.

One starting point of approaches emphasizing user-driven innovation (e.g. von Hippel 1986) is fostering the "articulation of needs" (Edler 2016). While this articulation can be based on foresight techniques, big data analytics can significantly ease interaction between innovators, producers, and consumers. The availability of data on required innovative product functionalities and features and on expected market developments, combined with the capacity of analysing such voluminous data for design and production decisions, support the flow of information from consumers to innovators and producers. Those innovative firms – whether they are foreign or local – that control data on local demand patterns and are capable of analyzing these data through big data analytics are likely to have crucial advantages in designing, producing and marketing goods and services that result from user-based innovation.

An innovation process based on these features is considerably more complex than existing processes and its adoption demands significant state capacity that many smaller and poorer economies may not possess. In particular, it would need to take account of growing competition for the middle-market segment in developing countries from local subsidiaries of developed country MNEs. Evidence suggests that the growing importance of this market segment has prompted MNE-subsidiaries to change their strategic orientation and go beyond serving their traditional developed country market segments. They appear to have increasingly adapted their competencies and production processes not only to serve cost-conscious customers in developed markets but also to reach middle-market segments in developing countries (e.g. Giannetti and Rubera 2019), including by using their technological advantages to compensate for persistent gaps in knowledge on customer preferences and related marketing expertise. Existing innovation settings in developing countries are likely to be underprepared for such competition as they tend to be aligned to, rather than compete with, the competencies of MNE-subsidiaries. Yet, such competition may be crucial to ensure the persistence of incentives for continued innovation. Moreover, it may deepen the channels for closing technology gaps, as MNEs may more willingly localize production to increase their embeddedness in target markets. To the extent that localization implies joint ventures, local embeddedness could be linked to technology transfer arrangements that spur the innovation efforts of domestic producers.

An important question is whether traditional innovation processes, which target production for developed country markets and the ability to compete globally, can integrate the institutional features required for indigenous product innovation targeting domestic middle-market segments and for competition where the primary markets are domestic rather than foreign. An integration could be based on a shared business model and achieved through a modular approach with core design, features and standards employed for

both markets but flexibly adjusted according to customization requirements (Ernst et al. 2015). However, approaches of firms focused on production for export markets might differ significantly from the business model of firms using big data to design, produce and deliver products targeted on domestic middle-market segments: this business model bases value creation on customization and a significant degree of vertical integration rather than on mass production of standardized products; its value proposition emphasizes customer orientation and product variety; and its degree of social embeddedness and related emphasis on indigenous value and income generation is significantly larger. The two types of innovation processes may overlap only where joint leveraging of existing assets (such as infrastructure and other networks) is possible and where strategic alliances for collaborative partnerships can be formed.

It may also be difficult to incrementally integrate these new value creation and value proposition mechanisms into existing technology and production structures committed to raising productivity from economies of scale in production. Doing so would require an increasing coupling of some new digital applications to existing older technology, i.e. retrofitting to make old and new systems function in an integrated manner. It may therefore be more cost effective to enable two largely separate processes, i.e. (i) to maintain existing technology and production systems that will be continuously adjusted, such as through incremental robotization, to remain relevant for their more traditional purposes, and (ii) to create new firms that use new digital technology and production systems and target different market segments. Initially, the new digital systems could be used separately in the various stages of the manufacturing process, while a long-run objective would be to achieve fully integrated digital production systems that would allow quasi instantaneous responses in output adjustments to changes in data on customer preferences.

Uncertainty surrounding the achievability and viability of such innovation processes will be high and risk holding back related investment. Industrial policy can reduce this uncertainty by providing fiscal incentives and ensuring access to required digital technology, e.g. through dedicated industrial hubs and associated fiscal and infrastructural benefits (Mayer and Banga 2020). Industrial policy can also increase demand. Governments can create demand for domestic innovation, for example, by regulating competition (and hence the level of demand enjoyed by individual firms), by determining the number of licenses for certain activities or by imposing certain industry standards. Governments can also steer the direction of innovation by concentrating support to innovation in certain areas. They can also function as knowledge brokers, by linking innovators, producers and consumers, or as promoters of private demand, e.g. through tax incentives and subsidies that stimulate innovation from domestic firms (Chang and Andreoni 2016).

None of this will be easy to adopt. But it could prove one way to address the conundrum of how to advance industrialization in a world with dimmed prospects for traditional export-oriented manufacturing but new opportunities arising from digitalization.

6. Conclusions

The ability to use data on customer preferences is increasingly determining structural transformation, making a good understanding of the economic value of data and of the costs and benefits of associated regulatory choices and innovation policies a key element of development strategies. This paper has attempted to contribute to a better understanding of how data can affect industrialization and how national and international policies on data governance and innovation can help or hinder this process.

The paper outlines a response to the changed nature of industrialization that results from digitalization and from reduced global growth and related opportunities for developing countries to rely on export-oriented manufacturing as a development strategy. The outlined response has at its core data as an asset and the opportunity to advance industrialization by supporting manufacturers to use data on demand preferences and upgrade the price-quality features of their products to serve arising domestic market segments. Other responses are clearly possible, such as large-scale robotization or a digitalization policy aimed mainly at remaining a part of shortening global value chains. Nevertheless, the outlined response seems particularly pertinent for economies that have an industrial base and that might see opportunities for export-oriented industrialization rapidly dwindle from sluggish export demand prospects and a restructuring of GVCs combined with automation in developed countries. Large developing countries may be able to adopt this approach individually. Countries with small domestic markets could adopt it in the framework of regional agreements and South-South cooperation.

Countries that choose the outlined response could start with small but well-informed steps to test data and innovation policies, including in industrial parks, before embarking on large-scale policy implementation. Such a choice could pave the way for a mixed strategy within the same country. It would combine remaining and upgrading in existing supply chains, including through digitalization of supply chains, with fostering own innovation-driven growth and enhanced use of data.

Some developing countries may not possess the human and financial resources for the investment required to engage in the increased complexity of industrialization. But even for these countries and irrespective of the response to digitalization that policymakers eventually choose, it is important to be aware of the value of their data, because once foregone, gainful access to these data will be difficult to recover.

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