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Digitalization and industrialization: friends or foes?

Abstract

Digitalization can provide new opportunities for industrialization in developing countries if these countries can leverage data on market demand for design and production decisions. The greater weight of developing countries in the global economy makes global demand patterns increasingly heterogenous and increases the value of data on developing countries' demand patterns. Digitalization facilitates translating these data into intangible assets and makes it easier and cheaper to use these data for design and production. Using the framework of value chains and drawing on insights from recent trade theory on firm and product heterogeneity, the paper discusses channels through which these mechanisms can boost industrialization. It also highlights required support from innovation, industrial and regulatory policies to promote a fair sharing of the benefits from digitalization.

Key words: digitalization, industrialization, development policies

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1. Introduction

Recent industrialization patterns are causing increasing pessimism about manufacturing as an engine of development. Peak shares of manufacturing in total employment and output in today's economies are lower and in many developing countries occur at lower levels of per capita income than in the now industrialized countries – a phenomenon known as "pre-mature" de-industrialization (e.g. Rodrik, 2016).[1] In addition, the global trade slowdown and expected prolonged structurally weak growth in developed countries are darkening prospects for traditional export-oriented industrialization strategies (UNCTAD, 2013; IMF, 2017). Moreover, international production sharing through global value chains has made different countries to adopt different modes of production in the same industrial sector, so that the productivity and employment gains from manufacturing have been determined less by sectoral specialization and more by modes of production. Finally, some argue that robotization puts at risk two-thirds of all jobs in developing countries (e.g. World Bank, 2016), and that reshoring to developed countries further jeopardizes their manufacturing activities (e.g. Boston Consulting Group, 2011).

Services are often proposed as an alternative escalator to economic development. Some see services play this role on their own, mainly in two ways: first, some services (transport, communication, finance) are found to promote productivity growth at least as much as manufacturing activities (e.g. Ghani and O'Connell, 2014; IMF, 2018a) and, second, services liberalization is seen as further increasing the potential for the unbundling of production, which together with new information technologies can allow business process outsourcing or online gig work to emerge as new export-led development strategies (e.g. Baldwin, 2016). Others argue that services can drive development as a complement to manufactures, based on two observations: first, firms increasingly augment their manufactured goods with firm-specific assets based on services in advertising, finance and after-sales care that reinforce brand loyalty (e.g. Hallward-Driemeier and Nayyar, 2017) and, second, digitalization causes a blurring of the traditional boundaries between industrial and services activities and sizably changes how the manufacturing process is undertaken and organized in value chains (e.g. De Backer and Flaig, 2017).

Two features stand out from this discussion: (i) a reduced scope for traditional export-oriented industrialization as a development strategy, implying that developing countries may need new sources of activities that allow for employment and per capita income growth; and (ii) an ambivalent role of digitalization: it may cause reshoring and oust manufacturing as an engine of development, or it may cause manufacturing and services activities to be more closely interwoven, with the ensuing servicification of manufacturing providing novel ways for industrialization to drive economic development.

Large-scale use of digital technologies is still unfolding, particularly in developing countries, and the precise impact of digitalization remains uncertain. But a clear understanding of the channels through which these technologies may affect industrialization is crucial to monitoring and influencing these effects. The paper's main contribution is to facilitate such a better understanding and to highlight what policies could make digitalization and industrialization complements, rather than substitutes, as well as allow for the benefits of digitalization to be shared widely.

The paper uses the framework of value chains and insights from recent trade theory. Much of the high value-added pre-production (research and development (R&D), and design) and post-production (marketing, logistics and distribution) segments are currently located in developed countries; developing countries specialize in the lower value-added production segment, focused on mass production (e.g. World Bank et al., 2017). Digitalization affects this pattern by allowing market-related data to be increasingly important determinants of both the design and production

[1] For critical discussion, see Haraguchi, Cheng and Smeets, 2017; and Wood, 2017.

segments of manufacturing. It also makes product innovation and design cheaper and smaller production runs economically profitable, driving an overall shift in emphasis from mass production towards more customization. This shift could imply production to be located geographically close to the designers and engineers that develop products. Insights from the recent trade literature focusing on firm and product heterogeneity (e.g. Eckel and Neary, 2010) and the role of uncertainty in shaping trade (e.g. Arkolakis, 2010) indicate under what circumstances the pre- and post-production segments might move to developing countries, instead of seeing the production segment moving to developed countries.

The next section describes the main characteristics of new digital technologies and discusses channels through which digitalization may affect the various segments of the manufacturing process and how they are organized through value chains. It interprets evidence on the greater weight of developing countries in the global economy to imply an increase in the economic value of data on their demand patterns for design and production decisions. Given that digitalization enables the translation of these data into intangible assets and that it makes both market intelligence and product design cheaper and easier accessible for developing countries, the section emphasizes the capacity to leverage data on market demand for design and production decisions as a key determinant for digitalization to provide new opportunities for industrialization in developing countries. Section 3 turns to related policy issues. It recognizes that integration of developing countries into the digital economy is contingent on their provision of digital infrastructure and skills, as well as associated institutional capabilities. But it emphasizes that a fair sharing of the benefits from digitalization will depend on ambitious policies both (i) in developing countries, especially regarding innovation and industrial policies, and (ii) by the international community that needs to adjust antitrust, competition and regulatory policies to avert the winners-take-most tendency of digitalization. Section 4 summarizes the main findings and policy conclusions, emphasizing that whether digitalization and industrialization are friends or foes is largely an outcome of policy choices.

2. Digital technologies in value chains: channels for industrialization

Digitalization gives intangibles a more prominent role in income generation, including along value chains. Intangibles refer to R&D, design, blueprints, software, market research and branding, databases etc. (e.g. Haskel and Westlake, 2018: table 2.1).[2] The data that express these intangibles and their codification through digitization drive the various new digital technologies, emphasized here (table 1).

Industrial use of these new digital technologies is at different stages of readiness. Industrial robots have experienced rapidly growing deployment, especially since 2010, even though their use remains concentrated in developed and a few developing countries at an advanced stage of industrialization (Mayer, 2018). The use of additive manufacturing has also grown rapidly. But this growth partly relates to the expiry of some core patents, so that improved accessibility of 3D-systems mainly regards technology that is somewhat dated and concerns prototyping and product development. Frontier 3D-systems allowing for decentralised batch production of final goods from multiple materials remain expensive (Ernst and Young, 2016) but are expected to be widely accessible by 2022–2025 (WEF, 2015). Big Data and cloud computing is projected to grow exponentially (Purdy and Daugherty, 2017) and to be widely accessible by 2024. Wide accessibility of artificial intelligence is expected by 2025–2026 (WEF, 2015).

[2] For discussion and empirical evidence on the greater role of intangibles in economic activities, see e.g. WIPO, 2017.

Table 1. Main digital technologies used in a digitalized manufacturing process

Technology	Attributes
Industrial robots	Industrial robots are automatically controlled, reprogrammable, multipurpose manipulators programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications. They largely rely on algorithms driven by software, which may be enabled to communicate with other machines through the Internet of Things and to engage in self learning and autonomous reprogramming through artificial intelligence. Industrial robots tend to substitute routine tasks in workers' occupations.
Additive manufacturing (three-dimensional (3D) printing)	3D printing builds products by adding materials in layers. Using 3D modelling software, machine equipment and layering material, additive manufacturing equipment reads data from CAD files and applies layers of liquid, powder, sheet material or other, to fabricate a 3D object. Using these techniques reduces the time, material use and number of skilled workers needed for design, prototyping and product layout and facilitates product customization.
Big data and cloud computing	Big data analytics refers to a set of techniques that allows voluminous amounts of machine-readable data to be rapidly generated, accessed, processed and analysed. These processes are often undertaken through cloud computing that substantially increases the availability and affordability of computing services by using servers, storage, databases, networking, software, analytics, etc. over the Internet (i.e. the "cloud"). Machine learning systems can employ these data and recommend product features by predicting what customers will like.
Computer-aided design and computer aided manufacturing (CAD/CAM) techniques	CAD/CAM techniques refer to software used to design and manufacture prototypes, finished products, and production runs. CAD systems allow an engineer to view a design from any angle with the push of a button and to zoom in or out for close-ups and long-distance views. In addition, the computer keeps track of design dependencies so that when the engineer changes one value, all other values that depend on it are automatically changed accordingly, first in building designs in blueprints, and then in creating or assembling physical products and parts using computer-controlled equipment.
Artificial intelligence and machine learning	Algorithms allowing computers and machines embodying or linked to computers to learn from data and to mimic and predict human behaviour.

Source: Author's elaboration.

2.1 Market-related data, product customization and heterogeneous demand

Unlike traditional technologies, technologies based on intangibles are generally not embodied in physical capital. Instead, the activities related to intangibles may be considered services. This means that, in a digital world, services increasingly permeate the goods sector and blur the traditional boundaries between goods and services in the manufacturing process.

A crucial part of the data reflecting intangibles regard sales and other market-related information.[3] The increased availability of such data and their transformation into economically meaningful knowledge, which can be used for design and production decisions, increases the role of customers (both firms and households) in the manufacturing process. It also makes a firm's ability to customize production according to such market-related information an increasingly important determinant of sales and revenue creation. Most importantly from an analytical perspective, it allows moving away from traditional value-chain concepts that focus on the production side and consider customers as an amorphous homogeneous entity (e.g. Baldwin, 2016) towards approaches that take the heterogeneity of customers and variety in the structure of their demand patterns into account.[4]

From a development perspective, the importance of approaches that give greater attention to heterogeneous demand is to allow for an examination of the manufacturing process and its organization in value chains by linking potential changes coming from digitalization with the increased weight of developing countries in the world economy and the increased importance of their firms and citizens as potential customers. The greater the weight of developing country firms and households in global demand, the larger is the economic value of data on their demand patterns for design and production decisions.

Much of the literature on the increased weight of developing countries in global demand relates to extrapolations of broad-based income convergence before the Global Financial Crisis (e.g. Popov and Jomo, 2018). The fading of some forces that were driving these developments, such as high commodity prices, may now be causing a reversal of the widened heterogeneity of global demand patterns. However, the share of developing countries in global output measured in market prices almost doubled between 2000 and 2016 (table 2) and measured in terms of purchasing power parity accounts for over half of world output; per capita income measured in purchasing power parity continues to grow in all major developing economies (table 3a); income growth in developing countries continues to exceed growth in developed countries (UNCTAD, 2018), and wealth indicators for 2017 significantly exceeded 2000-levels in the main developing country regions, except Africa, despite falling back from 2007- or 2010-peaks (table 3b). This indicates that developing countries' weight in the world economy and the purchasing power of their citizens continue to exceed levels attained at the beginning of the millennium and that, on a variety of measures, these increased shares extend beyond a small number of individual developing countries. As a result, the economic value of data on developing countries' demand patterns has increased for both firms from developed countries that export to developing countries and for firms from developing countries that aim at serving their domestic markets or increasing South-South exports, in addition to exporting to developed countries.

[3] Market-related information comprises personal and non-personal data. Control over personal data raises concerns about privacy and abuse which need to be addressed in country-specific manners, such as by regulation requiring citizens' agreement for the use of their personal data. It is still unclear whether Europe's digital trajectory combining an absence of large European digital firms with a lead in setting standards for regulation and privacy protection indicates a trade-off between strengthening data privacy and developing competitive firms that control data, or whether high data-protection standards will eventually provide an advantage for firms that base their data use on trust through respect for privacy and protection against abuse. The focus here is on controlling non-personal, product-specific data that would appear to raise fewer such issues, even though clearly distinguishing between these two data categories may not always be easy.

[4] Markusen, 2013, revived attention to heterogeneous demand patterns in trade theory, while this aspect has been a mainstay in development economics and structural change analyses following Chenery and Syrquin, 1975.

Table 2. Shares in global output, selected country groups, 1970–2016 (percentages)

	1970	1980	1990	2000	2005	2010	2016
Developed economies	69.7	69.6	78.8	77.2	74.2	63.8	58.9
Transition economies	13.2	8.2	3.8	1.1	2.2	3.2	2.4
Developing economies	17.1	22.2	17.4	21.7	23.6	33.0	38.7
Africa	3.2	4.6	2.4	1.9	2.4	3.0	2.8
Latin America and the Caribbean	5.3	6.3	5.0	6.7	5.8	7.9	6.8
West Asia	1.3	3.2	2.0	2.2	2.7	3.3	3.3
East, South-East and South Asia	7.3	8.1	7.9	10.8	12.6	18.8	25.7
Oceania	0.1	0.1	0.1	0.0	0.1	0.1	0.1

Source: Author's calculations, based on UNCTADstat.
Note: Shares based on market prices and market exchange rates.

Table 3a. Median wealth per adult and income per capita, selected economies and economic groupings, 2000–2017

	Median wealth per adult ($ '000)						Income per capita (2011 international dollars, '000)					
	2000	2005	2007	2010	2015	2017	2000	2005	2007	2010	2015	2017
Africa	0.5	0.7	1.0	0.9	0.7	0.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
South Africa	1.9	4.8	6.5	5.4	4.3	5.1	9.7	11.1	12.0	12.1	12.5	12.3
Asia-Pacific*	1.3	2.3	3.6	3.4	3.1	3.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
China	2.3	3.8	5.4	4.6	6.7	6.7	3.7	5.7	8.6	9.4	13.5	15.2
India	0.7	1.0	1.4	1.3	1.3	1.3	2.5	3.3	3.8	4.5	5.9	6.5
Indonesia	0.5	1.2	1.9	2.2	1.7	1.9	5.9	6.9	7.5	8.6	10.5	11.3
Rep of Korea	24.4	42.2	59.3	56.8	64.9	67.9	20.8	25.5	28.0	30.4	34.2	35.9
Taiwan Province	64.6	63.1	67.5	77.1	83.5	87.3	27.2	32.5	36.2	39.4	44.1	45.8
Thailand	0.7	1.5	1.5	2.0	1.7	3.0	9.3	11.6	12.6	13.5	15.2	16.3
Latin America & Carib.	1.1	4.0	6.1	6.3	4.8	5.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Brazil	2.2	3.4	5.4	7.4	3.7	4.6	11.5	12.4	13.4	14.6	14.8	14.2
Chile	5.1	8.1	12.0	13.6	17.6	20.1	14.2	17.0	18.5	19.3	22.2	22.4
Mexico	7.7	11.8	13.9	9.2	8.8	8.7	15.8	16.0	16.7	16.1	17.6	18.1
Europe	7.9	13.3	19.2	16.4	12.8	14.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Japan	103.0	96.7	97.6	125.1	111.6	123.7	33.9	35.7	36.8	35.9	37.9	39.0
United States	42.8	57.3	58.3	39.5	51.1	55.9	46.0	49.7	50.9	49.3	53.0	54.2
memo item												
World	1.9	2.9	4.2	3.7	3.6	3.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Source: Author's calculations, based on *Credit Suisse Wealth Databook*, 2017, and International Monetary Fund, *World Economic Outlook database*, April 2018.
Note: ** Including Australia, Japan and New Zealand. Wealth data based on market prices and market exchange rates; income data based on purchasing power equivalents.

Table 3b. Net household wealth as a share of world total, selected economies and economic groupings, 2000–2017

	2000	2005	2007	2010	2015	2017
	Share of world total (*per cent*)					
Africa	1.0	1.1	1.4	1.2	1.0	0.9
South Africa	0.2	0.3	0.3	0.3	0.2	0.3
Asia-Pacific**	11.3	13.3	16.4	17.5	20.7	20.3
China	4.0	5.0	6.9	7.5	10.5	10.3
India	1.0	1.2	1.6	1.7	1.7	1.8
Indonesia	0.3	0.4	0.6	0.8	0.6	0.7
Rep of Korea	1.5	2.0	2.1	0.8	2.4	2.3
Taiwan Province	1.6	1.2	1.0	1.3	1.2	1.3
Thailand	0.1	0.1	0.1	0.2	0.2	0.2
Latin America & Carib.	2.9	2.6	3.1	3.7	2.7	2.9
Brazil	0.7	0.7	0.9	1.4	0.8	0.9
Chile	0.1	0.2	0.2	0.2	0.2	0.2
Mexico	0.8	0.8	0.9	0.7	0.7	0.7
Europe	28.6	33.1	36.7	33.7	28.9	28.4
Japan	16.5	10.5	8.3	10.7	8.3	8.4
United States	36.2	34.7	29.0	27.6	33.2	33.4
memo item						
Developing countries	15.1	17.0	20.9	22.4	24.4	24.1
Developed and transition economies	84.9	83.0	79.1	77.6	75.6	75.9
	(*US dollar*)					
World	116957	172294	220834	219847	253754	280289

Source: Author's calculations, based on *Credit Suisse Wealth Databook*, 2016 and 2017.
Note: ** Excluding Australia, Japan and New Zealand.

The remainder of this section examines the channels through which an increased role of heterogeneous demand in the post-production segment for decisions regarding design and production in the pre-production and production segments of the manufacturing process may change income creation across the various stages along the value chain. It also examines the dynamics of governance structures in value chains. The subsequent section focuses on policies that developing countries could adopt to harness this income potential for their industrialization.

2.2 The distribution of value added in value chains

Assessing how digitalization affects the manufacturing process and how its various segments become more closely interwoven may be based on what is known as the "smile curve". The smile