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Leapfrogging into the unknown

The future of structural change in the developing world

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Abstract: This paper traces a set of major trends and future scenarios in global structural change. It argues that across multiple domains of change, developing economies are facing novel constellations of lateness and prematurity in technological and economic development. The paper explores these novel constellations in employment and value added, global trade, and technological upgrading. It argues that an expansion of service sector work in lockstep with rising economic development will likely continue to shape the medium-term future of structural transformation, albeit with trends of convergence and a hybridization of sectors. New employment challenges may be emerging for participants in a global value chain due to the debated threat of 'reshoring' of offshored production. The paper finally discusses automation in the non-tradable sector and the ramifications of technological leapfrogging or 'technology creep' for the future of structural change.

Key words: technological change, structural change, employment, catch-up development, future scenario, developing countries

JEL classification: O14, O20, O33

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1 Introduction

What will the future of structural transformation look like in the developing world? This paper discusses and extrapolates a set of trends in the structure of employment and value added, global trade, and technological upgrading that are likely to shape developing economies going forward. Across each of these domains, the paper reviews assessments in current empirical and theoretical literature. Further, it offers a conceptual framework for understanding the opportunities and challenges around structural transformation posed for developing countries in the face of contemporary technological change.

The paper posits that a defining issue for the future of structural change is that of new 'asynchronies' in the sequencing of development pathways—echoing themes of prematurity, economic catch-up, and technological imitation. The notion of 'leapfrogging', i.e. of adopting frontier technologies and skipping intermediate stages in technological development, has recently gained traction and is critically assessed here. It is argued that emerging development challenges across different domains of economic activity centre around understanding and managing the risks and opportunities offered by novel constellations of maturity and prematurity of development.

The paper is structured as follows. Section 2 offers a framework for understanding scenarios of catch-up structural transformation in a context of technological borrowing. It argues that novel constellations of earliness and lateness in economic and technological development are key to this understanding. Section 3 sketches and extrapolates long-term trends of structural change in employment and value added. The novel constellations here are a trend towards premature tertiarization, new forms of global structural convergence and the 'hybridization' of economic sectors. Section 4 explores the issue of trade and globalization in times of automation with a focus on the debated threat of 'reshoring' of previously offshored activities. Late-developing countries now face competition from labour-saving technology up the stream of global values chains. Finally, Section 5 analyses technological leapfrogging in the service sector, drawing on empirical trends and examples from Southeast Asia that could be considered typical for modernizing middle-income countries. Section 6 concludes.

2 Catch-up in the age of automation: an analytical framework

In the 1950s, economic historian Alexander Gerschenkron (1951) posited that a country's 'economic backwardness', i.e. its relative lack of industrialization, could in some respects be considered an advantage. By importing modern technologies from leading industrialized countries and by investing in cutting-edge machinery and equipment, 'latecomers' to the development process could skip stages of modernization that previous scholars like Walt Rostow had deemed necessary in any successful path towards economic development. Skipping, in Gerschenkron's view, would enable late-developing economies to generate faster and more capital-intensive industrial growth, unhindered by societal constraints and orchestrated by a strong, dirigiste state (for a more recent discussion see Mathews (2006); see Nayyar (2013) for a history of the catch-up paradigm).

Arguments in the vein of Gerschenkron are currently seeing a revival in the flourishing discourse of technological 'leapfrogging' (e.g. Lee 2019). The idea that less-developed countries could reap the benefits of skipping intermediate stages in technological progress—e.g. jumping straight into mobile-phone-based e-payment systems without first building an ATM infrastructure—can also be heard across the board of international development organizations. There are, however, critical voices. Pritchett (2019) argues that technological research and development (R&D) in high-income countries reflects distorted price signals due to immigration barriers, among other things. This makes technology economize on factors of production such as routine manual labour that are in fact abundant in low-income countries. In the view of Pritchett (2019: 3), 'this pattern of innovation is a massive negative externality to the global economy as what is needed, (…) is jobs for low to medium skill labor'. Pritchett's view implies that the adoption of technology developed in and for high-income countries is not necessarily advantageous in other circumstances.

In a simplified overview, one could conceptualize the possible configurations of economic development and technology adoption along a two-by-two matrix of earliness and lateness in each dimension (see Table 1 and Figure 1). A conventional 'lining-up' pathway would envisage late-developing countries adopting a new technology later than high-income countries—in the strictest sense, adoption would take place only at a time when the adopting countries have reached a comparable level of economic development to that of developed countries at the time of adoption.[1] Examples for lining-up of that kind can be found across a whole range of economic activities, most notably in agriculture, that are predominantly carried out manually in developing countries yet are automated in OECD countries. Technology adoption might happen only after prices have dropped, after patents have expired, after goods are sold in a second-hand used state (e.g. machinery, vehicles), etc. However, as the overall structure of the economy in late-developing countries is characterized by numerous forms of lateness, a lining-up approach should be distinguished from the notion of lagging behind. Technology adoption depends on complementarities of skill, infrastructure, regulation and of other factors and would thus not typically be expected in the absence thereof.

In contrast, 'lagging' would mean late adoption of technology despite economic maturity and the presence of relevant complementarities. Consider, for instance, the current lack of high-speed rail networks in the USA and the UK while such infrastructure has long been present in high-income countries (HICs) like Japan, France, or Spain, and even in some middle-income countries (MICs) like China. The US is similarly lagging in some aspects of airport infrastructure compared to other HICs. Several countries in continental Europe could be considered to be lagging in innovation in the digital and engineering sector compared to the USA or Scandinavia, in the adoption of self-checkout technology in the retail sector, or in the availability of high-speed internet.

From California's 'Silicon Valley' to Berlin's 'Silicon Allee', technological 'leading' is almost by definition predominantly found across the high-income OECD world but also increasingly so in China. Finally, cases of 'leaping' (or 'leapfrogging'), meaning early adoption of technologies despite late development, can be found across the developing world. The mobile phone-based financial service *M-Pesa* in Kenya and Tanzania is often mentioned under this rubric. Automated train and subway systems exist in many MICs, notably in Asia, and self-checkout and e-kiosk systems in retail and food services are currently being rolled out in some countries in these regions. All of these are cases of 'early adoption during late development'. Section 5 of this paper will discuss in more detail the introduction of automated toll booth technology in Southeast Asia as an example of leap(frogg)ing.

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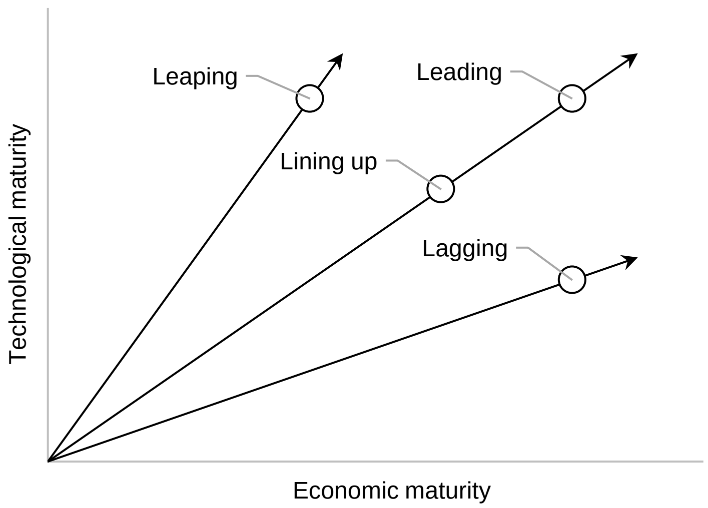
[1] Within the class of 'lining up' developing countries, one could potentially further differentiate between earlier and later adoption given a comparable level of development, i.e. lagging within lining up.

Table 1: Constellations along the technology-development nexus

		Economic development: Late	Economic development: Early
Technology adoption	Late	*Lining up* A conventional pathway of following step-by-step historical patterns without 'jumping the queue' of technological development	*Lagging* A conservative pathway of delaying overdue technological steps and of late borrowing from innovators
	Early	*Leaping* A disruptive pathway defying historical patterns by skipping steps in technological development	*Leading* An innovative pathway of pushing the technological frontier and of taking new or rapid steps in technological development

Source: author's illustration.

Figure 1: Development pathways with reference to economic and technological maturity



Source: author's illustration.

A view of development as sequenced adoption of technology along a stepwise pathway serves as no more than a point of orientation and comparison. Empirical evidence on the benefits and downsides of developmental asynchronicity is relatively scarce. Empirically, Gerschenkron's original research focused on newly industrialized countries in Eastern Europe and Russia, which the data of the time fitted. Later research on economic convergence, in contrast, has long struggled to find much evidence in support of economic convergence, which should follow from latecomer advantages (e.g. Pritchett 1997, Nayyar 2013). China's rapid industrial catch-up, thanks in part to an aggressive strategy of borrowing and copying foreign technologies, on the other hand, would appear to lend some credibility to Gerschenkron's optimistic thesis. The neoclassical standard model of growth, the Solow–Swan model, also suggests higher growth potentials during catch-up than at the technological frontier.

There is some evidence that developing countries 'import' OECD-type challenges like skills-biased technological change and labour market polarization via technology transfers in global value chains (GVCs) (see Ugur and Mitra (2017), who provide a systematic review of technology adoption and employment in least-developed countries (LDCs) finding both skills bias and challenges of employment creation; see also Yasara and Rejesus (2020); Pahl and Timmer (2019)). Chang and Andreoni (2020: 7) further point out that 'the debate around digitalization is dominated by the idea of a leap into a post-industrial age, without the realization that manufacturing processes and the materiality of production will still matter in such an economy'. Even if one rejects Gerschenkron's optimism, though, it seems sensible to concede that optimal structural change is a moving target that depends on changing conditions such as relative factor prices, technological frontiers, and a changing landscape of international competition. Policies of structural change will thus have to be adaptive and staying 'in line' with development conventions is by no means always advisable.

Table 2 sketches an indicative list of opportunities and risks with a view to the leaping approach. Disadvantageous leaps are referred to here as 'technology creeps', capturing the idea that technology is creeping into domains without a plausible development rationale. Unquestionably, though, the dividing line between 'leap' and 'creep' is fuzzy and the same phenomena might well be labelled differently by different scholarly camps. The present paper explores the debate of prematurity with a focus on the first three domains on which Table 2 provides examples, while the bottom three are mentioned for indicative purposes only. The list is not exhaustive.

Table 2: 'Early adoption during late development': opportunities and risks

	'Technology leap' Early adoption of technologies conducive to catch-up development (Gerschenkron's 'advantages of backwardness')	*'Technology creep'* Early adoption of technologies impeding catch-up development (Pritchett's 'distorted patterns of innovation')
Examples across different domains:		
Structural change	Hybridization of sectors and upgrading/convergence of industrial activity	Premature deindustrialization/tertiarization ('Disrupted Development' per Schlogl & Sumner 2020)
Labour market	Automation displacing scarce or augmenting abundant labour	Automation displacing abundant labour; jobless growth
Trade	Offshoring with technology transfers	'Value-added erosion' due to GVC participation (per Caraballo and Jiang 2016)
Politics and governance	Free access to information, distant learning, e-participation	Mass surveillance, manipulation of online discourse, misinformation
Global power relations	Technological independence due to early-mover advantages	Technological dependency due to patents or lock-in effects, 'data colonies'
Environment	Efficiency gains, green technology, carbon decoupling	Growing energy consumption, electronic waste, rise in emissions

Source: author's illustration.

3 Towards structural convergence and hybridization

What do earliness and lateness imply for the realm of structural change? Historically, the trend over the past decades has largely been for sectoral employment shares to gradually decline in agriculture from already low levels and to grow in the service sector. Industrial employment shares have declined in all but the very lowest-income countries. This general pattern of structural change tends to be visible across different geographical regions and country-income groups (see Sen (2019), who discusses the standard model and deviations from it in low-income economies).

Extrapolating this historical trend, sometimes referred to as 'Petty's Law', into the future would suggest a continued increase of service-sector work at the expense of both industrial and agricultural work. Farmers would be increasingly concentrated in the LDCs, where they are already concentrated today, while farming everywhere else would become ever more capital intensive. Even if there are calls for more decentralized, organic forms of agriculture, it is hard to imagine a reversal of the declining employment trend in agriculture given rapid technological advances in this field from drones to automated crop picking to satellite-assisted 'precision agriculture'. As the world continues to reduce human labour input to farming and manufacturing, the 'post-industrial' revolution, which took off in mid-twentieth century Europe, keeps unfolding until a point where the vast majority of human labour is pursued in some variety of service sector. Most potential for structural change of this conventional, cross-sector, kind is left in low-income countries (LICs) and it is in in these countries where it is already showing the fastest pace (Merotto et al. 2018).

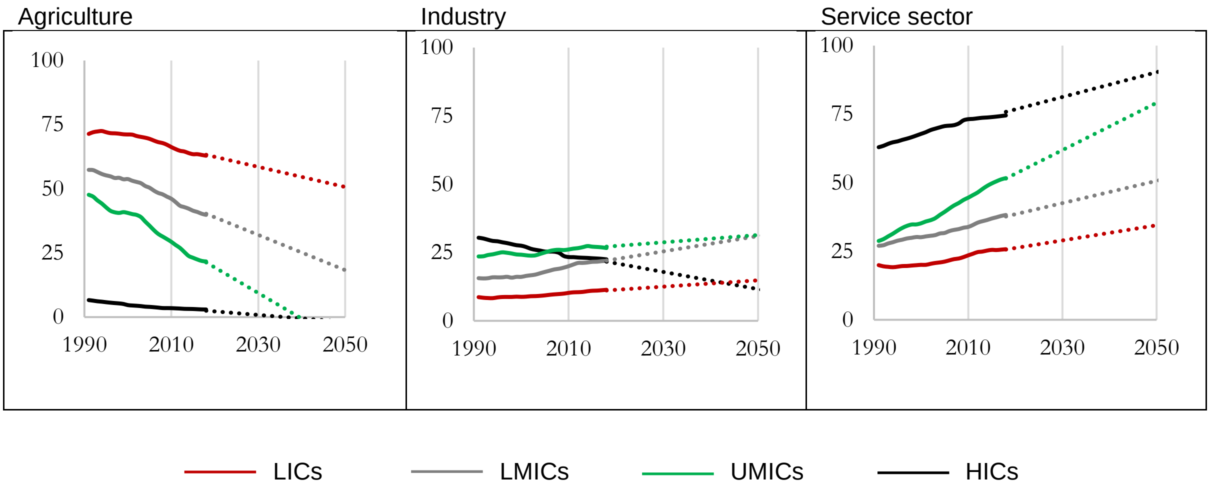
It is noteworthy that the country-level share of industrial employment (currently at around roughly a fifth to a fourth of the labour force on average) has, over time, increasingly become detached from the level of economic development of a country. LICs like Benin or the Republic of Congo, lower-middle income countries (LMICs) like Bangladesh or India, upper-middle income countries (UMICs) like Mexico or Paraguay and HICs like Finland or Switzerland employ around 20–25 per cent of their labour force in the industrial sector (World Bank 2020). The countries with the lowest gross domestic product (GDP) per capita are still dominated by agricultural employment, while the richest ones are strongly service sector-based economies, yet the global trend appears to be towards increasing homogeneity in terms of industrial employment shares.

There is thus a trend of structural convergence as LICs have expanded their industrial employment shares (from low levels) while HICs show declining shares from moderate levels, on a population-weighted account. Projecting this past trend into the future (see Figure 2) would imply that the developing world will overtake high-income economies in terms of country-level industrial employment shares. If the historical inverse-U-shaped pattern, which suggests that industrial employment first expands and then contracts during economic development, continues to hold, the share of employment in industry will at some point go into reverse: from industrialization to deindustrialization. This turning point—which would adequately be called the 'Clark turning point' after Clark (1940), who first noted these sector dynamics[2]—lies, at least on average, in the future.[3] Since the developing world has larger labour forces than the developed world, industrial employment convergence is compatible with the world having gone through a rise, in absolute terms, in the global number of workers employed in industry.

[2] Clark (Clark 1940) was the first to note that 'the proportion of the working population engaged in secondary industry appears in every country to rise to a maximum and then to begin falling, apparently indicating that each country reaches a stage of maximum industrialisation beyond which industry begins to decline relative to tertiary production'.

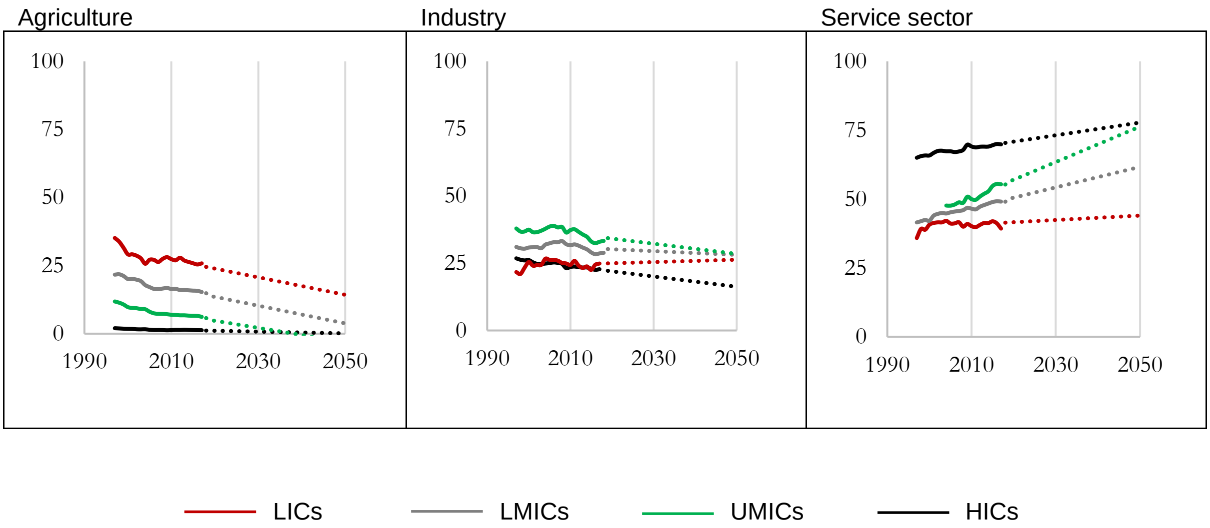
[3] The narrower category of employment in *manufacturing* as opposed to industry seems to have gone into reverse earlier in developing countries, as pointed out by Rodrik (2016) and others under the thesis of 'premature deindustrialisation'.

Figure 2: Employment in sectors as a share of total employment, 1994–2019 and linear projection (population-weighted averages)



Source: author’s calculations based on International Labour Organization modelled estimates by World Bank (2020).

Figure 3: Value added by sectors as share of GDP, 1994-2019 and linear projection (population-weighted averages)



Source: author’s calculations based on World Bank (2020).

Employment in agriculture has declined across all countries over the past 50 years. The change has been most dramatic in East and Southeast Asia and least dramatic in sub-Saharan Africa. The value-added share of agriculture (see Figure 3) has also declined in all but the richest developing countries (Brazil, Chile, and South Africa) where it already fell to a low level decades ago. The only other sectoral trend which has been equally geographically universal is the rise in service sector-based employment, which is visible in all major developing economies. Other shifts in the economic structure appear to be more country- or region-specific. East Asia, for instance, has seen an expansion of manufacturing employment not present in other regions. What does this mean for the future? Most potential for conventional structural change lies in Africa, which currently still employs around 60 per cent of its labour force in agriculture—a share roughly equal to that of developing East Asia (excluding China) around 1970. Moreover, it is worth noting that once labour has exited the agricultural sector, the dynamics of structural change become more static.

Is the expansion of the service sector, tertiarization, likely to stay with us? The trend will arguably continue even if countries place some weight on a degree of agricultural and industrial self-sufficiency and if the international division of labour thus remains partial—as Keynes (1933) advocated for and as modern defenders of industrial policy keep promoting today. Technological advances mean that a growing 'robot reserve army' is pushing the human labour force into non-automatable tasks, creating a technological 'dual economy' with new dynamics of labour surplus exchange (Schlogl and Sumner 2020). This is clearly a new development constellation which late-developing countries are facing.

Alonso-Soto (2020) shows that contemporary patterns of structural change are exposing emerging economies to labour-displacing technologies and thus reduce manual—though not always routine—work. Non-automatable tasks will be increasingly located in sectors like education, health care or social services, which require human interaction, flexibility, creativity, human touch, empathy, and similar difficult-to-automate qualities (Autor et al. 2003; Goos and Manning 2007; Autor and Dorn 2013; Frey and Osborne 2013). Though the service sector contains an extent of automatable work (e.g. cognitively repetitive or structured tasks), which may become redundant thanks to digitization and artificial intelligence (Willcocks and Lacity 2016), most scholars expect that this sector will remain a refuge of human competitive advantage (Autor 2015).

Does this mean that the world is deindustrializing? In one sense, in terms of country-level employment shares, it does, albeit less so in LICs. Tech companies like Google or Amazon, as the modern equivalents of past manufacturing giants, employ far fewer people than Ford or GM did while ranking similarly on the Fortune 500 (Madrigal 2017). Factories will surely continue to be built in developing countries but should be expected to depend on less labour input relative to other sectors. Labour-intensive cut-mend-trim or assembly-type activities might become obsolete in light of rapid advances in garment and manufacturing technology (see e.g. Nayak and Padhye 2018).

In another sense, however, in terms of the absolute number of workers employed in industry, the world may not deindustrialize given growing labour forces in developing countries. And, in yet another sense, in terms of industrial value added to GDP, this is a more open question. Globally, the population-weighted average value added of industry (including construction) has been on a declining trajectory, driven by the continued value-added tertiarization of high-income economies followed by MICs. A majority of LICs, on the other hand, have seen value-added shares in industry expand, albeit from a low level. Put differently, employment deindustrialization means that relatively fewer workers will be required to produce a unit of industrial output but not that less industrial output is produced. Generally, value addition and employment are, though, on similar trajectories (see Figures 1 and 2).

In yet another sense, though, what may be more likely than deindustrialization in any strict sense is an increasing conceptual blurring of economic sectors—an argument also made by Gollin (2018). On the one hand, services are already increasingly industrial, meaning scaled up for mass consumption and assisted by technologies. Medical care or education, for better or worse, belong to a 'service industry' in the sense that they are capital intensive, characterized by economies of scale and agglomeration, and that their business processes tend to be increasingly highly structured, standardized, and have a highly developed division of labour. In many cases, services are also tradable nowadays. Computing and information and communication technology (ICT) is a hybrid of industrial and service sector-based business, sometimes classified into the 'quarternary sector'. As ICT gets injected into ever more economic activities, the boundaries between services and industry get blurry and services become 'industries without smokestacks' (Newfarmer et al. 2018).

Industrial manufacturing, on the other hand, depends on service inputs and partly creates or incorporate these, e.g. financial and business services. Advances like 3D-printing and digitization also mean a higher degree of personalization and customisability in industrial production. There are thus 'industrial services' emerging. Farming, of course, is already an industrial enterprise in many places, operating with considerable machinery to turn agricultural raw materials into processed outputs for mass markets. 'Industrial agriculture' is the dominant form of food production in HICs. More recently, agri-tech start-ups have also ventured into domains like 'farming as a service', blending these sectors as well. Perhaps, the future of structural transformation is thus less one of deindustrialization in a conventional sense and rather one of sectoral *hybridization*.

If so, would this be a problematic development? Gollin (2018) argues that 'growth theory and empirics are relatively agnostic as to the sectoral pathways of development'—a dollar added to the economy is a dollar added, regardless of what activity generated it. This is the sector-agnostic neoclassical view (Schlogl and Sumner 2020). This view chimes with findings that productivity growth increasingly 'tends to come more from gains *within sectors* than from the movement of labor between sectors' (Merotto et al. 2018, my emphasis; see also McMillan et al. 2014; Timmeret al. 2014). Gollin (2018) argues that the knowledge-related externalities traditionally associated with manufacturing are likely to also be present in the service sector.

Much will, of course, depend on what activities emerge in the heterogeneous service sector. It is hard to picture a successful economic development model based on the kind of informal, low-skilled, low-productivity services—from street vending to transport to security services—which tend to be prevalent in the low- to middle-income developing world today. Advocates of industrial-led development argue that sustained economic and productivity growth without manufacturing is empirically rare, that the service sector is still less tradable than manufacturing, that service expansion depends on manufacturing development and that technology might not erode manufacturing jobs after all (for a recent discussion see Hauge and Chang 2019). The key issue for the future of structural change nevertheless is arguably about the quality and value-adding capacity of specific economic activities rather than one about broad (and to some degree arbitrary) sectoral categories. Not only that, the long-standing debate of whether industry is the key to development is increasingly being superseded by a new debate: Is technology adoption key to development?

4 Peak globalization?

Questions about technology adoption and the future of structural change are intricately linked to questions about the future of globalization. In their seminal book *The Second Machine Age*, Brynjolfsson and McAfee (2014: 184) argued that the 'biggest effect of automation is likely to be on workers not in America (…) but rather in developing nations that currently rely on low-cost labor for their competitive advantage'. They argued that 'off-shoring is often only a way station on the road to automation' (Brynjolfsson and McAfee 2014: 184). In a recent talk on the future of work, the economic historian Robert Skidelsky, flat out speculated that we may have reached 'peak globalization' because of automation.[4] The impact of robotics, Skidelsky argued, would be a substantial reduction in supply chain trade and an overall falling trade share. Avent (2017) is similarly concerned with the risk of 'reshoring', meaning the return of offshored processes to

[4] In a public lecture on 'Technology and Utopia' given by Skidelsky on 12 June 2019 at the Institute for Advanced Studies, Vienna.

OECD countries. One could cite examples like Adidas's speedfactory, which is now producing millions of 3D-printed shoes in the USA and Germany rather than in Vietnam or India.

To what extent reshoring is a real threat to developing countries, remains controversial. UNCTAD (2017: x) sees 'relatively little evidence for such reshoring'. In a forward-looking view, Baldwin (2016: 283) even argues that the future of globalization allows people from LICs 'to offer their labor services in advanced economies without actually being there' and that the negative impact on jobs in developed, rather than developing, countries 'could be shocking'. He argues that the costs of ICT and of international trade will continue to fall, enabling communication and face-to-face interaction across a distance, and thus fostering tele-presence and tele-robotics. Further drops in separation costs will mean offshoring in international production networks continues rather than coming to a halt, with rising wages in developing countries only acting as a mild counterforce, if we are to believe Baldwin's account.

Baldwin thus expects the global division of labour to deepen, rather than GVCs to disintegrate, and he sees East Africa among the main beneficiaries. If the 'GVC revolution' continues, developing nations beyond the Asian tigers 'could join the rapid-industrialization parade' (Baldwin 2016). In his most recent book, Baldwin follows this argument, positing that global tele-migration and 'remote intelligence' will disrupt labour markets *in favour of* low-skilled work in the Global South (one could call that the 'Mechanical Turk Model'). Rather than a collapse of low-cost arbitration, Baldwin (2019) sees the future trade of developing countries based on qualitative specialization and fractionalization akin to intra-EU trade today. One could contend that Baldwin's account seems to best fit ICT-driven business process outsourcing (e.g. call centres in the Philippines), which constitutes a minor part of overall GVC trade in terms of value added. There are also various barriers to globally scaling up this kind of tradable services, among them language.

Empirically, there is some evidence suggesting that automation technologies could benefit developing countries. Banga (2019) argues for India that manufacturing firms, by expanding their digital capabilities, managed to upgrade their product portfolio, making it more sophisticated and thus more internationally competitive. Hallward-Driemeier and Nayyar (2019) find that robotization in HICs has generally been associated with growing green-field foreign direct investment (FDI) to developing countries. Artuc et al. (2018) argue, based on a task-based Ricardian model that an increase in the adoption of robots in HICs leads to a rise of imports in intermediate goods from developing countries and a rise of exports of manufactured final goods to developing countries. The robots, in their model, are deployed in the global North due to higher labour costs there—initially depressing labour demand and wages in this region and thus making Northern producers more competitive. This technology-driven structural change continues until all labour has moved into sectors where automation is difficult and the North has reached a frontier in the feasibility of further robotization. The effect is then reversed, and wages start bouncing back. For the South, Artuc et al. (2018) predict moderate gains in real wages and welfare as consumer prices of final goods drop and demand for exports from developing country rises.

The model of Artuc et al. (2018) is, arguably, based on optimistic assumptions. First, the 'initial' slump in real wages is significant and will only be offset in the long run (when, as Keynes' saying goes, 'we are all dead'). In the meantime, the political fallout from continued wage stagnation, rapid creative destruction and labour displacement could be significant (see. Frey 2019). While real wages in the South do improve somewhat, they will be outpaced at a later point by wage growth in the North, if the model holds true. We would then experience a drop in developing-country real wages at a point where further drops in robot costs may be ever harder to achieve (consider also that robots themselves are final products manufactured in HICs and thus their cost is not exogenous).

Second, is this kind of trade specialization favourable to the South? As was pointed out, sectors do not matter from a neoclassical point of view. Surely, though, a pattern whereby developing countries import disproportionately larger amounts of final goods while exporting a somewhat larger quantity of raw materials or intermediate goods, will worsen the terms of trade. Artuc et al. (2018) view developing countries as providers of intermediate goods, but that assumption might be questionable. The key development challenge of today's developing countries is that they import large amounts of intermediate goods (refined/processed commodities, high value-added components etc.) and then export final goods after only low-value-added assembly. This GVC structure harms developing countries' terms of trade. Introducing automation here will then lead to advanced countries continuing to produce intermediate goods, but they will now increasingly assemble them onshore (i.e. consuming intermediate goods domestically). Therefore, advanced countries will end up exporting final goods, but unlike developing countries of today, with large domestic value added. In this case, the developing countries well end up specializing in raw materials.

Even if developing countries do provide intermediate goods, a world in which a set of economic 'centres' are running robotized systems that add large economic value while developing-country 'peripheries' provide the material inputs, may raise new questions of structural dependency. More than 30 years ago, Ernst (1985) warned that automation technologies in electronics manufacturing would likely only penetrate 'into a very select group of Third World industrial growth poles' and would be 'largely controlled by the OECD-based multinationals'. He advocated appropriate 'countervailing strategies' by governments of LDCs.

Third, Artuc et al. (2018) predict that the adoption of robots will depress labour demand mainly in the North. In a GVC world, however, robots in the North compete with low-skilled labour downstream in the South—notwithstanding this labour being cheap. The sheer potential of automation could thus act as an increasingly forceful break on developing-country wage growth. It is questionable whether an increase in the demand for primary and intermediate goods by the North will create labour demand (and thus broadly shared wage gains) in developing countries, given that extractive and heavy industries as well as manufacturing and assembly of intermediate goods are becoming ever less labour-intensive. Finally, there seems to be some evidence of a premature spread of automation technologies into developing economies via leapfrogging, likely facilitated by technological subsidies and the public-good nature of technology. The spread of automated payment systems in the South, for instance, is hardly reflective of relative labour costs (see Section 4). It may mean that workers in developing countries will be increasingly competing against machines at lower levels of development than used to be the case for workers in the North.

A more pessimistic view is taken by Rodrik (2018: 14) who argues that 'new technologies present a double whammy to low-income countries': first, they are biased towards high skills and thus reduce the low-cost and low-skill labour advantage of developing countries; second, developing countries are integrated into GVCs, which make it harder to compete via a low-skill advantage. Rodrik argues that, on balance, the disadvantages offset the advantages for developing economies. Caraballo and Jiang (2016) find empirically that there is a 'value-added erosion' for countries getting integrated into the lower-stream parts of GVCs while high value-adding activities are completed by foreign-led firms upstream in the GVC. Further, in a later empirical paper, Artuc et al. (2019) find that robotization in the USA lowers growth in exports from Mexico to the USA, challenging the somewhat more optimistic modelled predictions of Artuc et al. (2018). Empirically, Guerriero (2019) also finds a global trend for the labour share of income to have fallen since the mid-1980s—a trend, which has been associated with automation (IMF 2017: 121f.; Schwellnus et al. 2018). Taken together, such findings seem to spell some trouble for the future of structural change.

If the automation sceptics are proven correct, the future of structural change will bring about policy challenges around global economic distribution. The 'developer's dilemma' (Sumner 2017, 2018) of promoting structural transformation while sharing economic benefits widely could become harder in an age of concentrated capital-intensification and widespread declines in the labour share. On top of 'value-added erosion' of the previous globalization period, we may find 'value-added absorption' as multinational companies 'take back' the activities currently conducted by developing countries at the middle part of the GVC smile curve with the help of automation technologies. The policy-prescriptive literature in international development has been foregrounding measures like 'upskilling' of developing countries' labour forces or Danish-style 'flexicurity' (World Bank 2009; World Economic Forum 2017; Baldwin 2019). These measures are largely borrowed from HIC contexts and it remains questionable if they can be transferred to developing countries, where high-quality tertiary education is typically rare and social safety nets are rudimentary. Technological catch-up also tends to be faster than convergence in social and educational policy—the tensions created by this configuration will remain a challenge for future structural policy.

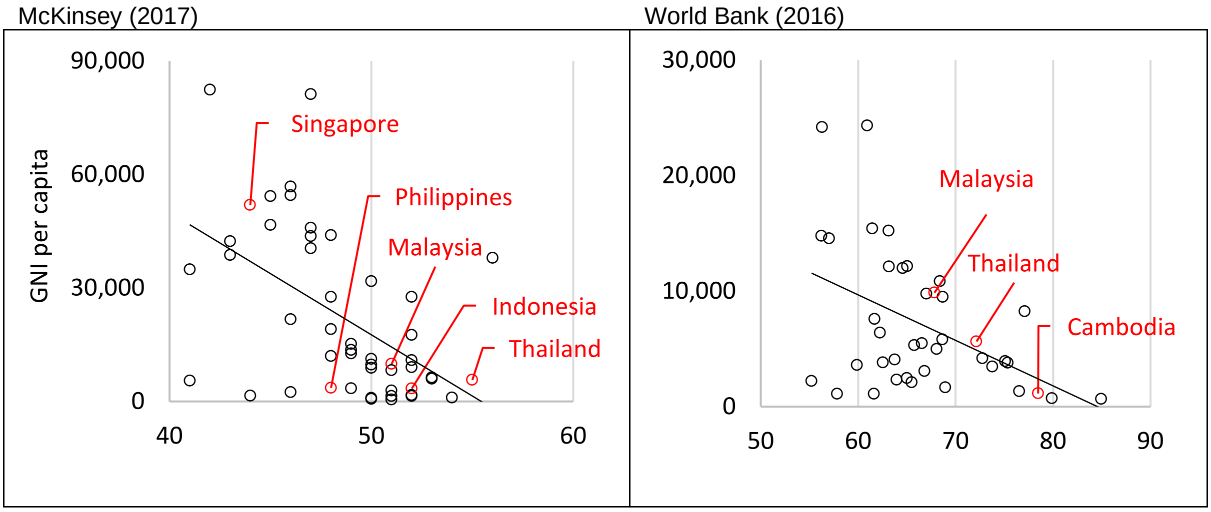
5 A glimpse of the future: Southeast Asia between technological catch-up and 'automation creep'

Southeast Asia is a region which exemplifies, in a nutshell, several broader trends and challenges of structural change during late (post-)industrialization. The region comprises a number of populous semi-industrializing MICs which are integrated into GVCs, are fairly vulnerable to automation, face a much debated 'middle-income trap', and have adopted a path of unequalizing tertiarization. The following section briefly describes the structural context of this region and then discusses a new trajectory of structural change—so called leapfrogging—which is likely to become salient in the wider developing world.

To begin with, the movement of labour across economic sectors in Southeast Asia has followed a similar pattern as outlined in Figure 1. Throughout the last twenty years, employment in agriculture has generally contracted while it has expanded in the service sector. Industrial employment shows a more chequered pattern, with most countries still increasing their employment but some—the richer ones: Malaysia, Singapore, Brunei—on the declining slope of employment. The available country-comparable data suggests that Malaysia reached the 'Clark turning point' of industrial employment transitioning into decline in the late 1990s; Brunei likely in the early 1990s; and Singapore's turning lies further back in the past. The remaining region is still on the upwards slope of job industrialization.

Singapore had the region's highest level of service-sector employment at 83 per cent in 2018, surpassing even US and UK peak levels. Consequently, the share of work considered in current estimates to be susceptible to robotization is the lowest in the region (see Figure 4). According to McKinsey (2017), as much as half of the labour force in countries like Malaysia and Indonesia is, in principle, automatable using existing technology. The World Bank estimates are even more pessimistic.

Figure 4: Share of the labour force susceptible to automation: estimates



Note: GNI stands for Gross National Income.

Source: author's calculations based on McKinsey (2017) and World Bank (2016, 2020).

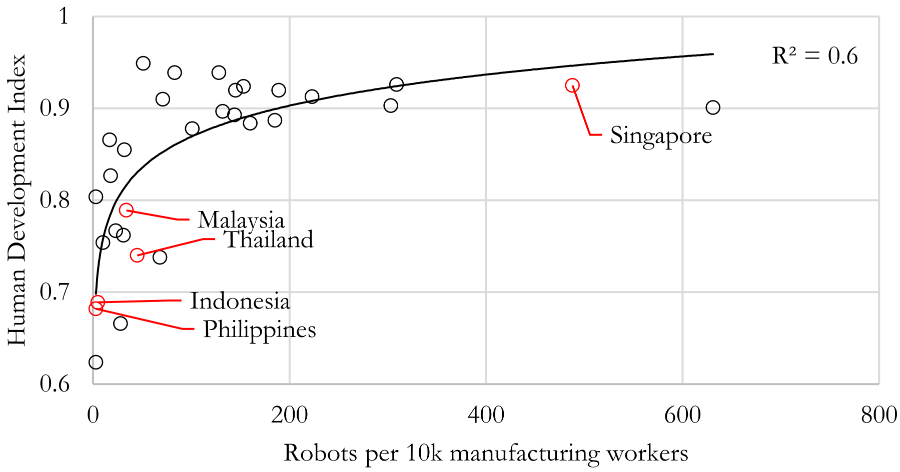
With the exception of Singapore, Southeast Asia has relatively large populations in low-skilled manual occupations like agriculture, leaving much potential for robotization in the future. In line with this, the productivity gap, measured as output per worker in constant PPP-adjusted dollars, of ASEAN countries with OECD countries is still wide (World Bank 2020). Notwithstanding continuous increases in productivity since the 1990s, the region has only converged by a few percentage points since the beginning of the 1990s, despite the dent in OECD output left by the 2008 Great Recession.

High automatability thus reflects a low degree of robotization on a per capita basis in Southeast Asia. This would chime with a thesis that developing countries, including in Southeast Asia are 'under-robotized', which is, for instance, implicit in UNCTAD (2017) which argues that:

> Robotization has had a relatively small direct effect in most developing countries so far, and this is unlikely to change in the foreseeable future, given their lack of diversification and technological upgrading. Despite the hype surrounding the potential of robot-based automation, the use of industrial robots remains small, with an estimated total of only 1.6 million units in 2015. (UNCTAD 2017: ix)

From this perspective, robotization, paired with skills upgrading and employment tertiarization—technologically displaced agricultural and industrial labour moving into the service sector—will push countries up the productivity and development ladder (see Figure 5). Robotization would be especially pressing in the tradable sectors where countries face international price competition.

Figure 5: Industrial robots and development



Note: data refer to the year 2016.

Source: author's calculations based on UNDP (2020) and IFR (2018).

'Under-robotization' is thus one way of interpreting the challenge of economic development in the age of automation. There are a few caveats. First, considering that Singapore has the world's second highest density of installed industrial robots per employee in the manufacturing sector, according to the International Federation of Robotics (IFR 2018), McKinsey's estimate of almost half the labour force being technologically replaceable by existing technology is concerning. Even a country with superior technological upgrading faces the 'robot reserve army'. Second, while developing countries are under-robotized both on a per capita and GDP per capita level, the *growth* in robot density adjusted for wages is high in developing countries (Atkinson 2018). The region is thus on a path towards catch-up with automation.

Third, even if the 'direct' effects of robotization in developing countries, which UNCTAD (2017) refers to, may so far be negligible, indirect effects could well be significant. Among such indirect effects, the aforementioned phenomenon of reshoring would only be the most extreme case. Less extreme would be the mere potential, or threat, of reshoring—or offshoring into new robotized tech clusters located elsewhere—putting a brake on wage growth in the tradable sector of developing countries. Robots installed in countries with high labour costs are competing with workers elsewhere and thus have spillover effects to countries with low robot density nonetheless, even if offshored activities are not actually reshored. Fourth, we are witnessing the adoption of cutting-edge labour-saving technology across Southeast Asia even in non-tradable sectors, including the service sector. There is a new form of 'automation creep' beyond the expectable area of tradable industrial production, which is deserving of much greater scholarly attention. This form of 'automation creep' could potentially threaten the labour absorption capacity of the non-tradable sectors, which are driving structural transformation in countries experiencing slow industrialization or stuck in the low-value-adding section of GVCs.

Consider the recent spread of automatic tolling systems in a number of South and Southeast Asian countries, including Thailand, Malaysia, the Philippines, Singapore, and Indonesia. Tollbooth operation, i.e. the handling and checking of toll payment on toll roads, is a prototypical example of the labour- intensive, manually repetitive, and low-skilled professions which tend to be at high risk of technological disruption. The spread of technologies such as electronic payment systems, 'smart cards' and near-field communication, object detection sensors, and automatic boom barriers will continue to make human workers in this sector redundant.

Indonesia is one example where an automated tollbooth system (ATBS) was recently rolled out on a nationwide scale. The state-owned toll road service provider Jasa Marga introduced an e-payment system with contactless charge cards in 2017. While formerly each toll gate had required five employees working in shifts to ensure vehicles had paid the road toll, the cashless system now runs essentially without human operators. On the upside, this speeds up the transaction process and reduces traffic congestion in a country plagued by traffic jams. However, it has placed a question over 20,000 jobs, according to media reports, coinciding with an announcement by the Indonesian Minister of Finance at the annual meeting of the International Monetary Fund and the World Bank that automation might create a case for a future universal basic income in Indonesia. As of early 2018, Jasa Marga asserted, though, that former toll gate keepers, rather than getting laid off, 'would instead be relocated to different positions within the company (…) and would keep their permanent employee status' (Aisyah 2017).

In line with Jasa Marga's announcement, there have been no reports of mass layoffs in Indonesia so far, albeit these could unfold in a gradual manner over time or take the form of a reduced intake of new employees in the future. In a detailed investor report on Jasa Marga, the Korean consulting firm Mirae Asset (2018) argued that the new e-toll system was 'needed to suppress rising personnel expenses' in the company. Mirae Asset (Mirae Asset 2018) finds that:

> [A]lthough JSMR has officially reiterated its intention not to lay off employees despite 100% e-toll implementation, we still think the spread of e-toll will help curb rising personnel expenses. Instead of massive layoffs, the company offers a rotation program (called A-Life) for its toll booth personnel. (…) Although we do not expect the majority of workers to leave JSMR (…), personnel expense growth should still be limited, as the A-Life program should reduce the need for additional recruitment in the coming years. (Mirae Asset 2018: 16)

To the extent that ATBS reduce the cost of road operation and Jasa Marga reported the capacity to absorb 20,000 people in other sectors of its operation, this raises the question of whether, by raising overall productivity and competitiveness, automation allowed the company to expand its business. The latter would mean that automation has the double effect of reducing labour demand per unit of capital in one domain (e.g. manual toll collection) while raising labour demand in complementary domains (e.g. higher-level administrative or lower-level construction tasks). In labour economics, a situation in which automation raises labour demand due to an expansion of a business is referred to as a 'scale effect' or a net complementarity of capital and labour.

There is also a set of institutional reasons that could be an explanatory factor for why Jasa Marga—a partially state-owned enterprise and thus facing potential developmental obligations—has not laid off workers: political and social-norms pressures as well as legal constraints could be preventing the toll road operator from firing employees. One could imagine the political backlash of a state-owned enterprise making 20,000 people unemployed. There may also be concerns over strikes, attacks on new toll booth machinery, political interventions (including fears of the political replacement of senior management making such decisions) or negative media reports which demonstrably influence business decisions in parts of state-owned enterprises and to some extent in private companies too. These factors could be even more pertinent in developing countries where systems of social security such as unemployment insurance are weak and displaced workers would face dire consequences.

Indonesia's Jasa Marga is only one example for the adoption of an ATBS. Singapore was the world's first country to implement a congestion charge in the city centre and adopted an electronic road pricing scheme in 1998; electronic toll collection systems were introduced on motorways in and around Bangkok on the Thai expressway network and the Thai motorway network; Malaysia introduced Smart TAG and Touch 'n Go as well as an experimental free-flow high-speed tolling system called 'multi-lane free flow' on the Malaysian expressway networks; and the Philippines implemented various autotoll systems across Luzon and Manila. Examples like the spread of e-tolls or electronic security services show that activities far beyond the confines of GVC-based production are affected by labour-saving technology.

What is the reason for this 'runaway' automation in non-tradable sectors in Southeast Asia? First, it could be the result of a deliberate development strategy. Cost competition does not end at the doors of a factory hall where goods for international supply chains are produced. For instance, workers have to commute to factories and, if an e-toll system reduces transport costs and time, such cost reductions will indirectly lower the cost of labour and thus of factory production. The same would hold for other domains like public infrastructure, food, housing, and so on. The wider domestic economy is thus not insulated from international trade (as OECD countries know well from debates about the sustainability of social welfare programmes under global regulatory competition). The fact that in Indonesia it was the government which mandated cashless toll road transactions in 2017 (Mirae Asset 2018) would speak for the thesis that this a part of an orchestrated developmental strategy. Atkinson (2018), who puzzles over why Southeast Asia is ahead of other countries in terms of the growth in robot density, also cites 'national goals and strategies' and 'proactive tax policies' alongside a pro-robot 'culture'. Technological adoption is also actively promoted through international norms, e.g. UN organizations pushing and subsidizing digitization, 'smart cities' and technological upgrading.

Second, technological leapfrogging of this kind could be due to the global *public-good nature* of technology. This view would hold that the spread of technology is hard to contain, whether or not macro-economic benefits prevail. Even if contactless pay cards were not developed for use in toll gates in Indonesia, but rather for telephone and ATM cards in high-wage Europe, in line with the notion of 'directed technological change', such technology is today available for worldwide commercial adoption at falling costs. For instance, the fast food chain McDonald's is currently rolling out its self-service kiosk system to countries in Southeast Asia. Comin and Mestieri (2018) show that the lags in technological adoption between poor and rich countries have converged over time. Technological innovation receives substantial public subsidies in HICs in the form of higher education finance and R&D incentives, among other policies. Adding to that weak labour organization in the Global South, adoption of such labour-displacing technology might paradoxically be easier in countries where labour costs would otherwise provide a much smaller incentive for robotization.[5] Technological 'leapfrogging' of this kind presents a double-edged sword: rather than high labour costs incentivizing the development and adoption of labour-saving technology, developing countries adopt these technologies at comparatively low wage levels.

Service automation in developing countries suggests that the future of structural and technological change raises questions about the ideal sequencing of economic development and the right timing of technology transfer from advanced nations. Further, it also raises questions about the social policy context in which the developer's dilemma is to be managed going forward.

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[5] For instance, Cheng et al. (2019: 84) argue that, in China the 'lack of strong and independent unions may partly contribute to their tolerance of robot adoption'.

6 Conclusion

This paper discussed the future of structural change with a focus on new constellations of maturity and prematurity in technological and economic development. It sketched potential trajectories of catch-up structural change along the dimensions of early or late technology adoption and early or late economic development.

Going forward, a key configuration is that of 'early adoption during late development'. Advocates of this path speak of 'leapfrogging' and argue that skipping steps along the path to technological maturity constitutes, using the words of Gerschenkron (1951), an 'advantage of backwardness'. Critics contend that the adoption of technology developed in and for HICs may not always be advantageous in other places, notably in the absence of relevant complementarities. To illustrate this idea, the paper introduced the notion of 'technology leap' versus 'technology creep'. It then analysed examples and reviewed assessments of new development constellations of particular relevance for the future of structural change: the changing composition of employment and value added, the changing landscape of global trade, and technological upgrading in services.

Extrapolating historical trends, a continued increase of service-sector work at the expense of both industrial and agricultural work is likely to unfold in the medium term. In historical comparison, country-level shares of industrial employment appear to be increasingly detached from the level of economic development of a country. A conceptual blurring, or 'hybridization', of economic sectors is taking place as mass agriculture, the service industry, and the skilled manufacturing industry begin to share structural similarities of tradability, economies of scale, or capital intensity, among others.

Whether automation and digitization pose a threat to developing countries in a GVC world is debated with arguments and evidence brought forward on both sides. The paper argued that tensions about terms-of-trade deterioration and structural dependency might resurface in a situation in which a developing-country periphery provides simple inputs to highly robotized industrial clusters. In a similar vein, there are voices of concern about new forms of technological domination (e.g. Kwet 2019). The paper discussed the notion that developing countries are 'under-robotized' and presented evidence pro and contra this view.

To exemplify challenges around leapfrogging, the paper explored the case of automation in late-industrializing Southeast Asia. Despite regional heterogeneity, the region broadly fits the global picture of structural change but also provides examples of technological upgrading that are likely to become salient across the middle-income developing world going forward. The available country-comparable data suggests that the richest countries in this region have reached the 'Clark turning point' of industrial employment going into decline while the rest of the region is still on the upwards slope of industrialization. Automation is progressing, somewhat paradoxically, in non-tradable sectors like transport. Along with the worries of premature deindustrialization, the next challenge of structural transformation in middle-income regions like Southeast Asia could be automation in routine services, currently a refuge of human comparative advantage over machines.

While a changing global division of labour in the age of automation thus raises questions about structural dependency, leapfrogging raises questions about the optimal sequencing of economic development.

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