World Trade Review (2023), **22**, 302–311
doi:10.1017/S1474745623000241

ORIGINAL ARTICLE

Globotics and Development: When Manufacturing Is Jobless and Services Are Tradeable

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(Received 29 March 2023; accepted 29 March 2023)

Abstract
Globalization and robotics (globotics) are jointly transforming the world economy at an explosive pace. While much of the literature has focused on rich nations, the changes are quite likely to affect developing nations in important ways. The premise of the paper – which should be regarded as a thought-piece – is based on an extreme thought experiment. What does development look like when digital technology has rendered manufacturing jobless and many services freely traded? Our conclusion is that the service-led development path may become the norm rather than the exception; think India, not China. Since success in the service sector is based on quite different factors than success in manufacturing, development strategies and mindsets may have to change. This is an optimistic conclusion since it suggests that developing nations can directly export the source of their comparative advantage – low-cost labour – without having first to make goods with that labour.

Keywords: Development; digitalization; globalization; service trade

1. Introduction

Globalization and robotics (globotics) are transforming the world economy at an explosive pace since they are driven by digital technology that is advancing in phenomenal increments – increments that get twice as large every couple of years or so. The impact of the change is likely to be felt quite strongly in developed nations (Brynjolfsson and McAfee, 2014; Baldwin, 2019).[1] The change is also quite likely to transform development in important ways.

This paper – which should be considered as a 'thought piece' – argues that the globotics transformation is likely to disable the traditional manufacturing-led development 'journey' of the type China is taking, while enabling the service-led development journey of the type India is following. While these conjectures are unprovable since they concern the future, we believe they may merit consideration.

A growing body of evidence has begun to challenge the view that manufacturing is the prime route for development (Hallward-Driemeier and Nayyar, 2017; Loungani et al., 2017; UNCTAD, 2017; Nayyar et al., 2021). First, many of the pro-development characteristics traditionally associated with manufacturing – tradability, scale, innovation, learning-by-doing – are increasingly features of services (Braga et al., 2019). Second, digital technology is changing globalization in a way that is making services easier to trade by creating forms of communication that make remote workers seem less remote (Baldwin, 2019; OECD, 2019). Third, other aspects of digital technology ('digitech') are changing the nature of manufacturing by taking the 'manu' out of

[1]This paper draws heavily on the longer working paper of the same title, Baldwin and Forslid (2020), which itself draws on previous work the authors have published. This paper is intended as a policy piece aimed at a broader audience.

manufacturing and replacing it with robots, turning manufacturing into 'robofacturing', so to speak (Gilchrist, 2016). Taken together, these aspects of globotics are pulling the rug from under the traditional development strategy that equates development with industrialization. While nations may still export robofactured goods, these sectors will be more like oil wells that create value and exports but few jobs.

The premise of the paper is based on an extreme thought experiment with two parts. First, we assume that digitech's advance has little effect on the trade costs of trading goods, but a big effect on reducing the labour-cost share for manufacturing goods. Once the labour-cost share is low enough, trade in manufactured goods, based on international wage differences, will disappear as it becomes cheaper and easier to manufacture goods near customers. Second, we assume that digitech has little impact on lowering the labour-intensity of services, but has a big effect when it comes to lowering service trade costs. Given the enormous international wage differences for most service sectors, lower trade barriers should greatly expand trade in services.

In the face of these two outcomes – manufactures that are non-traded and services that are freely traded – we explore the question: What does development look like when manufacturing becomes jobless and localized, but most services are freely traded?

We start by considering technology (Section 2) and take a closer look at the economic logic that is making manufacturing jobless and services traded (Section 3). These background considerations are then matched with a more thorough consideration of a form of services trade called telemigration (Section 4). The paper ends with a section on how we might conceptualize service-led development (Section 5) and a consideration of how mindsets might have to change when switching from national development strategies premised on industrialization to those premised on service exports (Section 6).

2. Digitech – Why This Time Is Different

There is a very natural, very healthy tendency of economists to view research as a linear approximation around a steady state. Each contribution is small, and those that look like they are not, are usually old wine in new bottles (no value creation) or, worse yet, new wine in old bottles (false value creation). The tendency is in full swing when it comes to many economists' reaction to digital technology. Digital technology, after all, is really just ICT that is faster and cheaper. Since ICT has been a factor since the late 1980s or early 1990s, claims that digitech is changing the world tend to get classified as old wine in new bottles. In this section, we make the argument that something really has changed.

2.1 Computers Gain a New Type of Cognitive Capacity

When computers became generally useful in the 1970s, automation crossed one cognitive threshold. Computerization allowed the automation of many tasks that previously had to be done by hand. The way today's robot arms in automobile assembly plants sense and interact with chassis as they pass down the line would look very much like magic to a 1950s worker – or at the very least like science fiction.

The range of tasks that could be automated is, even today, limited compared to the vast range of tasks done by workers in all occupations. Mostly, automation affected routine, repetitive, manual tasks such as those found in assembly line factories. Indeed, a very large share of industrial robots work in the automotive sector. Limited automation was not due to a lack of creativity on the part of factory designers – rather there was a very clear structural reason for the it.

Computers back then were just following an explicit set of logical steps called a computer program. Automation was limited because computers were limited by programming; they were strictly obedient to the computer code written by a human. Since the human could only program based on a type of thinking that people understand, the cognitive capabilities of computers were

https://doi.org/10.1017/S1474745623000241 Published online by Cambridge University Press

limited to a narrow range of human thinking. This cognitive limitation created Moravec's Paradox: computers were good at what humans found hard but bad at what humans found easy. The reason was all down to the nature of classical computer programming.

Humans taught computers to do things with computer programs, so computers could only perform mental tasks where humans understood precisely how we humans do the mental task. But as Marvin Minsky (1986) put it, humans are: 'least aware of what our minds do best'. Machine learning – which really came into its stride around 2016 – solved the paradox by skipping the programming. Daniel Kahneman (2011) characterized Minsky's distinction between the thinking we do best and the thinking we are aware of as 'thinking slow and fast'.

With machine learning, computers started to be able to do some types of fast thinking as well as the slow thinking they had been doing since the beginning. With machine learning, computers could do some of the things that human brains do well, but where it was impossible to write a classic computer program because humans are unaware of how they perform the task (such as recognizing a cat in a photo). How is machine learning done?

It is significant that computer scientists use the word 'training' instead of the word 'programming' when they develop computer programmes to perform thinking-fast tasks. Machine learning 'trains' a very large statistical model that is designed to guess solutions to particular problems. This requires very large amounts of data and huge amounts of computing power to invert the matrices needed to 'train', i.e. estimate, the computer model.

With this new way of 'programming' computers, white-collar robots (i.e. artificial intelligence, or AI, software) can perform as well as humans in many new mental tasks, such as photo recognition, handwriting recognition, or language translation. This is one key reason that the present is different. Software robots can perform a whole range of mental tasks that they could not before 2016 or so. Of course, the breakthrough was incremental and based on advancing ICT (gathering, storing, process, and transmitting information), but the result was quite discrete. Most people in developing nations are using vastly more AI-enabled services without even knowing it.

As it turned out, many of the new mental capacities gained by computers are useful in the office and service jobs, and so many new service-sector tasks are automatable now, whereas before, they were not. This is one reason digital technology is more than just better ICT.

As far as development is concerned, the upshot is that many manufacturing tasks that previously required a human hand can now be automated with robot hands. And many office tasks involving information 'assembly-line' work can be automated by robotic process automation (RPA) suites, virtual assistants, and the like. This matters in offices, but it is also leading to factories that need very few manual workers.

2.2 Globalization and Automation Are also Affecting the Service Sector

To date, the gains and pains of globalization and automation have been mostly felt by the manufacturing sector or commodity-producing sectors – both in developed and developing nations. Going forwards, the gains and pains will be felt by professional and service-sector jobs. However, since most services are under-priced in developing nations compared to developed nations, it is likely that this will mostly be an export opportunity for developing nations and an import opportunity for developed nations. The basic point is that service jobs were shielded by high face-to-face costs. As digital technology tears down those barriers, the differences between the wages of accountants in, say, the UK, and in, say, Kenya, will narrow.

The next section considers in more depth how digitech is making manufacturing jobless and non-traded while making services freely traded.

3. Globotics Are Making Manufactures Less Traded

Every economic theory starts with a handful of bold and useful – but incorrect – distinctions and assumptions. Or as Krugman (1994, 8) put it when describing Albert Hirschman's theorizing:

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'You make a set of clearly untrue simplifications to get the system down to something you can handle; those simplifications are dictated partly by guesses about what is important, partly by the modelling techniques available. And the end result, if the model is a good one, is an improved insight into why the vastly more complex real system behaves the way it does.'

When it comes to trade theory, one of the most useful – but most incorrect – distinctions has been to separate things into traded and non-traded categories. When using simple models to talk about reality – where services often make up a very thick wedge of the economy's total production, consumption, and trade – the standard approach is to take all services as non-traded and all goods as traded. The usual justification is that the trade costs for services are many times higher than they are for goods since many services require face-to-face interactions and moving people is very expensive.

3.1 Production-Cost Differences versus Trade Costs

We start from the simple proposition that goods will be traded if international differences in production costs (using a very broad definition of production costs) exceed international 'separation' costs, using a very broad definition of separation costs, i.e. the cost of moving goods, ideas, people, capital, and services from sellers in one nation to buyers in another. Operationalizing this point requires more specificity.

We conceptualize the cost of production of a given good or service as consisting of two components: the unit labour cost and the unit cost of all other inputs. The unit labour cost in sector i in a typical country compromises a unit labour input coefficient, a_i, and the wage, so that the unit labour cost is wa_i. The non-labour costs, which we denote as r_i, consists of machines, intermediate inputs, and the like. For simplicity, we assume labour is perfectly non-traded, but all non-labour factors are freely traded and so cost the same in all nations (thus r_i has no country subscript). The unit production cost for good or service 'i' in a typical nation is thus: $c_i^n = w^n a_i^n + r_i$, where the 'n' denotes the nation under consideration (North in this case).

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

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

where θ_L is the labour-cost share in the North. In words, this equation says that the cost difference depends upon the relative labour cost in the two nations and the importance of labour in total costs. A good or service is traded if the proportional production-cost differences exceed the proportional separation cost. In the extreme, a labour-cost share of 0 would imply a 0 production-cost differential across countries since all other factors of production are freely traded.

The endogeneity of tradability, and how digitech changes it, requires us to look across all goods and services. To this end, we employ a modified version of the Dornbusch et al. (1977) analysis.

3.2 Comparative Advantage and Trade Costs in a Simple Diagram

Comparative advantage analysis starts with a comparison of nations' sector-by-sector competitiveness and we limit ourselves to two nations, North and South, to keep the analysis simple. We assume North is at the technological frontier while South is not in the sense that Northern labour is more productive in every sector. We also assume that North's technological edge is greater in some sectors than others. Since North labour is more productive in every sector, the Northern wage, in equilibrium, exceeds the Southern wage (measured in terms of the numeraire).

As is well-known from standard comparative advantage analysis, equilibrium wages will be such that the North's comparative-advantage sectors are those where its technological strengths

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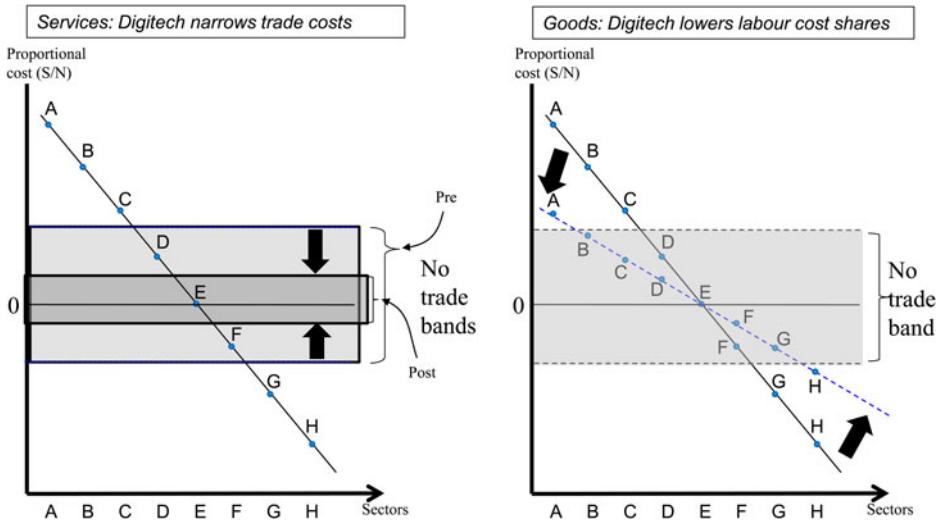

Figure 1. Endogenous tradeability diagram
Source: Authors' elaboration.

are most marked. For the South, its comparative-advantage sectors are those where its technological weaknesses are the least telling. A simple way to illustrate this is to plot the proportional production–cost difference for each sector, namely $(c^s - c^n)/c^s$, having labelled the sectors so that the differences are declining as in Figure 1.

The horizontal axis of the diagram lists the sectors – denoted by the shorthand A, B, C, etc., recalling that the sectors are labelled such that the North's cost advantage over the South's is highest in A and lowest in H. North exports the goods/services where its technology edge outweighs its higher wage; South exports the other sectors. As a matter of convention, we assume that there is no production cost difference in Sector E. Note that the North–South wage ratio is endogenous and not addressed in the diagram. We know, however, that in equilibrium, the wages must adjust such that North exports some goods and South exports others. Since the point of this conceptualization is to examine the determinants of tradability, we introduce trade costs.

Even in today's world, trade costs are quite substantial for most manufactured goods. One often-cited estimate by Anderson and Van Wincoop (2004) puts the ad valorem cost at 170% on average. More recent work indicates that these costs have fallen. Allowing for trade cost is simple to add to the figure in the form of the 'no trade bands'.

This setup allows us to focus on two determinants of tradability – the trade costs and the labour-cost share. Automation is rapidly lowering the latter for manufactured goods, and digital technology is rapidly lowering trade cost for services.

3.3 Digitech Drives Manufacturing Automation and Lowers Service-Trade Costs[2]

All around the world – including in developing nations – machines are taking over tasks that used to be performed by workers. The result has been a significant drop in the number of workers involved in manufacturing and thus a drop in the labour-cost share (see, for example, Dauth et al., 2018). Whereas jobs in developing countries still are less exposed to automation, this is changing (Das and Hilgenstock, 2022). The resulting reduction in labour-cost shares dampens comparative advantage based on international differences in technology and wages.

[2]This section draws heavily on Baldwin and Forslid (2014) and Baldwin (2016, Chapter 7).

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A core premise in this paper is the claim that advancing digitech is lowering trade costs and lowering labour-cost shares in both goods and services, but not at the same pace. For services, digitech is radically lowering trade costs, but lowering the labour-cost share only marginally (since robotic automation is still mostly focused on manufacturing). For manufactured goods, digitech is only marginally lowering trade costs (the big steps came with containerization and air cargo), but radically lowering the labour-cost share via robotics.

We simplify to clarify by positing extreme assumptions. We assume that digitech's advance has no effect on the cost of trading goods, but a big effect on labour-cost share in goods production. For services, we assume the opposite. The effects are shown in Figure 1. In the left panel, the no-trade band narrows, so more services become tradeable; specifically, sectors D and F switch from non-traded to traded. In the right panel, which represents digitech's impact on goods sectors, the reduced labour-cost shares rotate the relative cost-competitiveness line counter clockwise (the fact that it rotates on sector E was chosen as a matter of convenience). The obvious impact is that additional goods-producing sectors switch from traded to non-traded, specifically sectors B, C, and G.

This analysis puts aside a whole range of important factors. Perhaps the most important is the endogeneity of the relative wages. A massive reshuffling of tradability of goods and services would surely have a massive impact on relative wages. We do not account for that in this diagram, but it would be simple to include, as shown in Baldwin and Dingel (2021).

4. Telemigration

Shifting from theory to facts, the lower cost of trading services means that trade in services is booming even as trade in goods is not (Baldwin, 2022). Companies in G7 nations are turning to remote workers to perform an increasingly wide range of tasks. For the most part, these remote workers are in the same nation as the companies, so it is not globalization, but wage differences and talent shortages are driving more and more companies to turn to foreign-based online service workers, whom we could call 'telemigrants'. A recent study of Upwork contracts found that the top three nations hiring telemigrants were high-wage English-speaking nations – the US, Australia, and the UK. The three biggest sources of telemigrants were the Philippines, India, and Bangladesh (Horton et al., 2017). The US was the only high-wage nation that was both a major buyer and seller of this sort of online remote labour. When it comes to accountants, computer programmers, engineers, nurses, and many other service jobs, complete replacement of a domestic worker with a telemigrant would be impossible, but some substitution of low-cost foreign remote workers for high-cost domestic workers would surely save money.

Who are today's foreign freelancers? The online payments company, Payoneer.com, queried 23,000 freelancers worldwide. About a quarter of respondents were in Latin America and Asia, 20% in Central and Eastern Europe, and about 15% in both the Mideast and Africa (Sukman, 2015). The vast majority of freelancers surveyed are in their 20s and 30s (about 85%). A bit more than half had university educations. The companies paying for their services were about half in North America and Europe (split equally), about 15% in both Latin America and Asia, and 7% in Australia and New Zealand.

How fast will telemigration grow? The answer will differ across the various types of service sectors since some lend themselves much more easily to integrating remote workers or have more widely accepted standards. Government regulation will also surely play a large role.

4.1 Factors Driving Telemigration

There are four factors suggesting that telemigration will grow faster than most think in almost all sectors. Perhaps the most remarkable is how fast digitech is lowering the language barrier.

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Machine translation now rivals average human translation for language pairs where large, hand-translated datasets are available. According to Google research, which uses humans to score machine translations on a scale from 0 (complete nonsense) to 6 (perfect), in 2015 Google Translate got a grade of 3.6 – far worse than the average human translator who gets scores such as 5.1; by 2016, Google Translate hit numbers like 5, and it is widely used. Google does a billion translations a day for online users. Instant and free-spoken translation is also possible with the Skype Translator add-on option.

Computing power and massive new datasets are the reasons why machine translation got so good, so fast. Machine-learning trained AI-systems can now recognize language patterns well enough to do human-level translation – the real constraint is the lack of human-translated sentences. For the language pairs where data are available, the translation is good; for others it is poor.

Machine translation will fundamentally alter the global supply of service workers. About 400 million people speak English as their first language, and, including good second-language speakers, there are something like a billion people who could sell services in English online. It would seem that machine translation might multiply this number by two or three, creating a tidal wave of online talent.

4.2 Work Reorganization and Telecoms

Another factor that is accelerating the trend towards remote work is the way in which US and European companies are reorganizing themselves to make it easier to slot in telecommuting workers. They are using new collaborative platforms – such as Business Skype, Slack, Trello, Basecamp, and more – that help organize communication among team members. The changes induced by the Covid-19 pandemic have accelerated these changes.

One telecommunication technology that is coming on fast uses augmented reality – that is, the projection of a digital image on to reality via a headset or glasses, or even a smartphone screen. The two key technologies are augmented reality (AR) and virtual reality (VR). Many companies, both start-ups and giants like IBM, are using AR and VR to improve remote collaboration. They are redefining what it means to work side-by-side with someone. They are going a long way towards taking the 'remote' out of remote work.

There are other forms of telecommunication technology in testing stages, such as 'holographic telepresence'. This projects real-time, three-dimensional images of people (along with audio) in a way that makes it seem as if the remote person is right next to you. This is the stuff of science fiction, but it is not unimaginable – having been used in the 2017 French presidential election and the 2014 Indian election.

5. What Globotics and Telemigration Means for Development Strategies: Conceptualization

If the automation of manufacturing means localized, jobless manufacturing, many national development strategies will have to be rethought. The changes may not appear for 10 or 20 years, but this is in line with the timeline of most national industrialization strategies, so looking ahead is important.

That manufacturing is changing is not a new point. 'A nascent yet growing body of evidence has begun to challenge the long-held tenets of economic development that industrialization is the prime engine of growth' (Loungani et al., 2017). This message is also clear in Hallward-Driemeier and Nayyar (2017): 'Globalization and new technologies are impacting the desirability and feasibility of what has historically been the most successful development strategy', namely manufacturing. 'Many of the pro-development characteristics traditionally associated with manufacturing – tradability, scale, innovation, learning-by-doing – are increasingly features of services.' As Braga

https://doi.org/10.1017/S1474745623000241 Published online by Cambridge University Press

et al. (2019, 3) put it: 'While industrial development has played a key role in export-led development trajectories in the past … ICT-enabled services in particular offer potential for export diversification that defy the logic of traditional paradigms by relying purely on electronic cross-border delivery, making it accessible even to countries with underdeveloped physical trade infrastructure.'

6. Globotics and Development Mindsets

The hardest aspects of development are only marginally changed by globotics, this for the very simple reason that the trade-and-development component of development is not the hardest part. Even in quite open economies, most economic activity is by, and for, local citizens. Getting it to work requires all sorts of difficult inputs such as good roads and ports, good institutions, good education, good health systems, trust among citizens, trust by citizens of their government, and many more. However, the globotics transformation is likely to radically change the way we think about development if the posited thought experiment comes true, that is if labour-cost-based trade in manufactured goods comes to an end and services become freely traded, ways of thinking about development will have to change. This is not a novel thought.

The Pathways for Prosperity Commission's 2018 report *Charting Pathways for Inclusive Growth* lists 'Global trade in services' as its Pathway Three. The report lists the main ways to unlock the pathways – the most relevant of which is about how governments and businesses can create a digital-ready country. Many of the recommendations are akin to those suggested by UNCTAD in its many publications on e-readiness that stress five pillars: enabling digital infrastructure, enabling legal and regulatory frameworks, enabling human capital, enabling finance, and enabling coordination.

A study that focuses on creating digitally enabled jobs for African youths (Mastercard Foundation, 2019) suggests a few 'no regret' measures that policymakers could take, such as collecting better data locally, monitoring international developments closely, providing training for local policymakers on digital economy matters, promoting the provision of digital 'soft' commerce skills (e.g. digital marketing and relationship management) as well as hard skills (e.g. coding), and embracing a 'test-and-learn approach' to deal with the uncertainties and rapid pace of change. The 2016 ECLAC report 'Innovation and Internationalization of Latin American Services' presents many ideas for how governments should think about and prepare for digitech's impact on development (Hernández et al., 2016).

Here we do not repeat or even catalogue the suggestions, rather we attempt to focus attention on how services are different when it comes to development mindsets.

6.1 How Are Services Different?

There are two critical shifts in thinking when it comes to service-led development that we can summarize in two pithy aphorisms.

- Stop thinking capital equipment and technology and start thinking people and training.

The key to industrialization was to get the right equipment and the right technology in place and to line up the factories with sufficiently large customer bases. In the traditional development strategy, labour in the manufacturing sector is not viewed as a relevant constraint. It is a bit of a sideshow since one of the great features of manufacturing is that workers can, almost, walk out of the rice fields into a factory and start being productive with very little preparation. This is not true of modern services.

When it comes to modern services, the people are the 'capital equipment', so to speak. And the people do not come with embedded technology, unlike a robot welder from Germany. Foreign

https://doi.org/10.1017/S1474745623000241 Published online by Cambridge University Press

know-how may be important but for many types of export services – say coding, copyediting, or project management – the technology is a bit of a sideshow. The skill and experience of the people, the service providers, are the real constraint.

Joining the service value-added chains require less of a great push than the development of an industrial base, but the accumulation of human capital may take a longer time than the accumulation of physical capital.

Secondly,

- Stop thinking factories and start thinking of cities as productive platforms.

Cities are where people meet and form local networks for face-to-face connections and exchanges, where people exchange ideas, and competition among ideas plays out. Cities facilitate matching between service workers and service firms. As the economic geographer Enrico Moretti puts it, cities become 'brain hubs' (Moretti, 2013). Workers and firms implicitly benefit from each other's knowledge creation via face-to-face interaction and social networking. This point is not new.

In 2010, the Netherlands Bureau for Economic Policy Analysis wrote a study of how the Netherlands could future-proof its economy and the answer was: cities. Cities should not be thought of as mere collections of people, but rather as complex work spaces that generate new ideas and new ways of doing things (Ter Weel, van der Horst, and Gelauff, 2010).

Governments should start thinking of cities as production hubs, not just living quarters. Cities should be conceptualized as geographic centres for face-to-face interactions that foster the production of export-oriented services. Winning cities will attract high-quality jobs and lock them in with agglomeration forces.

Another change in thinking is actually a continuation of the thinking about manufacturing. We are all by now familiar with the notion of the role of the second unbundling in manufacturing-led development. The idea that there is a value chain that a developing nation can join is clear. The same thing is true in services.

7. Concluding Remarks

This paper seeks to think through the trade implications that digital technology may have for developing nations, for their development strategies, and for the broader world. Our conclusion is that the service-led development path may become the norm rather than the exception. Since success in the service sector is based on quite different factors than success in manufacturing, our conclusion suggests that development strategies and mindsets will have to change. While change is always hard, this is a fundamentally optimistic conclusion for developing nations for a very simple reason.

Digitech will allow many emerging markets to directly export the source of their comparative advantage (labour which is low cost given its quality) without having first to make goods with that labour and then export the goods. One way of thinking about comparative advantage trade in a Ricardian model is that trade in goods is a veil for trade in labour services. Digital technology is merely pulling back the veil. The resulting expansion in service trade is likely to be an overall net export gain for emerging markets and an overall net import gain for developed economies.

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Cite this article: Baldwin R, Forslid R (2023). Globotics and Development: When Manufacturing Is Jobless and Services Are Tradeable. *World Trade Review* **22**, 302–311. https://doi.org/10.1017/S1474745623000241