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THE SERVICIFICATION OF MANUFACTURING IN ASIA: REDEFINING THE SOURCES OF LABOR PRODUCTIVITY

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In this report, "$" refers to United States dollars.

Abstract

Services are playing an increasingly important role in the global economy. Over the last few decades, the sector's contribution to output, employment, and value-added trade has grown quite dramatically. The rise of services and apparent decline of manufacturing employment have raised concerns about the future of growth given the lower labor productivity of the former. But more recent studies have argued against this for several reasons. Among others, current measures of productivity do not properly account for the indirect contribution of services to other sectors. For example, the additional value generated by services in the production of manufactured goods can be substantial, but it is not properly accounted for because of the indivisible and intangible nature of services. Moreover, the rise of the digital economy has created new ways for services to contribute to production. This paper aims to tackle some of these issues by focusing on the servicification of manufacturing in Asia. Our contribution to the emerging literature is twofold. First, we propose a conceptual framework of servicification. And second, we offer some preliminary evidence of this phenomenon for Asia and measurement proposals to disentangle the contribution of services to labor productivity.

Contents

1. INTRODUCTION

Services are becoming increasingly prominent in terms of both output and employment. In 2016, services accounted for 66% of world GDP. The shift from manufacturing to services, otherwise known as the "deindustrialization-tertiarization phenomenon," is not just limited to advanced economies. A number of studies have pointed out that many developing countries are also transitioning to a service-led economy (Felipe and Mehta 2016). The fact that this shift is occurring even as manufacturing has yet to fully develop has prompted some to call the deindustrialization "premature" (Rodrik 2016).

The deindustrialization of economies around the world, based on the premise that manufacturing is the driver of growth, has incorrectly raised concerns about the role of services. Since services were considered to be less productive than manufacturing, and largely nontradable, Baumol (1967) predicted that growth would eventually slow down. However, like some recent studies, we argue against this for a number of reasons. First, the sectoral approach to measuring output ignores the increasing fragmentation of production wherein tasks may be outsourced to other sectors domestically or internationally. This practice may create a notional increase in the output of services without the creation of new value added in services (Hallward-Driemeier and Nayyar 2018; Nayyar 2010). The contribution of these services to the manufacturing process is thus not properly captured.

We show that current productivity measures suffer from biases in definition and measurement. Such measures are also unable to account for the indirect effect of services on other industries. For example, the additional value generated by services for manufactured goods can be substantial, but it is difficult to measure their contribution given their indivisible, intangible nature. At the same time, the contribution of services is multifaceted and is becoming even more important in a knowledge-based economy: As the digital economy has grown, measuring the value of output in many spheres has become even more challenging. This paper discusses the concept of "servicification" in manufacturing in Asia. It explains how there are certain services that are intrinsically performed as part of the manufacturing process, and which have a symbiotic relationship with the physical manufacturing of goods and are subordinate to the final output. It explains why national accounts do not capture it and proposes a new methodology using the principle of time use.

The paper is divided as follows. The following section discusses the recent literature's redefinition of the role of services in production, part 3 discusses the concept of servicification and provides evidence for Asia, and part 4 suggests a blueprint of new methodologies to measure labor productivity. Part 5 concludes.

2. THE ROLE OF SERVICES IN THE ECONOMY: SOME BASICS

2.1 Definitions and Key Concepts

Services encompass a wide range of activities that fall outside of agriculture, manufacturing, or other industries (Andersen and Corley 2003; OECD 2000). These activities result in the transformation of a good or a person's state (Hill 1977), often through the creation of value added by individuals (OECD 2000). Services differ from other sectors of the economy in a number of ways. Unlike manufacturing, which

produces physical goods, many services are intangible and difficult to store. Moreover, the production of services, such as cutting hair and teaching, requires direct interaction with consumers. In contrast to goods, which are relatively homogeneous, most services are highly customized or personalized. For instance, the treatments administered by doctors are tailored to the needs of each individual.

Nevertheless, the distinction between services and manufacturing is becoming increasingly blurred. Advances in technology have allowed some services to acquire characteristics that were previously unique to manufacturing (OECD 2000). In particular, technological progress has allowed some types of services to be stored. For example, movies, music, and other performing arts can now be streamed, recorded, or digitally stored for consumers to watch at their convenience. This development has enabled services to be traded and distributed to a broader market. Likewise, technology is gradually eliminating the need for personal interaction. For instance, customers can now execute financial transactions through Internet banking. Electronic commerce has also enabled goods and other services to be bought and sold virtually.

Given their heterogeneous nature, services have been classified by literature in different ways.

- **One of the most commonly used classification systems is based on the primary product of a firm or an enterprise** (Andersen and Corley 2003). For example, the latest revision of the International Standard Industrial Classification (ISIC) system divides services into more than 10 broad groups, which can be disaggregated further into more specific activities (see Appendix Table 1 for ISIC revision 4 classification). Moreover, the classification assumes that sectors will produce one or two types of service, which allows for the possibility that some firms or enterprises produce more than one type of service.

- **As a second alternative, services can be classified into two broad groups: *traditional* or *"stagnant"* services and *modern, hi-tech,* or *"progressive"* services** (Baumol 1985). Traditional services include wholesale and retail trade, personal services (e.g., barber shops), and publicly provided services such as defense. Most of them are characterized by a high degree of face-to-face interaction as well as limited use of information and communications (ICT) technology (World Bank 2009). On the other hand, modern services, such as finance, insurance, and business-related services, are heavily dependent on technology. This has contributed to their increasing transportability (e.g., through satellite and telecommunications networks) as well as their tradability (World Bank 2009). Typically, traditional services dominate during the early stages of economic development while modern services emerge as countries reach higher levels of income (Eichengreen and Gupta 2011).

- **A third classification is based on how services are used or consumed** (Petit 1986; Montresor and Vittucci Marzetti 2011). Services that mainly satisfy final demand, such as hotels and restaurants, recreation, and personal care, are known as *consumer services*. In contrast, services that primarily cater to intermediate demand are known as *producer services*. These include finance, insurance, real estate, and research and development (R&D). Producer services act as inputs to all sectors of the economy, ranging from agriculture to mining and manufacturing. Services can also function as inputs to other service sectors.

- **In terms of their role in manufacturing, services can be considered horizontal or vertical.** For example, R&D and product design typically occur prior to the fabrication of a good, while sales and marketing activities are usually conducted in the latter stages of production. These services, which are common to all manufacturing firms, are also known as "horizontal services." In addition, some firms may require vertical services, which are specific to their industry or subsector, for example clinical tests in the pharmaceutical sector (Gereffi and Fernandez-Stark 2010). Additionally, services such as transportation act as the "glue" that holds global value chains together (Low 2013).

- **Regardless of how they are classified, services can be supplied either for domestic or foreign use.** In terms of the latter, the General Agreement on Trade in Services (GATS) identifies four modes through which services can be distributed internationally (Lanz and Maurer 2015). The first mode is through traditional cross-border supply, which is similar to how goods are traded across borders. Alternatively, services can be supplied through the movement of labor and capital. In particular, people may move abroad to consume services (Mode 2) or to supply services (Mode 4). Likewise, firms may establish a commercial presence in another country through the movement of capital (Mode 3). With the exception of Mode 3, all other modes are captured through the balance of payments (BoP) system. Services provided through commercial presence are covered by the Foreign Affiliates Statistics (FATS) framework (Lanz and Maurer 2015).

2.2 Trends and Issues

Globally, services account for a large and increasing share of output and employment. Between 1995 and 2016, services' contribution to world GDP rose from 58 to 66 %, while employment grew from 36 to 51 % (World Development Indicators). Among advanced economies, the growth of services has occurred as a natural progression from the industrial stage of development. In contrast, many developing countries' employed populations are shifting to services even before their manufacturing sectors have "peaked" in earlier stages of development. This has been called "premature deindustrialization" (Rodrik 2016).

This "premature deindustrialization" has raised concerns about the future of growth given the lower productivity of services compared to manufacturing, but there are differing reasons for this. For one, the growth of services and concomitant decline of manufacturing may be more notional than real. As Hallward-Driemeier and Nayyar (2018) point out, the outsourcing or splintering of services creates an artificial increase in services output followed by a commensurate decline in manufacturing output. In this case, the change is caused by a reorganization of production and not by a real change in the value of output produced by the two sectors. Using data on 40 countries from the World Input-Output Database, Cruz and Nayyar (2017) found that the outsourcing of services by manufacturing firms accounted for only 10% of the growth in services' value added between 2000 and 2014. Nevertheless, Bernard, Smeets, and Warzynski (2017) look at the reasons for firms switching activities from manufacturing to services in Denmark, and find that those that splinter into services and specialize tend to become much more productive than those that do not, suggesting that the results are different at the firm level.

Aggregate statistics also mask considerable differences in the composition of services within an economy and comparatively fewer hi-tech services in developing Asia. As Noland, Park, and Estrada (2013) point out, most of developing Asia is still characterized by traditional services, such as wholesale and retail trade, hotels and restaurants, transport, and personal services. Only a handful of economies in the region, in particular Hong Kong, China; the Democratic People's Republic of Korea; and Singapore, have service sectors that are comparable with OECD economies in terms of sophistication. Distinguishing among different types of services is important because productivity rates vary significantly within the sector. In general, consumer services exhibit lower productivity than producer services. Some services, such as transport and communications and financial intermediation and business activities, have productivity rates that are on a par with, or even greater than, those of manufacturing (IMF 2018a). The key message is that some types of services could be just as effective as manufacturing in driving growth.

Current productivity estimates may be biased due to measurement issues. Simply defined, productivity is the amount of real output produced by a given set of real inputs.[1] This implies that the quantity of output and inputs, as well as the prices used to deflate both components, must be captured accurately. This is difficult to do in practice given the inherent characteristics of services to be discussed below. As a result, the output of manufacturing would appear larger and its productivity higher relative to services. Given the increasingly important role played by services in the manufacturing process, the bias could be significant.

More importantly, intersectoral comparisons overlook the indirect contribution of services to the productivity of other sectors. For example, telecommunications enable knowledge diffusion by acting as a "transport mechanism" for information and other digitized products. Similarly, technological innovation would not be possible without research and development. Even "unproductive" services, such as retail and wholesale trade, and health and education, can indirectly contribute to the productivity of other sectors. The former plays a key role in linking producers with consumers, while the latter helps improve the quality of the workforce, which is a key factor of production (Hoekman and Mattoo 2008).

More generally, the splintering of services from manufacturing has paved the way for specialization to occur (Francois 1990). The resulting economies of scale not only translate to greater output for manufacturing firms, but also to lower prices for services that are used as inputs to production. One way to gauge the contribution of services to the productivity of manufacturing is to examine the link between the two sectors more closely. By quantifying the contribution of services to the manufacturing sector, we can capture one of the ways in which services indirectly contribute to productivity.[2] In the next section, we explore the concept of "servicification" in more detail and provide some evidence for Asia.

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[1] There are many different types of productivity measures. Broadly speaking, these can be classified according to the number of inputs used (i.e., single-factor productivity measures vs multifactor productivity measures), or how output is defined (i.e., gross output vs value added output). For a detailed explanation of these measures, see OECD (2001).

[2] Box 3.1 of the IMF (2018a) tries to measure the services content of manufacturing for a set of advanced and developing countries between 1995 and 2011. They find that the change was quite small during that period, about 6%, with most of it due to a growth in consumer services. However, because of the level of aggregation of the sectors, as well as the time period studied (before hi-tech services became more prominent), they are unlikely to capture the contribution of services embodied in the manufacturing good.

3. THE SERVICIFICATION OF MANUFACTURING

3.1 Definitions, Concepts, and Drivers

The servicification of manufacturing, otherwise known as "manuservice," pertains to the increasing reliance of manufacturing firms on services. This manifests itself in several ways. First, production is becoming more intensive in services as reflected by the number of services that are used as intermediate inputs by manufacturers (Low 2013). Second, manufacturing jobs are becoming more service oriented: The number of workers performing service-related activities within the manufacturing sector has grown, while the number of those engaged in core production has declined (Miroudot and Cadestin 2017; Miroudot 2016). In addition, services are increasingly being embedded in, or bundled with, goods to create more value. Servicification is therefore a multidimensional phenomenon (Figure 1).

Figure 1: The Various Dimensions of Servicification
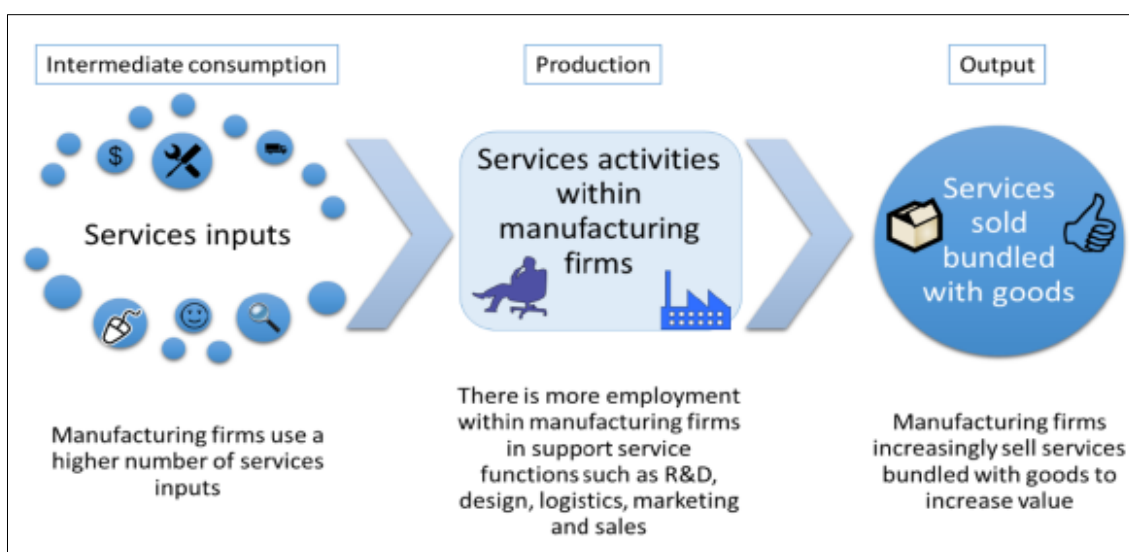
Source: Miroudot and Cadestin (2017).

Services may also be embedded into, or bundled with, a manufactured good. This phenomenon is known as "servitization."[3] This idea goes back to Vandermerwe and Rada (1988), who described the practice as "the increased offering of fuller market packages or 'bundles' of customer-focused combinations of goods, services, support, self-service, and knowledge in order to add value to core product offerings." Examples of these include warranties and aftersales services, as well as financing schemes that are designed to facilitate the purchase of a product. But with advances in technology, the types of services that can be embedded or bundled with a good have also expanded. One example is the smartphone: While the phone itself is a good, users can download applications that give rise to different types of services ranging from audiovisual (e.g., streaming of music or movies) to publishing services (e.g., e-books) (Hallward-Driemeier and Nayyar 2018). Consequently, manufacturing firms are employing more workers in service-related activities, such as R&D, design, and marketing, than in activities directly related to production (Miroudot 2016).

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[3] We thank Sebastien Miroudot for clarifying this terminology.

To understand the types of services offered by manufacturing firms, services are classified in two broad groups (Table 1). In line with Cusumano, Kahl, and Suarez (2015), the first group includes all services that act as complements to the manufactured good. These can be divided further into two types, namely *smoothing* services and *adapting* services. The former is designed to facilitate the purchase and use of the good without significant changes in the product's features. Financing schemes, warranties, and maintenance and technical support are all examples of smoothing services. The latter, on the other hand, pertains to services that enhance the overall value of a product by augmenting it with new features or making it more personalized. For instance, Xerox now offers "document solutions," which are essentially printer or photocopying machine bundles with services such as document management (Benedettini et al. 2009). Nevertheless, there are cases where services replace rather than complement goods. IBM, for instance, has evolved from a computer manufacturer to an IT and business services provider (Ahamed, Inohara, and Kamoshida 2013).

Table 1: Types of Services offered by Manufacturing Firms

| | Complementary with Products | | Replacement |
	Smoothing	*Adapting*	*Substituting*
Definition	Services that "smooth" the product sale or usage without significantly altering the product functionality	Services that expand the functionality of a product or help the customer develop new uses	Services that replace the purchase of a product
Examples	• Financing • Warranty/insurance • Maintenance/repair • Technical support • Training in basic uses	• Customizations that create new features specific to a user • Training or consulting that introduces new uses • Integration with other products or "solutions"	• Data processing services in lieu of mainframes • Software as a service instead of a software product • Zapmail service (Fedex) offered instead of fax machines • Rolls-Royce "Power by the Hour" instead of engine

Source: Cusumano, Kahl and Suarez (2015).

A second important form of servicification of manufacturing happens through splintering. The splintering of production could manifest itself as manufacturing firms closing their services departments and outsourcing. Essentially, this allows businesses to subcontract part of their operations to independent suppliers located in the same country (e.g., domestic outsourcing) or abroad (e.g., offshore outsourcing). This is usually done for noncore activities, such as back office processing, accounting, or customer support. The new services are provided through "arm's length" contracts, so firms have separate ownership and management (although they can customize the service for their clients). In this process, the true specialization of every stage of production can occur.

The gradual transformation of the manufacturing process to a service-oriented one is what creates the symbiotic relationship between goods and services (Figure 2). Servicification, perhaps a more general term (see Swedish National Board of Trade definition, 2016), can come in the form of servitization (in-house provision) or servification (splintering and outsourcing). There are variants of this relationship. An example is the movement from producing songs on compact disks to making them

available digitally: The music industry is still alive but is reclassified from producing a "good" to producing a "service." Another example is when an auto company separates its auto maintenance and leasing business. Each unit can act separately, but the efficiency and survival of the service and leasing units depend on the extent of sales of that type of car (subordination of the service to the manufacturing process).

In the next section, we survey the extent of servicification based on the literature as well as our own analysis for Asia.

Figure 2: The Servicification of Manufacturing
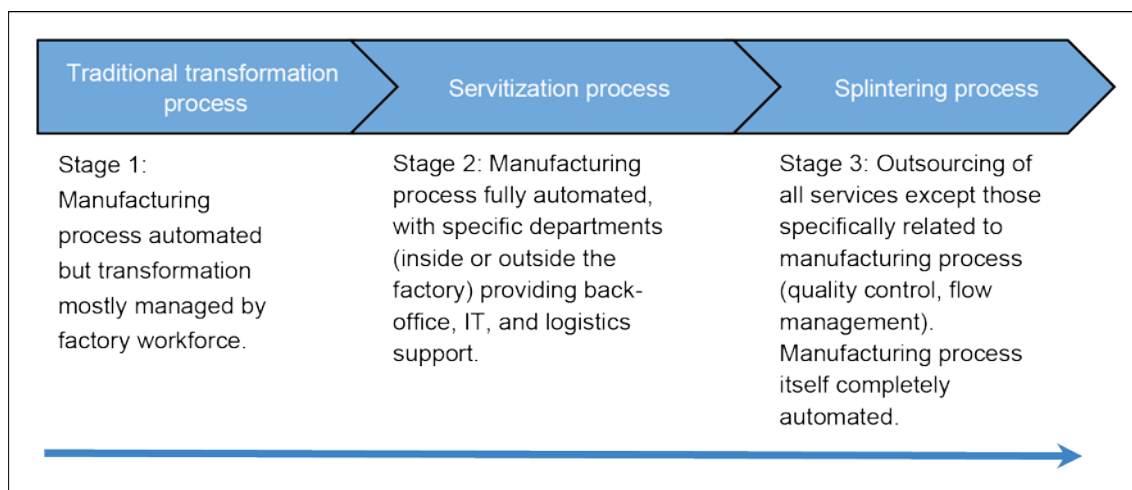
Source: Authors.

3.2 Trends and Patterns of Servificification

3.2.1 Evidence from Recent Studies and New Data

The main empirical contribution of this paper is the use of an updated global data set to provide a broad but fuller examination of servicification in manufacturing sectors in Asia. Most recent studies have focused on the impact on trade and global value chains. In this section, we examine trends and patterns of servicification using the Asian Development Bank's Multiregional Input-Output (MRIO) tables. The ADB MRIO builds on the World Input Output Database (WIOD), and extends it to cover more Asian economies.[4] It divides economies into 35 broad sectors, including 14 manufacturing sectors and 17 service sectors (see Appendix Table 1). For our analysis, we utilize the latest release of the MRIO, which covers a total of 62 individual economies and the remainder denoted the "Rest of World" for nine years (i.e., 2000, 2010–2017).

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[4] The ADB MRIO includes 24 economies in Asia equivalent to 97% of developing Asia's GDP, namely: the People's Republic of China; Indonesia; India; Japan; the Republic of Korea; Taipei,China; Bangladesh; Malaysia; the Philippines; Thailand; Viet Nam; Kazakhstan; Sri Lanka; Pakistan; Fiji; Lao PDR; Brunei Darussalam; Bhutan; the Kyrgyz Republic; Cambodia; the Maldives; Nepal; Singapore; and Hong Kong, China. The other 42 economies are mostly OECD economies, but an included region called the "Rest of the World" ensures that the system is closed as any economy not included individually is part of the RoW.

The literature estimating the importance of services in manufacturing is fairly new and focuses on manufacturing exports. ADB (2015) and OECD (2012) began reporting comprehensive indicators in trade in value added, more recently updated in OECD (2018). Recently, Heuser and Mattoo (2017) showed that the share of services exports in gross exports globally has remained at roughly 20% since the 1980s, whereas the contribution of services to value added exports has grown very quickly globally, from below 30% in 1980 to more than 40% in 2009. Using the updated MRIO 2017, our data show similar trends for Asia. Services exports as a share of total exports for Asia between 2000 and 2017 has remained steady at roughly 17% (Figure 3). Excluding Japan, it has declined from 18% to 16%. But in terms of value added, the contribution of services has increased. Services value added contribution to total exports of goods and services went from 27.7% to 34.4% between 2000 and 2017.

Figure 3: Services Exports versus Export Servicification in Asia
(% of total gross exports)
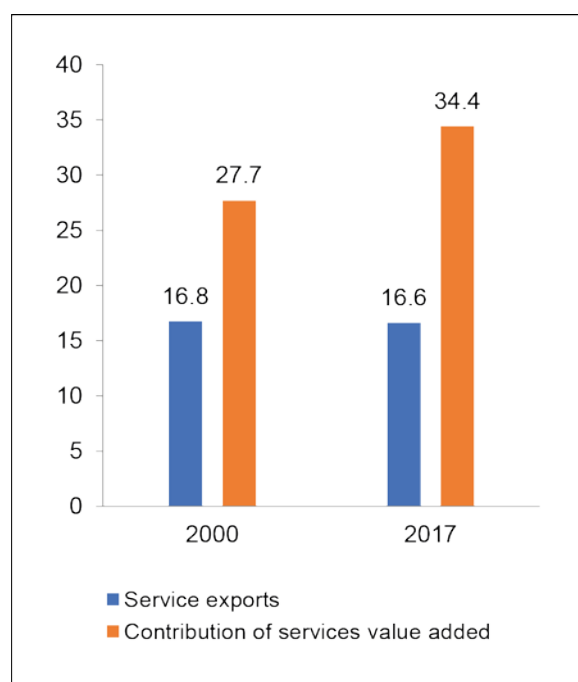
Source: Authors' calculations based on ADB TiVA statistics.

The share of services value added in exports was about the same in 2017 in Asia and non-Asia, though this share varies significantly across economies (Figure 4).[5] In part, these differences reflect various areas of specialization. For instance, economies that primarily export commodities (e.g., Mongolia and Brunei Darussalam) and manufactured goods (e.g., Viet Nam, the Republic of Korea) use fewer services as inputs than economies that actually export services, such as Hong Kong, China (where services contribute over 70%) and the Maldives, but the relationship is not straightforward. This result is consistent with Heuser and Mattoo (2017), who find that services between 1980 and 2011 accounted for 33% of value-added exports on average among advanced

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[5] The value added of services to gross exports can be broken down into its foreign and domestic component. The latter can be disaggregated further into three parts: (i) direct domestic services value added; (ii) indirect domestic services value added; and (iii) reimported domestic services value added (Heuser and Mattoo 2017).

economies, with the majority being domestically provided. Lanz and Maurer (2015) also look at services contribution and find that this ratio is a full 13 percentage points higher in advanced economies than in developing economies, with the gap largely explained by the indirect exports of services. Indeed, the availability of services within an economy appears to be crucial for the development of export sectors.

Figure 4: Own Services, Other Domestic Services, and Foreign Services Value-added Contribution to Value Added of Exports by Economy, 2017
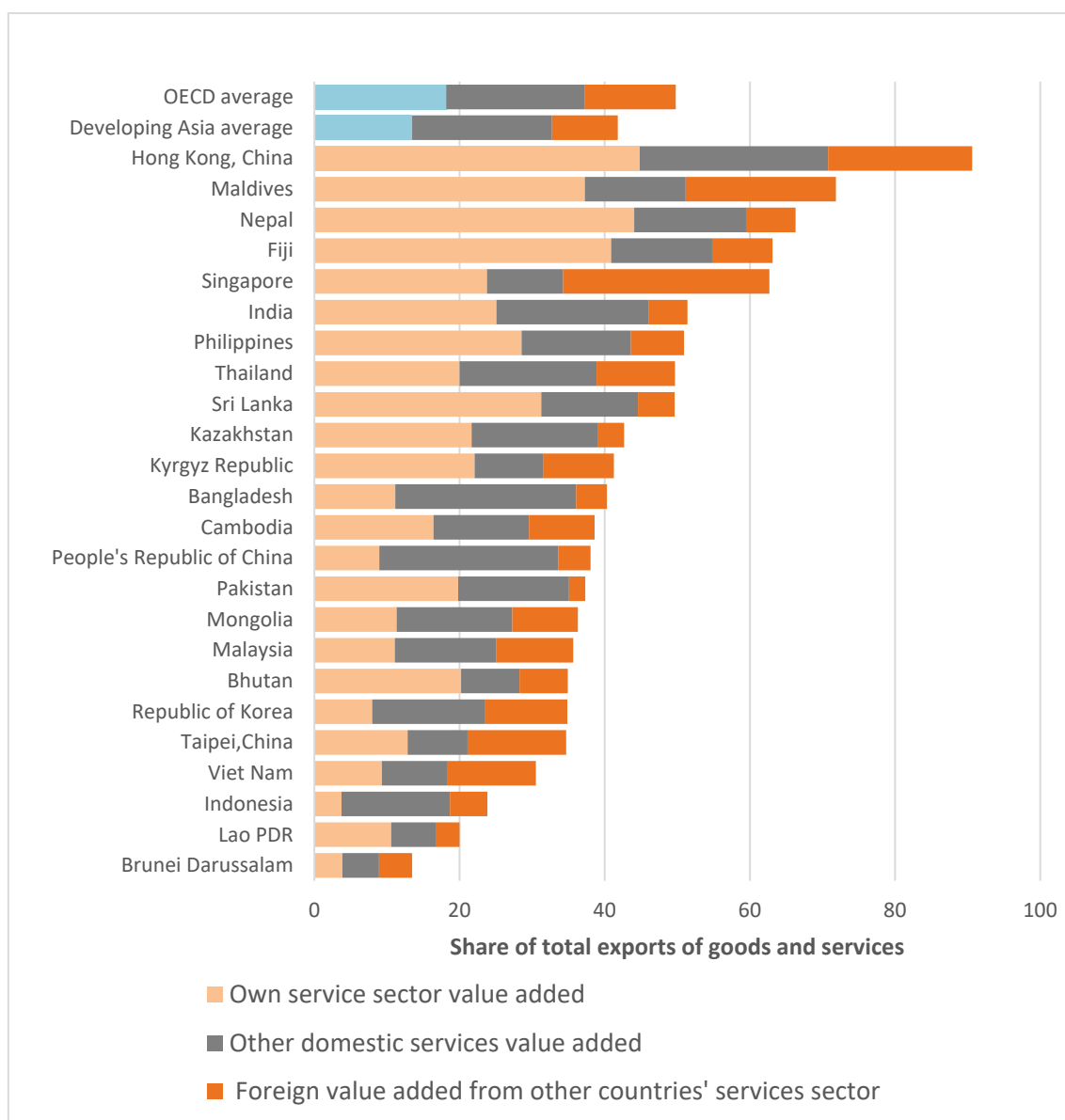
Note: Own service sector value added refers to value added originating from within the service sector to produce its own exports. Other domestic services value added refers to value added contributed by other domestic services sectors used to produce exports. Foreign value added from other economies' services sector refers to value added contributed by foreign services sectors to produce exports.

The Republic of Korea is in both OECD and developing Asia.

Source: Authors, using ADB MRIOT 2017 data.

Our data also show that more advanced economies have a higher contribution of services to GDP. More specifically, this ratio is higher the higher the GDP per capita

(Figure 5). This is not surprising given the specific sectors that play a key role in the manufacturing process and the "nontradable" nature of many services sectors, such as retail trade, telecommunications, and infrastructure services, which are more developed in advanced economies. This result was found in Chen et al. (2018).

Figure 5: Direct and Indirect Inputs of Services as a Share of GDP against In GDP per Capita, 2000–2017 (MRIO)
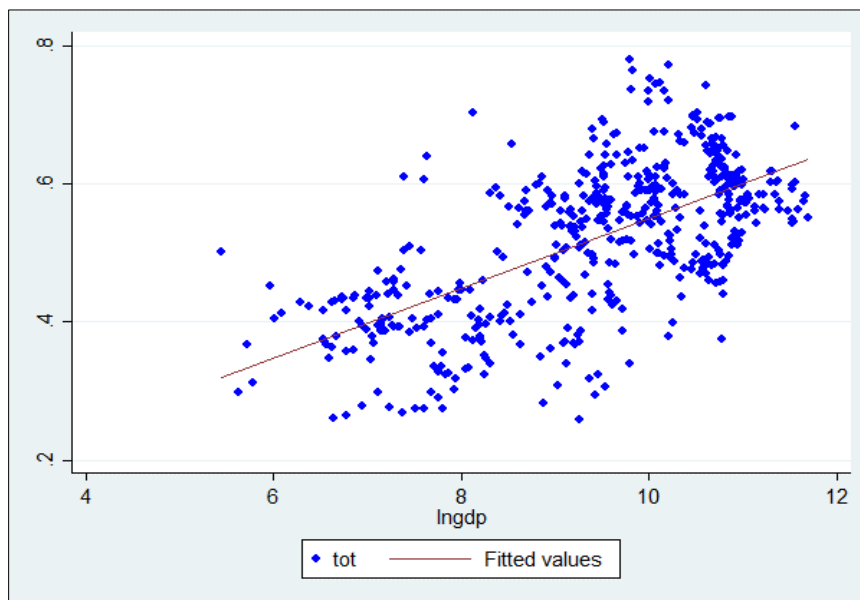
Source: authors using MRIOT 2017.

Services provided in-house within manufacturing firms—servitization—could be substantial but difficult to observe. Miroudot (2016) matched job functions to occupation data from labor force surveys using data for 37 countries, mostly from the OECD, to describe how the composition of employment in manufacturing firms has changed since 1995.[6] Overall, he found that the servitization of manufacturing jobs has increased in all countries with available data. Moreover, the analysis reveals large variations across sectors. Jobs related to core operating activities range from almost 30% for coke and petroleum to more than 90% in the case of agriculture (Figure 6). On average, only about 50% of jobs in the manufacturing sector are in production while the rest are in support services.

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6   The analysis was expanded further in Miroudot and Cadestin (2017) to include 41 countries. These are the 28 EU countries, Australia, Brazil, Canada, Iceland, Norway, Switzerland, Turkey, Japan, the Republic of Korea, India, Mexico, New Zealand, and the United States.

Figure 6: Decomposition of Jobs Embodied in Gross Manufacturing Exports by Function and Industry, 2011
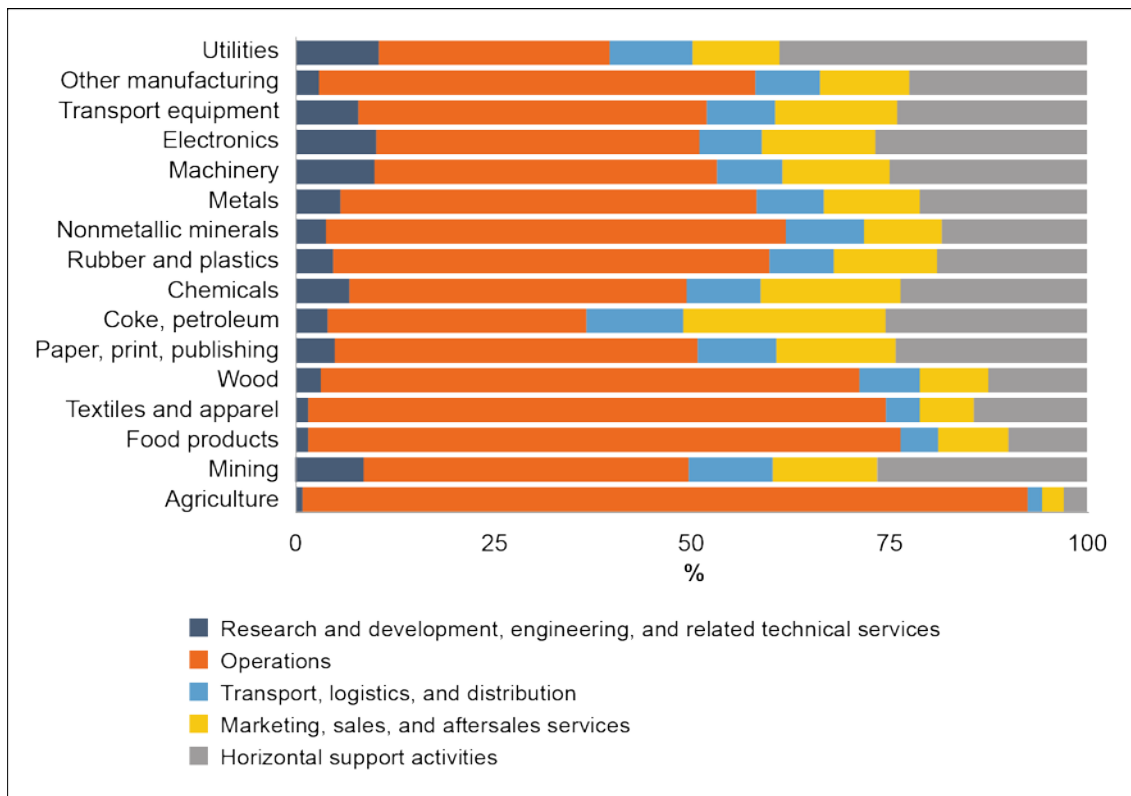
Source: Heuser and Mattoo (2017) based on Miroudot (2016).

Services provided in-house are not only used as inputs into production but are also bundled with goods sold by manufacturing firms, complicating the measure of their contribution to value added. In theory, national accounts should reflect the division between in-house goods and services of servicification. For example, the total output of a manufacturing firm that offers financing should be recorded as two separate transactions: the first as a good, and the second as a service. In practice, there are likely to be differences across countries and industries regarding how output is measured and recorded by national statistical offices. It is especially difficult to disaggregate output when the sale is conducted as a single transaction or when the service is not "consumed" simultaneously with the good (e.g., maintenance or repair). As a result, the servitization of manufacturing output is likely to be understated in national accounts. Crozet and Milet (2017) thus refer to this phenomenon as "hidden deindustrialization." Box 1 discusses the main challenges for national accounts.

Box 1: Can National Accounts Adequately Measure Today's Productivity?

National accounts were conceived during a very different time to today. Colin Clark, Simon Kuznets, and Richard Stone of the UK began to conceive the national accounts in the 1930s. This was a time when manufacturing and construction were the engines of growth: The production of goods was a clearly tangible process of man "working" with machines or tools to transform mostly physical goods into consumable outputs. Services were sometimes supportive (for example, transportation utilities, etc.). But services were mostly consumable or publicly provided; they were considered marginal to production or a leisure activity. To draw a line as to what should be value added in a given year, Kuznets chose to consider only "productive" activities in the new economic statistics, defined as those that produced goods or services that could be bought or sold in the market economy. Thus, their unit value was the price. It was also important to be able to measure the activities, and the industrial classification developed thus "treat[ed] services as 'immaterial' (i.e., everything that is not manufacturing or agriculture), while ignoring that the activity of services in the economy, as well as the corporate structure of firms, transcend such classification schemes at any level of aggregation" (Andersen and Corley 2003). However, as the definition of a "productive activity" or the definition of a "unit" of service became increasingly blurred in an age of hi-tech manufacturing, artificial intelligence, and apps that run on cellphones, the compilation of national accounts as originally conceived is experiencing serious challenges measuring intangibles.

The example of the national accounting of the Korean automobile company Hyundai illustrates the difficulty of measuring every process. Its factory in Montgomery, Alabama, in the US, can produce almost 400,000 cars and trucks per year with 3,000 employees for distribution across North America, but the company also leases them and finances their purchase, and its 800 dealerships provide the servicing. Almost all the parts, including sophisticated electronic components and sensors, are produced elsewhere around the world. How will national accountants put together Hyundai's economic contribution? They will request revenues and costs for all the operations of Hyundai, and will divide the main activities (primary, secondary, tertiary activities, etc.). At some reasonable cutoff for the number of "principal" activities of Hyundai US, they will assign the value added (revenues minus costs) to the different subsector categories under the NAICS classification. Leasing, repair, engineering services, logistics, accounting, etc., which are services contracted out to third parties, will be considered a cost for Hyundai and a revenue for the service providers, so the input-output links will clearly show that these activities are linked (although presentation of national accounts on the production side will not show the links). Labor compensation will be classified depending on the worker's place of affiliation. Overall, the value added will be in aggregate fully accounted for in one sector or another.

There are four important problems in this measurement that lead to undermining the contribution of services to productivity.

- **First, the labor productivity of that plant (number of cars per worker/hour, 400,000 autos per year/300 plant workers in man-hours) will be solely attributed to the auto manufacturing sector in the national accounts, and not to the myriad of services that contributed.** Due to bundling of services, batching of computer programming, robotics installed in earlier years, etc., most of the unit average costs in that period will be components, parts and utilities, consumption of fixed capital defined under statutory depreciation rules, etc. The contribution of services in that period will be small. Nonetheless, the output would be impossible without the provision of "indivisible" services with huge economies of scale. Their contribution cannot be accounted for as a share of the final output if it is included elsewhere as a stand-alone "service."

Box 1 *continued*

- **Second, workers involved in services within the Hyundai plant are unlikely to even appear as separate services employees in the accounting**, and thus cannot contribute to an increase in services value added in the national accounts, particularly if they comprise a small or ancillary cost of production. The extent of servitization mismeasurement is greater when the service is provided in-house (Crozet and Milet 2017).

- **Third, services are typically priced through bundling, cognizant of their indivisibility property**. It is common for insurance, accounting services, and TV and phone services to be priced as "monthly services," which means that two users of the same plan may use vastly different amounts of the "bundled" service. In practice, the difference in productivity derived from the service by each user may be huge. For example, national accounts will show the "phone services" of the customer service desk as being equal to the "phone services" of the staff lounge room and attach to it the bundle price, erroneously attributing the same value added to these two users. When deflated, services with different usage rates are assumed to be equally productive. This is compounded by the lack of homogeneity of the service unit once used up. Goods, on the other hand, are tangible and clearly divisible, so their unit value can be more easily measured.

- **Finally, there are many services that are becoming almost free because they rely on a repetitive code that has already been designed from before, as we rely on an accumulation of knowledge by others:** for example, an algorithm designed to optimize the shipping routes for Hyundai cars ready for delivery. This has a fixed cost (charged by the programmers), but no marginal cost. Again, national accounts may attribute the efficiency of the distribution process to the manufacturing process itself, when in fact it was the infinite economies of scale of the network specialist's algorithm that enabled this shipping efficiency.

Other issues discussed in the literature exacerbate these problems. However, various studies (for example, IMF 2018b) argue that the size of the estimated effects is insufficient to explain the fall in labor productivity over the last two decades. Going forward, these issues will lead to large measurement biases. There are perhaps five main issues that arise: (i) deflators of new goods or hi-tech goods do not reflect goods' "unit value" when calculating real GDPs, and not all statistical offices adjust appropriately; (ii) "free" goods, such as Facebook, Wikipedia, pictures from a phone, etc., are not included in national accounts (because their price is zero), thereby underestimating the value they contribute to GDP. If these platforms are used for e-commerce, for example (which is very common in developing Asia), their contribution to efficient distribution is not properly accounted for; (iii) goods or services produced but not remunerated (unpaid household work, family help) are also not included because they are free; (iv) when corporations splinter production offshore, the valuation of each of the stages of production sometimes relies on inaccurate pricing by multinational companies, who declare their ownership of each stage of production in the locality that minimizes their tax liability (transfer pricing). Even if all production stages could be accurately valued, it would require all countries providing full, accurate reporting and sharing their data on companies with other national accounts statistics offices, which is beyond the capacity of most countries' institutions (Moulton and van de Ven 2018); and (v) the spillover effects from agglomeration economies of a talented team working together to produce new knowledge is crucial to productivity and generally not accounted for. The human capital of a university scientist in the team, for example, is classified as an "education" service. Such a service is valued at cost—sometimes subsidized if provided by the public sector—because there is no tangible output.

Given the limitations of national accounts and trade statistics, studies on servitization have relied on firm-level data, which allows output to be disaggregated into a goods and a services component. Most are focused on Europe (Walter and Dell'mour 2010; Kelle 2013). Among them, Federico and Tosti (2017) utilized a data set with 3,000 exporters in Italy and found that 30% of services exports are produced by manufacturing firms. Crozet and Milet (2017) used French time series data, as did Lodefalk (2010) for Sweden, and found that the servitization of manufacturing output has indeed grown. Miroudot and Cadestin (2017) utilized the ORBIS data set, which contains firm-level data for 50 developed and developing countries (nine from Asia). Although the estimates are subject to a number of caveats, they also find that a significant number of firms produce both goods and services. The most common type of service bundled with goods is "distribution" followed by transport services. However, some services are tied to the production of specific goods. For example, engineering and R&D services usually accompany exports of chemicals and minerals, while construction is linked with exports of wood products.

A good example of servitization is in the very capital-intensive oil and gas sector. Originally dominated by large oil and gas conglomerates, the complexity of the oil and gas production chain has led to both servitization and splintering of oil and gas services. Oil majors have become resource owners and project managers of many smaller outfits that do the technical work (both inside and outside the consortiums). As the sector becomes more complex, this process is expected to increase (Box 2).

Box 2: Servitization in Oil and Gas Services

**Examples from the United States and Kazakhstan**

The oil and gas services sector provides a pointed example of servitization of production of nonrenewable resources. Oil production and exploration are performed by multinational companies organized around joint ventures (JVs), which contract the services of all sorts of experts: geologists and geophysicists, lessors of oil rigs, drilling services, welders, lawyers, pipeline companies, shippers, distributors, etc. These services are tightly linked to the production and extraction but are typically provided at arm's length by oil field and exploration services companies (OFS).

Oil field services (OFS) companies have driven innovation in oil and gas, increasing in scale and scope and enabling extraction from fields impossible to conceive before 2000. By 2011, the global revenue of OFS was estimated at USD750 billion (The Economist 2012). The market capitalization of the largest supplier in mid-2018, Schlumberger, stood at USD95 billion and exceeded that of major international oil companies, such as ENI and Statoil. It carries out most of the tasks involved in finding and extracting oil. Most of the recent innovations in oil and gas production and distribution are the result of OFS work, and the rate of innovations in the sector is astounding. Following the 2006 oil price increases, innovation was unleashed: Horizontal drilling and shale oil and gas (3D seismology and directional drilling), as well as enhanced oil recovery techniques, flourished. This allowed oil and gas accessible reserves to flow much more easily, but also gave producers the ability to draw on capacity in shorter periods of time. More importantly, it gave the sector the ability to splinter the production process even further and refine the value chains. Another discovery has been the ability to transport natural gas more economically in liquefaction boats—small LNG carriers and bunker vessels.

Box 2 *continued*

Figure B2.1: Stock Market Value of Oil Production and Oil Field Services, 2000–2018
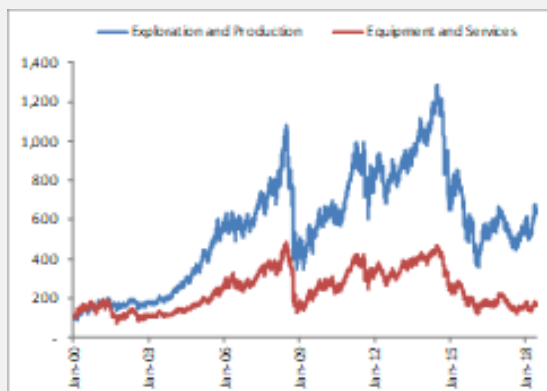
In the United States the technology advances have, in turn, increased the value of the oil and gas companies as well, with positive spillovers. In the US, at least, these spillovers have translated into a large valuation growth for producing companies, albeit not for service companies. According to national accounts, value added in oil and gas extraction soared between 2000 and 2016 while employment as a share of nonfarm employment in the US stayed roughly the same, implying significant growth in labor productivity (Table B2.1). In contrast, measured value added of oil and gas services hardly rose—from 1.2% in 2000 to 1.3% in 2015—but the employment as a share of total US employment rose by almost 20% to 0.42%. With employment growing faster than value added, it would imply flat productivity for oil and gas service companies based on the national accounts, when other evidence suggests otherwise. Moreover, while oil production has increased with oil prices, oil services have been much less volatile, and their value is not appropriately attributed in the stock prices (Figure B2.1). In other words, the production sector is getting all the "credit" despite the talent employed in oil and gas services.

Table B2.1: United States Economy: Share of Employment and Value Added to Total Employment and Value Added (Selected Sectors)

Concept	Employment (Full- and Part-time)		Value Added (GDP)	
Year	2000	2016	2000	2016
Oil and gas extraction	0.28%	0.3%	1.3%	1.7%
Downstream	0.4%	0.3%	1.1%	1.3%
Oil and gas services 1/	0.35%	0.42%	1.2%	1.3%
Memo item: Services over extraction	1.25	1.4	0.92	0.76

1/ excludes waste management and remediation services.

Source: US Bureau of Economic Analysis, Bureau of Labor Statistics, and authors' estimates.

The importance of OFS in Kazakhstan is also not obvious in national accounts. Kazakhstan is a typical highly resource-dependent country in central Asia, and like many has struggled to diversify. One way it has done this is through a concerted effort to establish local-content regulations, providing a chance for local engineers and oil services firms to get involved. On average, between 1994 and 2014 oil and gas production accounted for only 0.5% of total employment in Kazakhstan. However, the indirect impact through forward linkages on total employment was considerable, as the spending of oil rents then supported the growth of labor-intensive services: The share of service jobs in total employment grew from 38% in 2001 to 48% in 2014.

Box 2 *continued*

The direct and indirect inputs by services in Kazakhstan suggest considerable servicification. Between 2005 and 2015, the oil and gas sector purchased over 50% of all its intermediate inputs from the services sector, growing from 55% in 2005 to 74% in 2015 (Table B2.2). This likely underestimates the importance of know-how and skills that went with it: R&D services were crucial in developing the Kashagan field in the northern Caspian Sea, one of the largest in the world and estimated to hold 13 billion recoverable barrels of oil. It was discovered in 2000 but the geological and technological challenges led to $50 billion being spent on R&D over 17 years, of which almost a quarter went to local service firms, as joint ventures and consortiums between local and foreign OFS companies were promoted as vehicles for transferring technologies and skills. Despite the huge inputs of services, the national accounts show large increases in oil and gas production, but only slight services output increases by domestic services firms.

**Table B2.2: Share of Services in Intermediate Inputs Purchased
by the Oil and Gas Sector**

Service	2005	2010	2015
Repairs	1.08	0.48	3.28
Auxiliary mining services	17.17	13.99	20.67
Construction	1.61	0.48	1.68
Professional services	7.8	3.5	11.16
Oil field services	27.7	18.5	36.8
Total services (%)	**55.36**	**36.95**	**73.59**

Source: ADB (2018) using the Kazakhstan National Committee on Statistics.

3.2.2 Some Evidence Specific to Asia

Perhaps the earliest evidence of servicification in Asia was provided by Baldwin, Forslid, and Ito (2015) and Baldwin, Ito, and Sato (2014). Using the concept of the smile curve the authors find that in all nine major Asian countries between 1985 and 2005, the primary source of value added has recently shifted away from the manufacturing sector and moved to the service sector. This is particularly true for the semiconductors and electronics production process, with the major producers being based in Asia (Figure 7). Until 1995, the manufacturing sector still accounted for the majority of value added.

The MRIO tables allow us to measure sector-level components of servicification using some refinements on the well-known direct and Leontief coefficients. Using the technical coefficient matrix, we can quantify the number of services that are directly used as inputs in manufacturing sectors for arm's-length transactions. By subtracting this matrix from the Leontief matrix, we also obtain an estimate of services that are indirectly used by a particular sector (see ADB (2018b) for a detailed description of the decomposition). The Leontief coefficients themselves give us the total number of services used in manufacturing. In other words, they represent the sum of what we denote as *direct* and *indirect* **components**. To illustrate these concepts, consider the case of an automobile manufacturer. To produce one vehicle, it uses equipment leased from another company. The rent paid for the equipment is an example of a direct service used as an input by the automobile manufacturer. However, this does not account for all the equipment rentals that are paid in the production of one vehicle. For instance, the automobile manufacturer may require basic metals as part of its raw materials. Assuming

these metals are also produced using leased equipment, then the rent serves as an indirect input to the manufacture of a vehicle. Figure 8 shows that the direct contribution of services to manufacturing's value added between 2000 and 2017 stayed broadly constant: On average, a dollar of demand for manufacturing production generates nearly $0.20 of services globally. However, the indirect component is not only about twice as large but has grown by more than 15%: the total (direct and indirect) contribution of services to a $1 dollar value added in manufacturing increased from $0.55 in 2000 to $0.62 in 2017.

Figure 7: The Role of Hi-tech Services in the Manufacturing Value Chain
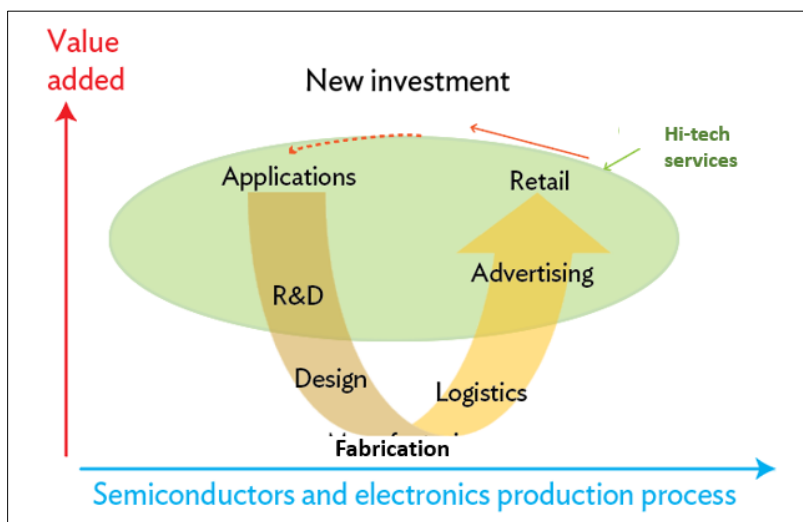
Source: Authors based on ADB (2018a).

**Figure 8: Global Direct and Indirect Contribution of Services
to Manufacturing Value Added**
(% of manufacturing value added)
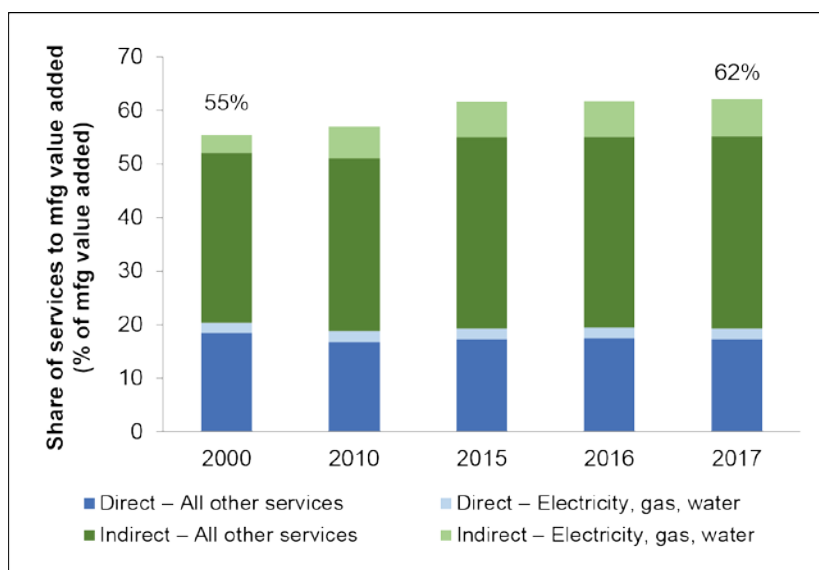
Notes: Figures represent the average of all manufacturing sectors, weighted by the country's GDP. Services sectors include publicly provided and community sectors, but exclude construction.

Source: Authors' calculations based on ADB TiVA statistics.

**Figure 9: Direct and Indirect Contribution of Services
to Manufacturing Value Added, 2017**
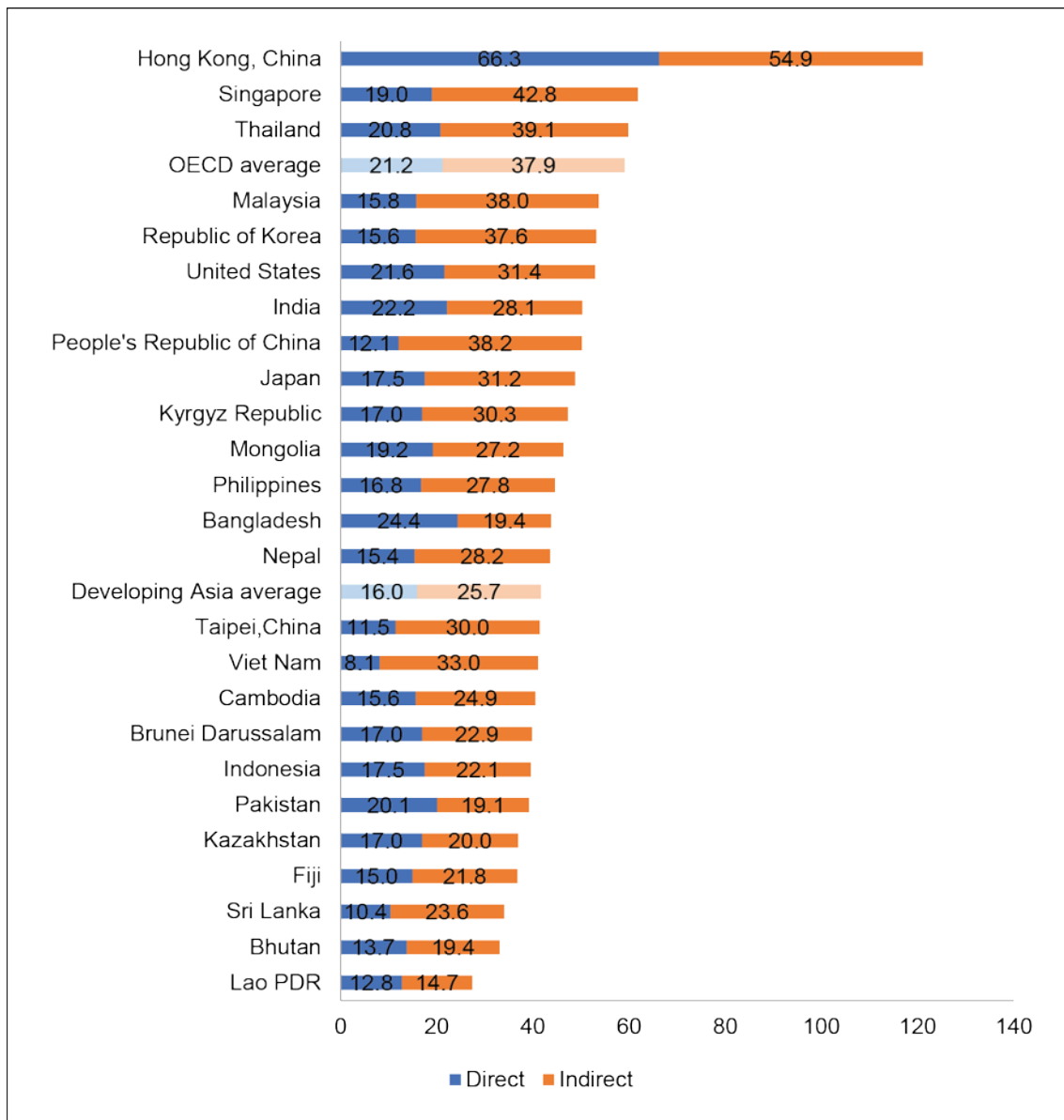
Notes: Figures represent the average of all manufacturing sectors for each economy. The original data are expressed in terms of one dollar of manufacturing output, so these were multiplied by 100 in order to convert them to percentages.

Source: Authors' calculations based on ADB TiVA statistics.

The degree of servification varies widely across economies but is generally lower in Asia than in OECD economies (Figure 9). In terms of direct inputs, Viet Nam's manufacturing sector is the least servified. On average, only 8% of a good's value is derived from services. The opposite is true for Hong Kong, China, the most servified economy in the group, where services directly account for two thirds of manufacturing output.[7] But Singapore and Thailand are more servified than the average OECD

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[7] Part of this result reflects the very small manufacturing base in Hong Kong, China, which in some sense magnifies the share of services and makes it an outlier. However, it also reflects its trade openness: It is worth remembering that direct and indirect contributions of the services sectors in an economy can originate domestically or from a foreign economy.

economy—both just over 60%—with two thirds attributed to the indirect contribution of services to manufacturing value added. The PRC, Malaysia, and India exhibit values similar to the US. The indirect contribution is generally slightly larger than the direct contribution for Asian economies except for Pakistan and Bangladesh. Services in developing Asia in total contribute 43% to manufacturing value added (unweighted average); however, many of the larger and more advanced economies in developing Asia are close to OECD average levels.

Figure 10: Total (Direct and Indirect) Contribution of Services to Manufacturing Value Added by Sector (2000 and 2017)
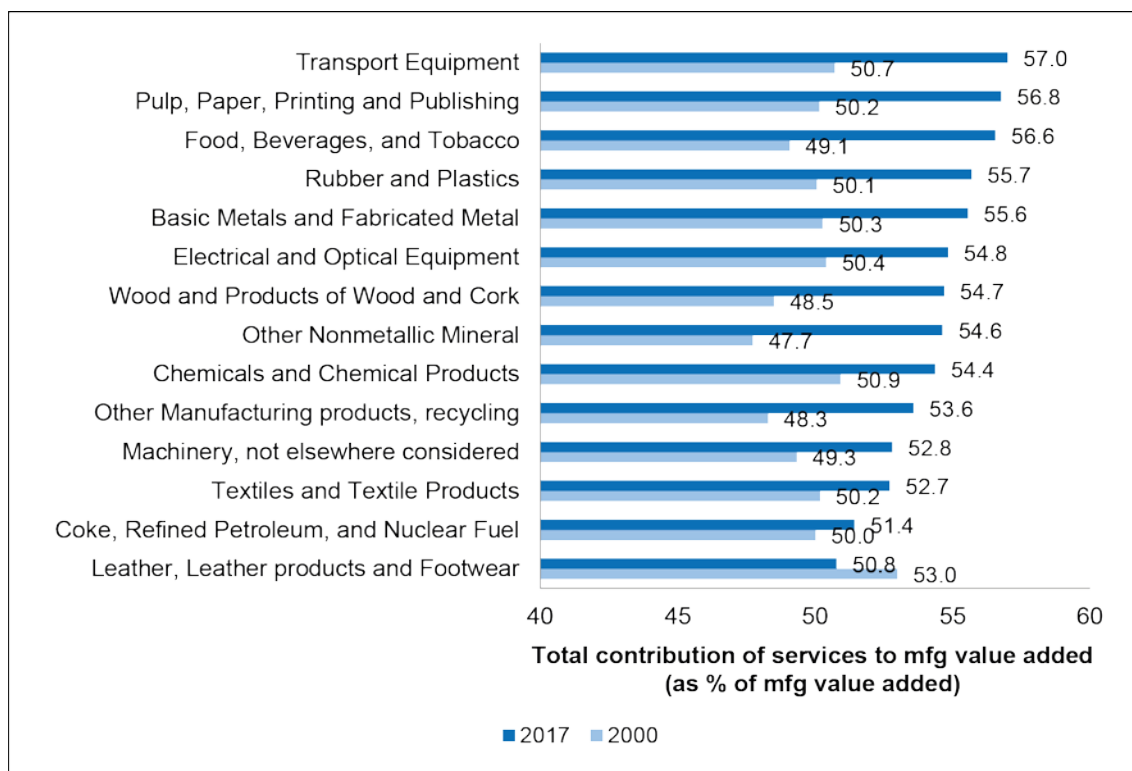
Note: Figures represent the average input coefficient of services for all 62 economies. The original data is expressed in terms of one dollar of manufacturing output.

Source: Authors' calculations based on ADB MRIOTs.

Globally, all manufacturing sectors show that services contribute to between 50% and 60% of their value added, and the phenomenon is not only limited to high-tech manufacturing sectors. Some services contribute more than others, with the category of "renting of machinery and equipment and other business services" (abbreviated henceforth as business services) having the strongest arm's-length links with manufacturing, especially in the United States.[8] Figure 10 shows the direct and indirect contribution of services to the value added of each manufacturing sector globally. Transportation equipment, which is deeply embedded in global value chains, is not only the most servified manufacturing sector (at 57% in 2017), but this contribution grew the most of all manufacturing sectors between 2000 and 2017. This is not surprising: Transport equipment, particularly autos, is also one of the most automated sectors (using

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[8] The key services used by manufacturers are distribution and business services, with each sector contributing about one third to the value added of services in manufactured exports. The remainder is divided among transport, finance, and other services (Miroudot and Cadestin 2017).

robots), in line with the complementarity of high-tech services with capital intensity (ADB 2018b). Other sectors, such as paper printing and publishing, as well as food, beverages, and tobacco, tend to be mostly nontraded, and are directly linked to services such as publishing and restaurants, respectively. Only one sector, leather and footwear, became less servified between 2000 and 2017, although services still contribute to 50% of their value added. The textile and garments sector is not too servified, which perhaps explains why Pakistan and Bangladesh, two large garments exporters, have lower average values of servicification.

In terms of the source of the contribution of services to manufacturing, there are stark differences across economies, although no discernible patterns are evident (Table 2). Most manufacturing sectors are embedded into long global value chains, with domestic and foreign arm's-length links. The magnitude of the increase varies significantly between 2000 and 2017. The indirect contribution, which is perhaps the most interesting, varies from an almost 100% increase in Brunei Darussalam, an oil producing economy, to a 48% decline in Fiji. Most of the direct contribution comes from domestic services inputs, but the opposite is true for indirect contribution, in which the foreign component is somewhat larger. For developing Asia, the direct contribution of services grew by 8%, although the indirect contribution continues to be more important. The direct foreign services contribution is low but growing: $0.04 for every dollar of manufacturing value added, but indirect foreign services contribute to two-thirds of manufacturing value added on average. It is worth noting that for nondeveloping Asian economies (mostly advanced economies), the contribution of domestic services has fallen precipitously since 2000, while the contribution of foreign services has soared.

We also examined "servification of services" and found that it is not as large as for manufacturing, although the variation across service sectors is huge. Two sectors stand out as being the most servified. A $1 increase in the demand for business services elicits a $1.70 increase in the value added of services in 2017, and this number is particularly high for OECD countries; the number is $1.61 in the sector "wholesale trade and commission trade." Financial services are also highly servified, although this phenomenon is limited to just a few countries—particularly those with large offshore centers, and Bangladesh. Except for the People's Republic of China, servification of high-tech services is very low in developing Asia.

Business services tend to be a key player in development for high-income economies, despite being barely traded internationally. Since the majority of services are not directly exported, but only contribute to the value of other exported goods, it is easy to undervalue their importance in the growth of manufacturing and an export-led development strategy. When high-tech manufacturing products are exported, this tends to stimulate business services (which include legal and professional services). Indeed, the greater the direct and indirect linkages (servification) of business services in manufacturing value added, the more developed the economy is (Figure 11). This number is generally low for most of Asia except for Singapore and Hong Kong, China. Interestingly, both direct and indirect linkages increase quickly in the early stages of development. Indirect linkages are highly correlated with development, particularly for advanced   economies   (Figure   11, right panel).[9]

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[9] There are some pointed examples of servicification in developing countries as well. Mercer-Blackman, Foronda, and Mariasingham (2017) found that the subsector in Bangladesh with the highest linkages to manufacturing of machinery is a services subsector: "sale, maintenance, and repair of motor vehicles." According to the statistics, these services are purely nontraded and they make up less than 0.25% of gross value added. This reflects the informal but thriving vehicle repair shops in Bangladesh that allow

**Table 2: Change in the Direct and Indirect Contribution of Services
to Manufacturing Value Added by Source, 2000–2017**
(%)

Economy	% Change in Direct Contribution			% Change in Indirect Contribution		
	Total	Domestic	Foreign	Total	Domestic	Foreign
Brunei Darussalam	–24%	–37%	47%	98%	103%	97%
Philippines	70%	71%	54%	54%	89%	35%
Bhutan	8%	3%	63%	47%	25%	57%
Kyrgyz Republic	113%	78%	1311%	39%	–11%	94%
Sri Lanka	16%	47%	–50%	35%	397%	8%
Republic of Korea	19%	18%	26%	32%	32%	33%
Hong Kong, China	38%	–10%	107%	22%	–5%	36%
People's Republic of China	–2%	–1%	–18%	21%	38%	–22%
Malaysia	71%	78%	32%	21%	191%	–21%
India	29%	34%	–33%	17%	29%	0%
Bangladesh	7%	7%	16%	9%	14%	2%
Japan	–2%	–4%	37%	7%	–13%	91%
Taipei,China	–14%	–21%	34%	5%	–27%	23%
Cambodia	22%	7%	114%	5%	34%	–4%
Singapore	29%	30%	22%	4%	11%	1%
Viet Nam	–38%	–20%	–83%	3%	3%	3%
Thailand	–4%	1%	–24%	0%	10%	–7%
Pakistan	–11%	–3%	–67%	–6%	–13%	6%
Kazakhstan	99%	115%	–52%	–6%	30%	–29%
Indonesia	–6%	–2%	–44%	–10%	–2%	–16%
Nepal	–14%	–14%	–13%	–13%	–32%	4%
Mongolia	–22%	42%	–80%	–17%	66%	–36%
Maldives	–32%	–42%	58%	–17%	–1%	–21%
Lao PDR	5%	5%	7%	–23%	–2%	–28%
Fiji	–32%	–43%	100%	–48%	–74%	–14%
Growth						
Nondeveloping Asia average	9%	–1%	62%	14%	–8%	33%
Developing Asia average	8%	6%	19%	6%	8%	5%
Memio item: share of servification, 2017 (% services input to manufacturing value added)						
Average, developing Asia	*21%*	*17%*	*4%*	*38%*	*15%*	*23%*
Average, nondeveloping Asia	*18%*	*15%*	*4%*	*28%*	*10%*	*17%*

Notes: Figures represent averages for all manufacturing sectors. Developing Asia excludes Japan.
Source: Authors' calculation based on ADB MRIOT.

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vehicles that would have otherwise surpassed their useful life in 10 years in most countries to continue
for 20 or more years through continued servicing.

Figure 11: Impact of Services Sectors on Manufacturing and Business Services and Economic Development
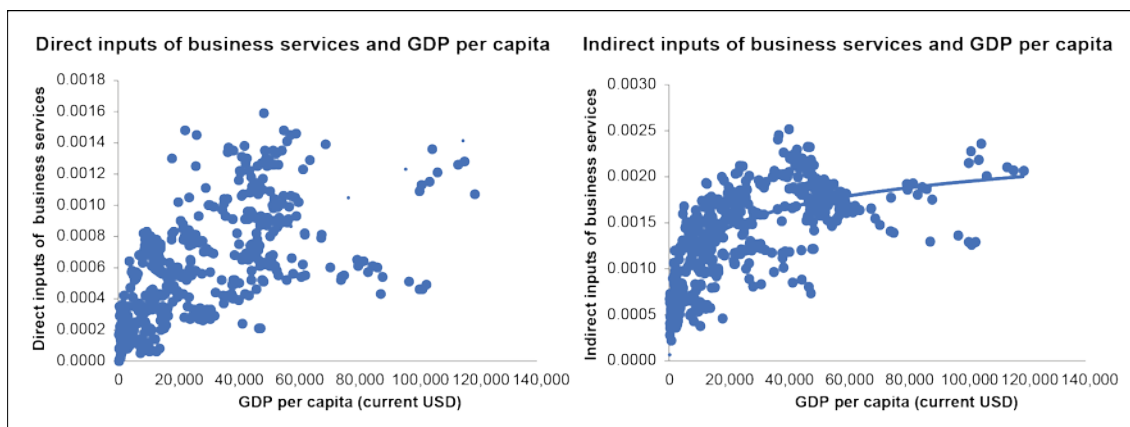
Taken together with the earlier evidence, the data seem to suggest that what is being couched as "premature deindustrialization" may simply be the process of splintering of services from manufacturing, or servification. Contrary to interpretations by Rodrik (2016), it implies that the barometer for the speed of economic development may no longer be to increase the share of employment in manufacturing, but instead the degree of links (servicification) between hi-tech services such as business services and manufacturing value added.

The patterns of employment can shed some light on the underlying drivers of servitization. So far, we have looked at what could be considered arm's-length servicification that may happen as a result of splintering, but not in-house servitization. Splintering allows firms to specialize, which in turn raises their productivity. In manufacturing, this should manifest itself through a reallocation of labor from noncore activities to core production activities. We examine whether this has occurred in Asia by looking at changes in manufacturing occupations for five major emerging economies: India, Indonesia, Thailand, the Philippines, and Viet Nam. To do this, we use one-digit occupation codes from labor force surveys (LFS) mapped to each of the manufacturing sectors in the MRIO.[10] In order to maximize the period covered, we use the earliest and latest available data for each of the five DMCs.

Our analysis shows that the composition of occupations within manufacturing has changed significantly. Most of these changes have occurred in two occupation groups: craft and related trades workers, and plant and machine operators and assemblers (Figure 12). These two groups arguably account for the highest share of production workers when compared to other occupations. In Indonesia, employment in these two occupations increased by nearly 30 percentage points while the number of workers in elementary occupations decreased by a similar magnitude. In Thailand and Viet Nam, there was a notable decrease in craft and related trades workers, which was offset by a growth in plant and machine operators and assemblers. However, the pattern is quite different for India and the Philippines. In both countries, the share of workers in

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[10] The one-digit ISCO breaks down occupations into the following broad groups: (1) Armed forces occupations; (2) Managers; (3) Professionals; (4) Technicians and associate professionals; (5) Clerical support workers; (6) Services and sales workers; (7) Skilled agricultural, forestry, and fishery workers; (8) Craft and related trades workers; (9) Plant and machine operators and assemblers; and (10) Elementary occupations.

managerial positions and elementary occupations grew, although the increase was much less pronounced in India.

Figure 12: Change in Occupations within Manufacturing
(in ppt, earliest to latest year)
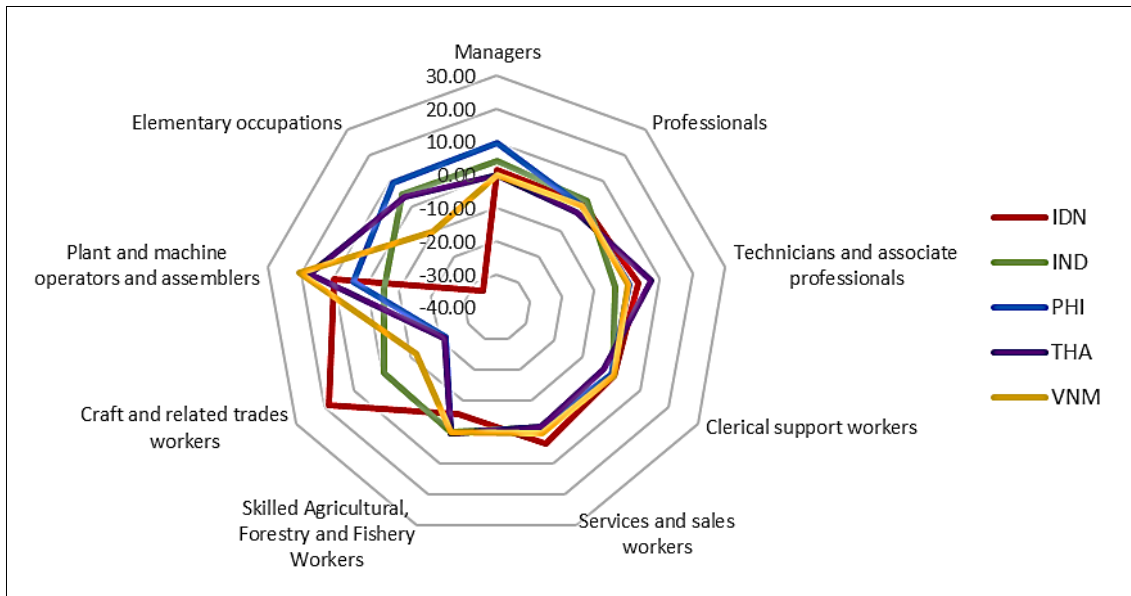
Note: IDN: 2000–2014; IND: 2000–2012; PHI: 2001–2013; THA: 2000–2010; VNM: 2007–2013.
Source: Authors' calculations based on country labor force surveys.

We find partial evidence of the role of splintering in these occupational changes, although further analysis is warranted (Figure 13). Specifically, the higher the share of production workers in a country's sector, the more servicified the sector; in other words, manufacturing sectors with a higher share of production workers use more services as inputs.

**Figure 13: Share of Production Workers and Total Inputs
of Services to Manufacturing**
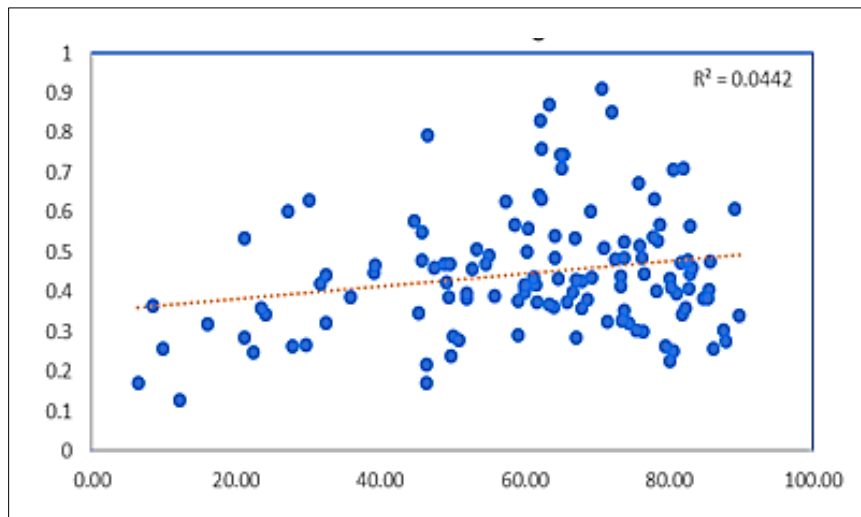
4. IMPLICATIONS OF SERVICIFICATION FOR PRODUCTIVITY MEASUREMENTS AND BLUEPRINTS FOR A PROPOSAL

4.1 Implications for Measurement

If there is servicification, how does that improve productivity? If it is the result of splintering, where services that were previously produced in-house within firms are outsourced to become an arm's-length transaction, then servicification merely reflects the reclassification of an activity from the manufacturing to the services sector. Assuming there is no improvement in efficiency, measured productivity—if properly accounted for— will stay the same. What is not appropriately accounted for is the role of the underlying service in the transformation of the raw material into the manufactured good because the service itself does not become "measurably" embodied in the physical manufactured good.

Alternatively, the growth of the product's value could arise from relative price changes. Where manufacturing activities are offshored to low-wage countries, their share of total value added decreases relative to services. We observe this in the data for advanced economies. At the same time, servicification can result from a real increase in the output of the sector, propelled by the rise of global value chains: As production becomes fragmented into geographically separate units, connecting services, such as telecommunications, transportation, or infrastructure services, become even more important. The changing nature of goods is another factor. The growing services content of manufactured goods implies that an increase in the demand for such products would also raise the demand for complementary services.

The empirical evidence linking servicification of the economy to productivity growth and economic development is still quite limited. Tracing the source of TFP growth to a single service or technology is an empirically challenging task due to endogeneity issues (World Bank 2016). Establishing causality would require exogenous changes, such as variations in the implementation of a new product or service. The main empirical approach that current studies have adopted is based on the framework proposed by Rajan and Zingales (1998). These studies examine how servicification impacts firm performance as measured by their productivity or comparative advantage. Similarly to ours, servitization is usually measured through *services linkage*, which is a function of the sector's use of services and services access (Heuser and Mattoo 2017). The latter plays an important role in overcoming the endogeneity issue since it can be used to introduce exogenous factors such as policy reforms or inflows of foreign direct investment. More recently, Arnold, Javorcik, Lipscomb, and Mattoo (2016) analyzed the effect of service sector reforms on the productivity of manufacturing firms in India, and found that fewer operational restrictions in banking, transport, insurance, and telecommunications made both domestic and foreign manufacturers in India more productive.

A new conceptualization of the future production model is required. A recent paper notes that "fully 28 of 29 other countries for which the OECD has compiled productivity growth data saw a deceleration in labor productivity growth over the last few decades. The unweighted average annual labor productivity growth rate across these countries was 2.3% from 1995 to 2004 but only 1.1% from 2005 to 2015" (Brynjolfsson, Rock, and

Syverson 2017, p. 6). This is a robust result, but the results come from the sole use of traditional measures of total factor productivity using national accounts.

4.2 Measurement Issues: The Old and the New

The traditional Solow-based models characterize the aggregate production function as a function of in-house factors of production. Real value added at time t (denoted Y_t) is modelled as a function, g, of essentially two factors of production: labor hours worked (L) and the contribution of capital (K). Technology and innovation from year t to $t+1$ can be described by a scalar A with an exponent. This characterized well the output of a manufacturing firm in the last century.

$$Y_t = A^t g(K_t, L_t) \tag{1}$$

This characterization is not accurate when the output is a modern service or automated manufacturing firm with outsourced services. The contribution of services and innovation to manufacturing productivity will be underestimated (Brynjolfsson and Syverson 2017). In the Solow model, assuming capital and labor are measured appropriately, the unexplained growth portion is labeled *total factor productivity*, which captures the efficiency that is created through better use of existing factors, better management, institutions, technology, etc. This made sense when conceived in the 1950s; The "productive" activities typically showed people working with machines to transform inputs. But it is an inadequate characterization of the production of a typical firm or production unit in 2018: It leaves room neither for production fragmentation, offshoring, or process specialization, nor for the contribution of services to raising manufacturing production. A better characterization of modern manufacturing is a node or web showing the contribution of different goods and services spread out geographically; in other words, a global value chain. Consider instead the characterization of the production of, say, the automobiles global value chain:

$$Y^{AU} = V^{AU} \{f_1, f_2, f^*_3 \ldots f_n, L^{AU}, S_1, S_2, S_3 \ldots S_m\}, \tag{2}$$

where Y^{AU} is the production of automobiles, with inputs being a function of a series of production units that produce intermediate goods such as auto parts, each with its own production function: $f_1 .. f_i$ with $i=1..n$ production units,[11] L^{AU} is in-house labor used in the production and/or assembly of automobiles, and S_j, $j=1\ldots m$ denotes the services inputs provided directly to the plant (such as energy, shipping, quality control, etc.). In turn, $S_j = V^j(f_{j1}, f_{j2}..f_{jr}, L^j, s_{j1}, s_{j2}\ldots s_{ju})$ would be a service produced by unit j, which uses as inputs other goods, L^j, and other services components. V^{AU} is the value added, which can be computed by combining—using factor costs as weights—the cost of f_i's, wages for labor L^{AU}, and some artificial aggregator unit (a regulated or "bundle" price) for services S_j. The combination or transformation function for autos V^{AU} could be a standard Cobb-Douglas form; for our purposes this is immaterial. In turn, each production unit will take the from $f_i=V^i\{f_{i1}, f_{i2}, f_{i3}\ldots f_{ip}, L^i s^*_{i1}, s^*_{i2}, s_{i3}\ldots s_{iq}\}$. We can also denote f_{i1} in the traditional way:

$$f_i = V^i \equiv Ag(K^i, L^i) \tag{3}$$

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[11] The ＊superscript denotes that the production unit is foreign.

Equation 3 characterizing production unit i looks very much like equation 1. K^i, capital services, only denotes the services provided in-house. This means that total factor productivity—incorporated in A—also incorporates the productivity that should be attributed to outsourced services, but its value is biased upwards because Solow models erroneously attribute to it only improved efficiency. The traditional notation implies that the greater productivity emanates from inside the firm or production unit.

In contrast, each input in equation 2 could come either from a separate unit of the same company (in-house provision), from a different entity, or from a foreign entity. The combination chosen minimizes costs over time for a given state of technology. In most cases, it minimizes costs through economies of scale, which are infinitely larger for services inputs. There is also the challenge that whereas it is possible to add up similar goods, it is not possible to add up services for the purposes of measuring productivity because they are infinitely divisible and have different values over time, which is why they have to be bundled for easier pricing (see Box 1).

Using this new characterization, the distinction between what is a manufactured good and what is a service becomes more blurred. This gradual transformation of manufacturing production characterized as a situation from a single production function of a firm in the 1950s (stage 1) to specialization of labor (stage 2) to splintering of production units (stage 3) is illustrated in Figure 14. Y_M is the output of manufacturing, whereas Y_s is the output of services. In the past manufacturing was more capital intensive, and a simple measure of labor productivity would always yield a greater number in the manufacturing sector than in the service sector ($Y_M/L_M > Y_S/L_S$). Once the output of manufacturing is characterized as the result of a value chain of production units (stage 3), it becomes less clear that output per worker is higher for manufacturing than for services, because the distinction is blurred.

The suggested setup divides inputs into *production units*, not a *good* or a *service*, as the distinction is increasingly irrelevant. The argument of whether we are talking about a good or a service becomes semantic for the purposes of measuring productivity, and the "products" will often be bundles of goods and services. For example, in providing music services for a wedding, whereas 20 years ago the disk jockey would have brought a compact disk collection, now he or she may use an online music service to provide entertainment. Although the main input used has changed from a physical good (CD) to a service (Spotify), the output is the same: musical entertainment.

This leads to understanding the activities as labor effort within the production unit in time and space. Time use, through activity and technical competence, is still important. This would entail classifying activities by degree of effort and valuing them according to difficulty or technical competence as is already done for time use surveys. Manufacturing or activities that transform physical goods (cooking, weaving, welding, building a car, painting) can still be conceptually separated from service activities (waitressing, teaching, strategizing, planning, designing). But comparing their productivity will depend on context and time.

Figure 14: Accounting for Labor Productivity within the Stages of Servicification
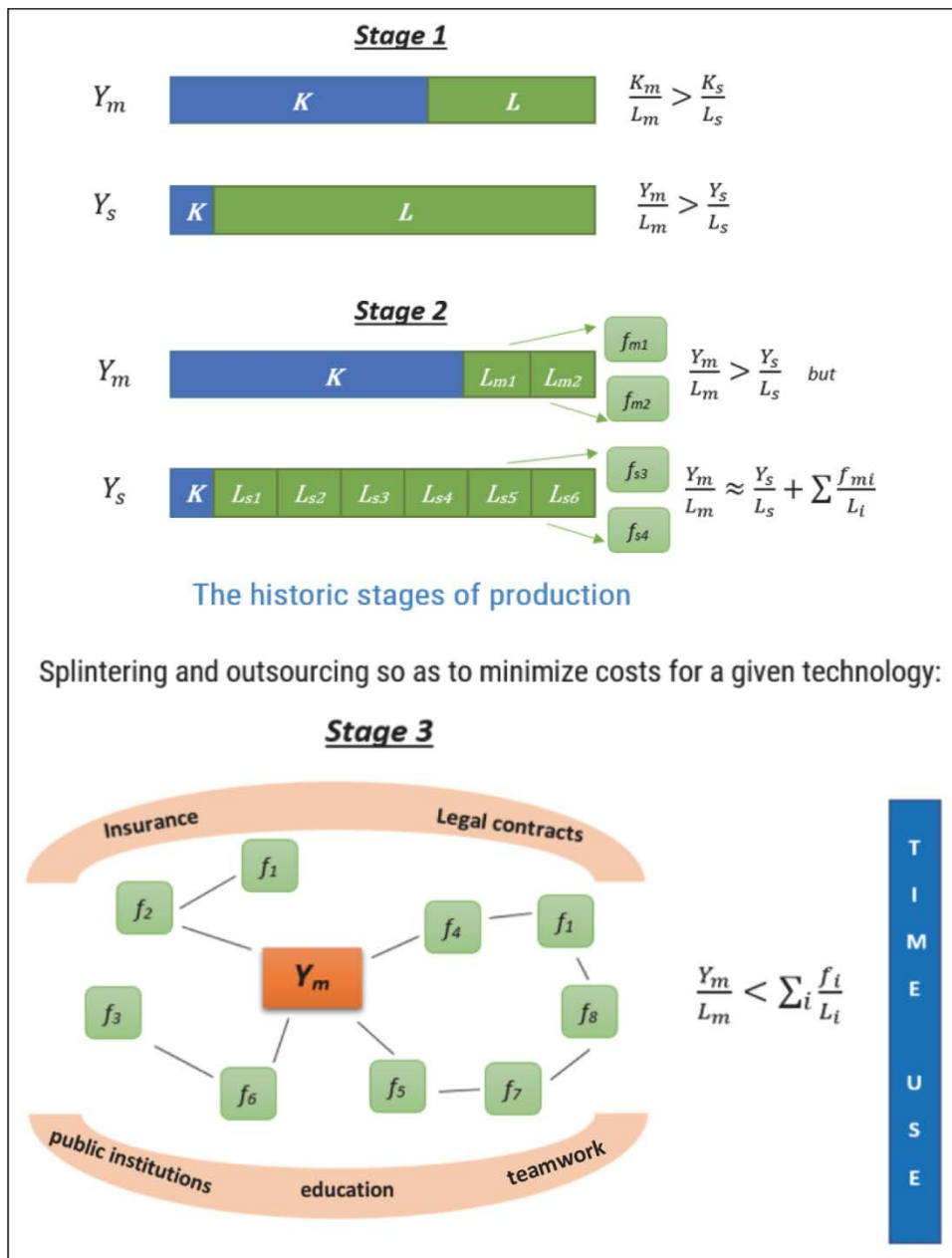
Box 3: Measuring Time Use as a New Measurement Approach

Unpaid care could be characterized as a servitization relationship within the family and, like other services, has been difficult to measure. Consider two adults in a household, with one earning wages in the market (Mr. Z) and the other performing unpaid home work (Ms. A). Mr. Z and Ms. A have a "servitization" relationship (in addition possibly to a marital relationship). Their work is co-dependent. If Mr. Z does not have someone to take care of and cook for dependents, he may not perform satisfactorily in his work and may have to work half-time, or in an extreme case may not be able to work outside the home. On the other hand, the homemaker, Ms. Z, would have to find employment to finance their consumption and that of dependents if the breadwinner, Mr. A, were to stop working. Due to its different measurement unit (time), it is difficult to incorporate this into the national accounts, let alone productivity measures. According to national accounts on the income side, the only "productive" person in this situation is the market earner, Mr. Z. However, if the homemaker were not available, the market earner would have to hire a child-care giver, cook, cleaner, and activity driver, as well as possibly a family manager. Hiring such services would cost roughly 30% of the total average income according to results from TUS in the US and UK.

Mainstreaming TUS into national statistical systems has been a challenge. Only a subset of Asian countries has conducted full time use surveys (Table B.3.1). Generally, the purpose is to analyze household bargaining and gender roles, so there is little appreciation of why countries should conduct TUS on a regular basis. As an alternative, a modular approach—adding on TUS questions to other surveys such as a labor force survey—has been undertaken in many countries. Typically, the use of these surveys for policy makers rarely goes beyond measures of gender inequality of nonmarket work. Based on high-quality surveys, the value of unpaid care work as a share of GDP varies from about 25% to 35% of GDP, with the majority of the work being performed by women. The US and UK have initiatives to include TUS in the national accounts on a more permanent basis, as the valuation of the time use can be adjusted for different purposes. In Asia, Bhutan and the Republic of Korea have advanced the most on this front.

Table B.3.1. Status of Time Use Surveys in Developing Asia and Some Advanced Economies

Status	Countries or Territories
Developed countries where time use survey is mainstreamed	Australia, Japan, Republic of Korea, New Zealand, United States (satellite account), UK, Australia
No time use survey conducted	Afghanistan, Brunei Darussalam, Maldives, Marshall Islands, Myanmar, Palau, Singapore
Small time use survey only	Indonesia, Fiji, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Tuvalu, Vanuatu
Official pilot time use survey only	Philippines
Only rural/urban time use survey	Iran (Islamic Republic) – only urban TUS
National modular time use survey	Cambodia, Lao PDR, Nepal, Timor-Leste, Malaysia, Viet Nam, Cook Islands
National/large time use survey using time diary	Bangladesh, Bhutan, PRC, India, Mongolia, Pakistan, Thailand

Source: Hirway (2016) and authors.

Measuring time use in the future will be the only way to gauge the level of productivity of individuals. As services become more prominent, time increases in value, the work hours of many professionals constantly go beyond the 40-hour day, the distinction between "work" and "nonwork" becomes increasingly blurred, and the current measurement of labor productivity makes less sense. Fortunately, survey tools have advanced, so monitoring time use is less intrusive (see https://www.timeuse.org/).

4.3 National Accounts versus Time Use Surveys: An Example

Through an example, this section shows how the mismeasurement of productivity of services has as much to do with servicification as it does with the concept of what constitutes "work." Most modern workers will perform a myriad of tasks in a given period, including community work and personal management tasks. One typical task could be the repair of a roof leak. How can the value of this service be accounted? How should that person's time spent repairing the roof be measured? Circumstances matter in traditional national accounting, though they should not. Define a task performed (quantity), such as "fixing a roof leak of 20 cm x 20 cm." How can this service be valued? For many activities, the best way to value is the local market price (how much the community is willing to pay to get a task completed).

The appropriate valuation of the same function should be equal irrespective of context, although the context should be reported, as illustrated in the following example. Suppose person A spends three hours on Sunday afternoon fixing a leaky roof in his or her house at the behest of his or her spouse. Person B spends three hours fixing a neighbor's leak in the neighborhood: He or she is good at it and is part of a church volunteer group helping elderly people with home repair. Person C works at a roofing company called "Roofs and More" (RM) and spends three hours fixing a leak. Each of these activities should have the same value or labor productivity (assuming they use the same technology and work with similar tools). The difference is purpose: Person A, based at home, performs unpaid work and thus loses 3 hours of leisure time. Person B may have received a small compensation from the church (say, a free pizza and a thank-you note from the neighborhood board of directors). Person C will have received wage compensation from his or her company (denoted w_{RM}) for the job of fixing the roof.[12]

Using national accounts valuation, the marginal product of labor of Mr. C equals:

$$\frac{\Delta Y_C^{RM}}{\Delta L_C} \equiv w_{RM} > \frac{Y_B^{CH}}{L_B} > \frac{Y_A^{HH}}{L_A} = 0, \tag{4}$$

where

Y_i^J measures the real output or activity in a unit of time performed by individual *i* Є *{A.B.C}* in sector *j* Є *{RM, CH, HH}*. **In the example, *RM*** is the roofing manufacturing and installation sector, ***CH*** is the charity and community sector, and ***HH*** is the household sector. L_i is the labor of person *i*. Person A and B's market wages are 0, so equation 1 erroneously ascribes their marginal productivity as zero too.

How will these tasks be classified in national accounts? If the roofing company also manufactures products (sector ***RM***), the value of person C's labor will appear as part of the manufacturing sector. In the case of person B, it would be recorded as a community service (a "service"), which may incorrectly appear as a very small share of charitable income deflated by the consumer price index, and the cost of materials and pizza may be subtracted. Person B's work does not appear at all in national accounts if calculated on the income or expenditure side. In the case of person A's labor, it does not appear in the national accounts at all and the effort is considered "unproductive," even though Mr. A also became more "time poor" because he had to spend part of his day of rest and leisure—assuming he had a full-time job in the market on weekdays—performing an activity he did not enjoy.

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[12] Here we are also abstracting from the recording of improvements to the housing capital stock, which is depreciation.

According to expression (4) above, manufacturing production is more productive than services if we use the national accounts methodology. Under the TUS methodology proposed, all activities have the same value because they required the same amount of effort and the same technology. If the sectors *j={CH,HH}* are in the services sectors, then twice the amount of value per worker was produced than in the manufacturing sector (Y$_{HH}$+Y$_{CH}$>Y$_{RM}$). Since $Y^{HH} = Y^{CH} = Y^{RM}$ and $L_A = L_B = L_C$ (assuming all persons use the same technology and the same amount of time), then it should be that the services sector is more productive as in expression 5. There is no need to be concerned about premature deindustrialization-type arguments.

$$\frac{\Delta(Y_A^{HH}+Y_B^{CH})}{\Delta(L_A+L_B)} > \frac{\Delta Y_C^{RM}}{\Delta L_C} \cong W_{RM} \tag{5}$$

There are many reasons why the labor productivity of an activity is better measured by time use surveys than by national accounts. This does not mean we should do away with national accounts: It is still the most useful gross accounting framework. What does need to be considered in the digital age and increasing servicification is the use of TUS to measure real labor productivity. This would have the additional challenge or requirement to measure, say, artificial intelligence capital and other factors (see Brynjolfsson and Syverson. (2017) for some ideas). But what TUS enables is different valuations of activities depending on the values given by society.[13] This valuation can be decided by citizens and governments, using the same methods used to value public goods. For example, the value of a walk in the neighborhood park, or the value of breathing fresh air or of leading a healthy life.

5. CONCLUSIONS

The premature deindustrialization hypothesis is based on the assumption that there is something inherently "special" about the organization of manufacturing production activities that neither agriculture nor services possess, which makes labor there more productive. The arguments presented and preliminary evidence using recent data suggest otherwise. Part of the problem is that services are being measured and valued using the same tools we use to measure tangible manufactured goods.

This paper argues that services are fundamentally very different from goods in character, but traditionally they are measured in the same way. Due to their indivisibility and heterogeneity, among other characteristics, services are priced in a very different way (usually bundled as packages or as an extension to the manufacturing output's value). Consequently, labor productivity in each sector is also mismeasured. Moreover, many services are integrated and intertwined with the production of goods, which is why they have a symbiotic relationship in production (a term we define as "subordinate servicification"). However, only goods are visible and tangible. As a result, the contribution of services to economic growth may be underestimated. We show evidence of the extent of servicification in Asia and globally, defined as increasing in-house production of services by firms classified as manufacturing firms, as well as outsourcing to services firms both domestically and abroad. While servicification is large and growing in Asia, it is still much more prevalent outside of Asia, particularly in advanced economies. Finally, we explain why national accounting is not able to properly capture the productivity derived from services. While these measurement issues were

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[13] As with national accounts, measuring time use does not necessarily say anything about the utility derived from the activity. In the above example, person A derives disutility from fixing the roof despite his appreciating the urgency of the work.

known for some time, they were considered small in size and thus not problematic. However, with the introduction of disruptive technologies in all spheres of life this measurement bias is likely to grow.

Policy makers and statistical offices need to adopt alternative measures of labor productivity sooner rather than later. The only method that could be expanded and institutionalized by countries to capture some of these changes—particularly in services—is the use of time use surveys (TUS) over distinct activities or production units. TUS also have the advantage of measuring disparities in workloads of different factions of the population (given the value of time), while providing an opportunity to value activities in more useful ways—something that market prices cannot properly do in the age of servicification.

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APPENDIX

Table A1: Breakdown of MRIO Sectors

Code	Sector	Classification
1	Agriculture, forestry, fishery	Agriculture and natural resources
2	Mining and quarrying	Agriculture and natural resources
3	Food, beverages, and tobacco	Manufacturing
4	Textiles and textile products	Manufacturing
5	Leather, leather products, and footwear	Manufacturing
6	Wood and products of wood and cork	Manufacturing
7	Pulp, paper, printing, and publishing	Manufacturing
8	Coke, refined petroleum, and nuclear fuel	Manufacturing
9	Chemicals and chemical products	Manufacturing
10	Rubber and plastics	Manufacturing
11	Other nonmetallic mineral	Manufacturing
12	Basic metals and fabricated metal	Manufacturing
13	Machinery, not classified elsewhere	Manufacturing
14	Electrical and optical equipment	Manufacturing
15	Transport equipment	Manufacturing
16	Manufacturing not classified elsewhere; recycling	Manufacturing
17	Electricity, gas, and water supply	Industry
18	Construction	Industry
19	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	Services
20	Wholesale trade and commission trade except for motor vehicles and motorcycles	Services
21	Retail trade except for motor vehicles and motorcycles; repair of household goods	Services
22	Hotels and restaurants	Services
23	Inland transport	Services
24	Water transport	Services
25	Air transport	Services
26	Other supporting and auxiliary transport activities; activities of travel agencies	Services
27	Post and telecommunications	Services
28	Financial intermediation	Services
29	Real estate activities	Services
30	Renting of machinery and equipment and other business activities	Services
31	Public administration and defense; compulsory social security	Services
32	Education	Services
33	Health and social work	Services
34	Other community, social, and personal services	Services
35	Private households with employed persons	Services