The smile curve: Evolving sources of value added in manufacturing

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Abstract. A dramatic disordering of global manufacturing has been seen in recent years. Production processes have fragmented, and many production stages have been offshored to developing nations. Organization of this new global supply chain has evolved into what are often called global value chains (GVCs). Less studied, but no less important, is the shift in the sectoral source of value added in manufactured exports. This phenomenon, often called the "smile curve," involves a swing in the share of value added in manufactured exports that is generated in the manufacturing sector itself instead of, for example, in the pre- and post-fabrication stages. Our paper presents new evidence quantifying the magnitude of the smile curve notion. Using international input–output databases, we find evidence supporting the smile curve at the aggregate level. Specifically, for almost all exporting sectors and nations, we find that the value added to exports has shifted decisively from the manufacturing sector to service sectors. We also find that developing countries reduced their own-sourcing service value-added share, while developed countries maintained their relatively high levels of own-sourcing service value-added share.

Résumé. Courbe du sourire : évolution des sources de valeur ajoutée dans le secteur manufacturier. Depuis quelques années, nous observons une réorganisation importante de l'outil industriel mondial. Les processus de production se sont fragmentés, et de

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nombreuses étapes ont été délocalisées vers des nations en voie de développement. L'organisation de cette nouvelle chaîne logistique mondiale s'est transformée en ce que l'on appelle fréquemment des « chaînes de valeur mondiale ». Un phénomène moins étudié, mais tout aussi important, réside dans la mutation de l'origine sectorielle de la valeur ajoutée des exportations de produits manufacturés. Ce phénomène, souvent appelé « courbe du sourire », résulte d'un glissement de la part de la valeur ajoutée des exportations de produits manufacturés, engendrée par le secteur manufacturier lui-même, vers les étapes en amont et en aval du processus de production. Notre article présente de nouveaux éléments pour mesurer l'ampleur de cette « courbe du sourire ». D'un point de vue global, et en nous appuyant sur des bases de données entrées-sorties internationales, nous avons découvert des éléments corroborant la théorie de la courbe du sourire. D'un point de vue plus spécifique, et pour presque tous les secteurs d'exportations de toutes les nations confondues, nous constatons que la valeur ajoutée des exportations s'est très nettement déplacée du secteur manufacturier vers le secteur des services. Nous constatons également qu'en matière de fourniture nationale de services, les pays en voie de développement ont réduit leur part de valeur ajoutée, tandis que les pays développés ont maintenu des niveaux de valeur ajoutée assez élevés.

JEL classification: F14

1. Introduction

GLOBALIZATION'S SECOND UNBUNDLING—the geographical unbundling of production processes—is transforming the global economy. This is especially true in the manufacturing sector. A key element of this shift is the displacement of value added from high-technology, high-wage nations to low-technology, low-wage nations. This shift, however, is accompanied by a seemingly paradoxical pair of concerns:

- Rich nations worry about the loss of manufacturing jobs to a handful of low-technology, low-wage nations.
- The receiving nations, however, are increasingly worried that they are getting the wrong kinds of jobs.

The first concern has been well documented (UNIDO 2013). As figure 1 shows, there has been a remarkable shift of manufacturing from developed to developing nations, especially to China, since 1990.

On the first concern, nations with advanced technology and high wages—such as Japan, the UK and the US—worry about a hollowing out of their economies as manufacturing jobs are offshored to low-technology, low-wage nations. Advanced economies around the world are rethinking their competitiveness strategies and revisiting industrial policy debates, which have not been given credence since the late 1980s.

On the second concern, the second unbundling has meant that developing nations can now industrialize by joining supply chains rather than by building them, but only certain types of jobs are being offshored to developing nations. There is a fear that the "good" jobs remain in the cities of advanced economies while the "bad" jobs are being shuffled off to the factories of developing

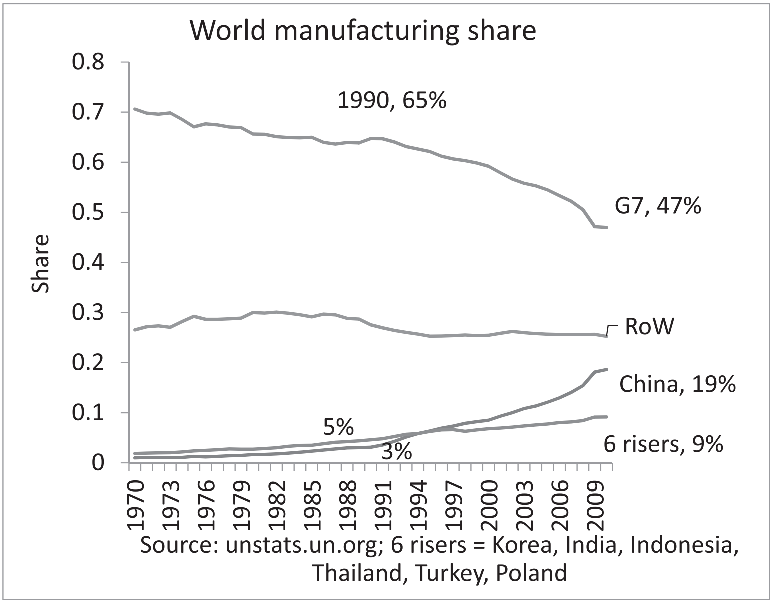

FIGURE 1 Global shift in manufacturing value added, 1970–2010
SOURCE: Authors' calculations

economies. The second concern is less well founded empirically but no less influential.[1] It is often organized around a keynote intellectual construction—the so-called "smile curve," sometimes called "servicification." Introduced by Acer founder and CEO Stan Shih in the early 1990s, the smile-curve logic asserts that the share of value added in manufactured products is shifting from the fabrication stages to pre- and post-fabrication services. The general assertion—widely held among policymakers in developing nations is that this distribution is moving against fabrication stages, i.e., the smile is deepening, as shown schematically in the left panel of figure 2. As a result, the emerging markets that are industrializing at historically unprecedented rates are now worrying that they are getting the "bad" jobs, i.e., jobs associated with low value added per worker, while the "good" jobs stay in the North.

The economics literature on the smile curve is surprisingly underdeveloped (although see Mudambi 2008) even though the concept is widely discussed in the international business literature (e.g., Yan and Saiful 2011) and is influential in Asian policy circles (Inomata 2013).

1 One paper in this topic is Ye et al. (2015). They drew the "smile curve" for industry/country using "distance" between industries for the horizontal axis, unlike our paper, which takes the given definition of industry classification of manufacturing and services for the horizontal axis. For the "distance," they essentially follow the concepts of average propagation length (Dietzenbacher et al. 2005, Dietzenbacher and Romero 2007) and upstreamness (Antras et al. 2012).

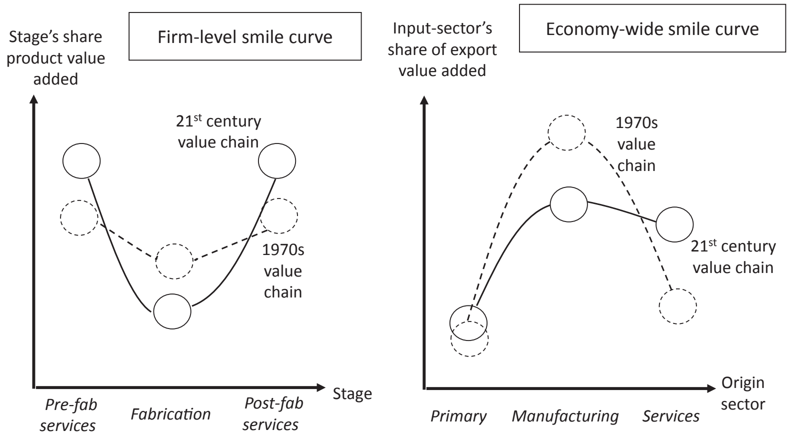

FIGURE 2 The smile curve: Firm-level versus economy-wide conceptualization
SOURCE: Authors' elaboration

This paper aims to shed light on how important the smile-curve notion is at an aggregate level. In particular, we focus on how value added has shifted along the value chain with regard to Asian exports. To this end, we use the Asian Input–Output (AIO) Table. This data is compiled and constructed by the Institute of Developing Economies Japan External Trade Organization (IDE–JETRO) and has been constructed every five years since 1985. The table covers 76 industries and is focused on Asian nations (Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Taiwan, Korea and Japan) and the US. It includes the US because the US is a major trading partner for almost all Asian countries. Partner countries other than the Asian countries and the US are aggregated as the Rest of World (ROW). As shown in detail in the summary table of Asian Input–Output Table and World Input–Output Database in the appendix, the number of industries varies across the years (1985, 1990, 1995, 2000, 2005). For the year 1985, the data are available in only 24 industries. For the other years, the data are available both in 24 and 76 or 78 industries. In the following analyses, we use both AIO 76, which has 76 industries, and AIO 24, which includes 24 industries only.

2. Economy-wide smile curve and prima facie evidence

The smile curve is based mostly on casual empiricism (although see Kimura 2003). There may be many reasons for this lack of evidence, but one clear problem is that the concept is defined at the firm level and product level where the notion of a value chain makes sense. Most systematic data sets, however, are at the economy-wide level where the value-chain concept is more obscure. The point is that firms' value chains intersect and overlap. Thus, at the economy-wide level, concepts such as upstream and downstream are not as

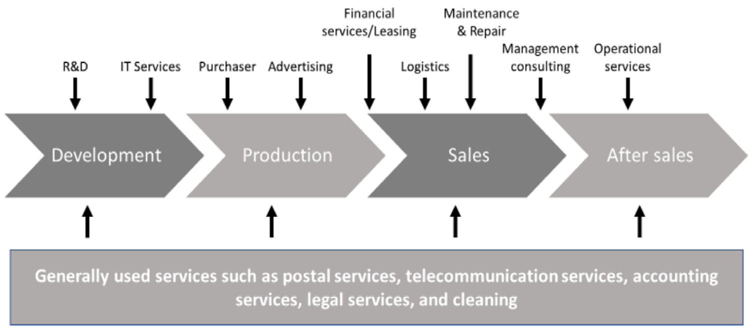

FIGURE 3 Stages of production processes
SOURCE: "Servicification of Swedish manufacturing" (National Board of Trade Sweden 2016)

precise as those at the firm level. What is an upstream service input for one firm is the final output for another. Thus, it is difficult to determine whether value is being shifted upstream or downstream when the service-input garners greater value added. Figure 3 illustrates stages of production processes. Service inputs are added at many stages. For example, as the figure shows, R&D is an input in both the development stage and the after-sales stage. In contrast, economy-wide data, typically input–output tables, are collected by sector, not by value-chain stage.

To overcome the firm-level to economy-level gap, we rejig the smile curve concept by focusing on the sectoral origin of value-added in a nation's exports. This brings it more into line with the concept of "servicification" (see, for example, National Board of Trade Sweden 2016). As a first pass, we work with a very high level of origin sector aggregation, namely primary, secondary and tertiary sectors, in this reformulated version of the smile. The right panel of figure 2 shows the economy-wide version of the smile curve.

The economy-wide concept surely misses some subtle aspects of the firm-level concept but is perhaps more pertinent for policy purposes. The basic fear that offshoring involves sending low value-added jobs to developing nations and keeping high value-added jobs in rich nations is, after all, an economy-wide concern. Moreover, the "good" jobs are loosely associated with high-wage service jobs such as research and development, marketing, product design, etc., while the "bad" jobs" are loosely associated with low-wage jobs in fabrication stages. The well-known iPhone example is a good illustration. The good jobs—and most of the profits—are in California, while the low-wage assembly jobs are in China.

2.1. Tracing back the source of value added in exports

It is important to note that one cannot simply read off the numbers we are after. From the AIO table, we can decompose a nation's exports of, say, transport equipment into direct value added in the nation's transport equipment sector and the sector's intermediate-input purchases. The purchased inputs may be from primary, secondary, or tertiary sectors, but each of these inputs themselves use purchased inputs. Thus, we need to iteratively trace all the value added to its origin. To start, we ignore the origin nation of the value added and focus on the origin sector.

By recursive use of information in an international IO table, we can determine the source of value added in every dollar worth of exports. The key is that simple accounting identity that states the sale-value of a product equals the cost of intermediate inputs and the direct value added of the industry producing the good. Here value-added refers to the cost of primary inputs such as capital and labour. The same identity applies to the intermediate goods used as inputs, so a recursive application can generate a full map of where a product's value was added.

For example, Thai auto exports worth $10,000 can be decomposed into the value-added of countries involved in the car production supply chain, which sources its inputs from the chemical industry or metal industry, which source their inputs from other industries. In each production stage, the value-added (essentially, labour and capital contribution) is put on. By tracking down the whole process until the production values reach the sum of value-added, we can decompose the production values into the value-added by industry/country. Through this computation, we can find which country/industry contributes to Thailand's car exports. In this paper—in which we aim to stick to a level of analysis that is amenable to graphical presentation—we often aggregate across all of a nation's exports. See figure 4 for a schematic illustration of how we get the three-way decomposition for a nation's aggregate exports.

The computation of value added is conceptually described above. We can follow the above-mentioned procedure to compute the value added, but in the actual computation, we use the matrix algebra shown below, as originally proposed by Johnson and Noguera (2012) and Koopman et al. (2014) and widely used in subsequent studies such as Timmer et al. (2014) or Backer and Miroudot (2013):

$$VAE = V(I - A)^{-1}E, \tag{1}$$

where VAE denotes a (NS × 1) vector of value-added exports for country N/industry S, V denotes a (NS × NS) diagonal matrix with diagonal entries being the value-added share for each county/industry in IO table, I denotes a (NS × NS) identity matrix, A is (NS × NS) input coefficient matrix in IO table and E a (NS × 1) vector of gross export value in IO table.

To get a feel for the result of such calculations, consider the case of the exports of textile and leather products. Here, our decomposition of the origin sector of the value-added shows that in 1985, 10% of the value-added came from primary sectors, 70% came from manufacturing sectors (including the textile and leather sector itself) and 20% came from service sectors. By 2005,

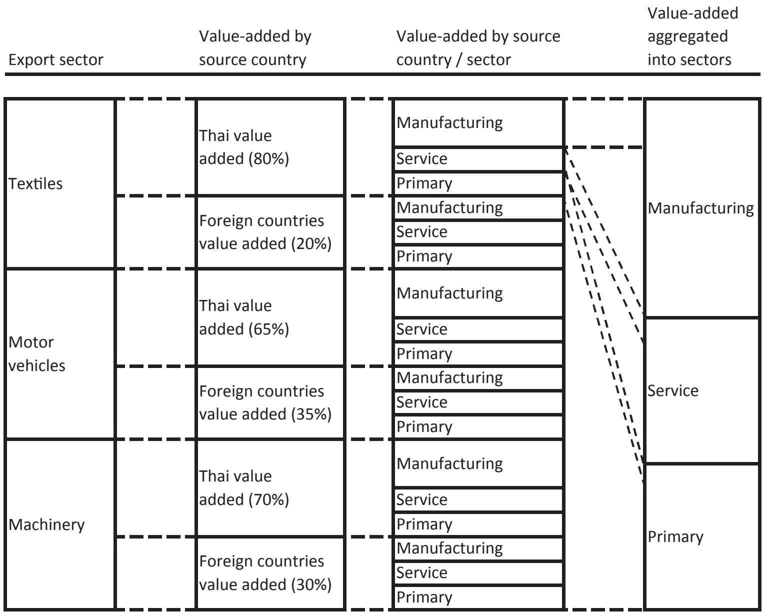

FIGURE 4 Value-added origin sector
SOURCE: Authors' elaboration

the corresponding figures were 13%, 63% and 24% for primary, secondary and tertiary sectors, respectively.

2.2. Prima facie evidence: Economy-wide smile curve

We illustrate concepts with the example of Japan before turning to other Asian nations in our dataset. Table 1 shows the results of our decomposition of value-added source sectors for Japan's aggregate exports. To make the analysis comparable to the one using the World Input–Output Database (WIOD), which is also used in the following sections, this subsection analyzes the change in the period of 1995–2005. The change from 1985 will be discussed later. In 1995, 71.4% of the value of Japanese exports stemmed from the value that was added in the manufacturing sector (in Japan or elsewhere). The fact that this number is high is not a surprise. Japan's exports are heavily skewed toward manufacturing and most of the value-added of manufactured goods is added in the manufacturing sector itself (the rest being added in the service and primary sectors that provide inputs into manufacturing). By 2005, this share had fallen to 67.8%. Because the shares must add to 100%, the service sector saw a corresponding rise in its share of value added in Japanese exports.

The figures in table 1—and corresponding numbers for Korea and Taiwan can be graphically displayed by plotting the changes as in figure 5. For all

TABLE 1
Distribution of value-added in exports by broad input sector, 1995 and 2005: Japan

Japan			
Source sector	1995	2005	Change
Primary	0.9%	1.2%	0.4%
Manufacturing	68.2%	64.7%	–3.5%
Service	30.9%	34.0%	3.1%

SOURCE: Authors calculations on AIO database

FIGURE 5 Aggregate smile curve, Japan, Korea and Taiwan
SOURCE: Authors' calculations on AIO database

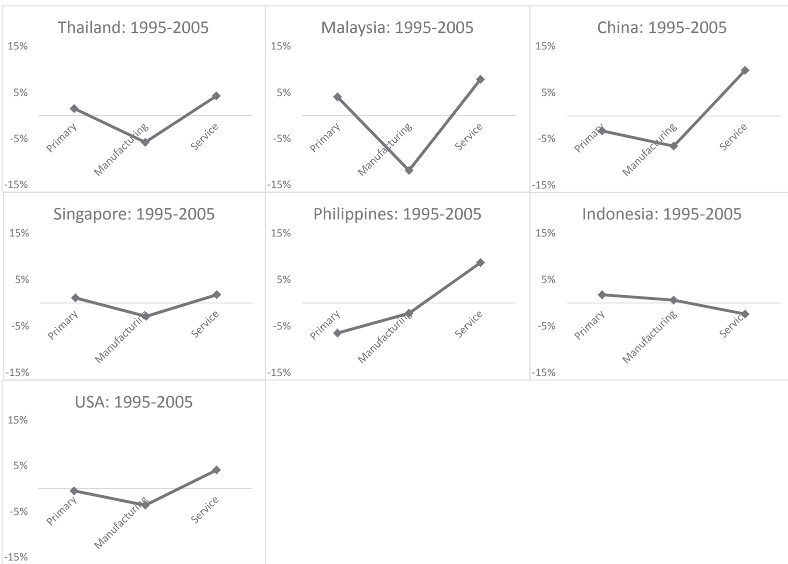

FIGURE 6 Aggregate smile curve for Thailand, Malaysia, China, Singapore, the Philippines, Indonesia and the USA
SOURCE: Authors' calculations on AIO database

three nations, the result is a smile curve of sorts (although it perhaps might be better dubbed the "smirk curve" because the corner of the "mouth" rises only for the left side).

In all three nations, the manufacturing share falls as a source of value added by 4 to 6 percentage points in all three nations. The service contribution rises by 3 to 6 percentage points in all three.

Interpreting these aggregate changes is not straightforward. The changes could be driven by many different factors. Before turning to interpretation, we present the aggregate smile curves for the other nations in our sample in figure 6. These charts show that most of the countries follow the classic smile or "smirk" pattern. The Philippines and Indonesia are notable exceptions that see almost no change in the manufacturing sector share.

2.3. Smile curve with World Input–Output Database

Whereas AIO is useful for investigating the Global Value Chains (GVCs) in Asia, in order to confirm our findings and also to see if the smile curve is present in other areas of the world, we do the same analyses using the World Input–Output Database (WIOD), 1995–2011 version.[2] A summary of the main features of AIO and WIOD is in the appendix. Figure 7 shows the

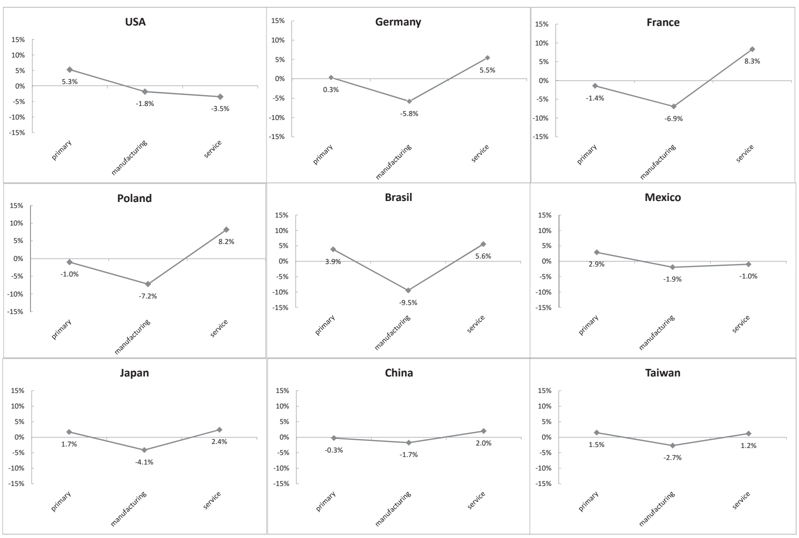

FIGURE 7 Smile curve by nation using the World Input–Output Database, 1995–2011
SOURCE: Authors' calculations on WIOD database

2 The other version is the 2000–2014 version. We use the 1995–2011 version to see the change in the 1990s and to compare the results with the AIO.

change in the value-added generated in the primary, manufacturing and service sectors in some selected countries. We selected these countries, which we consider to be largely representative of the world economies, namely the main European countries, middle-income countries and the countries that are also in the AIO database. The smile curve phenomenon is present in almost all countries and we observe it in almost all industries, as shown in figure A1 in the appendix. To compare the results with those of the AIO above, the same analyses are done for the period of 1995 to 2005, as shown in the figures in the appendix. The smile curves are observed, although slightly more attenuated than in the case of 1995–2011.

3. Economics of the smile curve

The forces behind the smile curve have recently been investigated. Using firm-level data in the European Union, Del Prete and Rungi (2018) show a supportive evidence for the smile curve, namely that tasks at the early and late stages of the supply chains generate higher value added. The goal of this section is to present an analytic framework that can help explain why the smile deepened and how policymakers should think about value-chain issues.[3]

Simple economics suggest two explanations for the economy-wide shifts: compositional changes across industries and changes within industries/firms. First, the smile may be down to the change of composition of nation's exports. That is, even if there were no changes in the production process at the product level, the shift that is evident in figure 5 and figure 6 could have been due to a shift toward exporting goods that happen to be intensive in their use of inputs from service sectors.

While the composition of these nation's exports clearly shifted from 1995 to 2005, a look at the industry aggregates suggests that this cannot be the whole story. The value-added shifts by industry are shown in figure 8 for all the manufacturing industries in the AIO. Here, we see that the smile phenomenon is observed in most industries.

This conclusion still holds when we look at a particular sector for each nation. The smile curve by nation and by industry for the case of machinery is shown in figure 9. Even if we look at the same industry across countries, the "smirk curve" remains although it is deeper for some nations.

The second explanation for the value-added shift concerns industry- or firm-level changes. The redistribution of value added by origin sector could be

3 This section draws heavily on Baldwin and Evenett (2012) for the analysis of the redistribution of value along firm-level value chains.

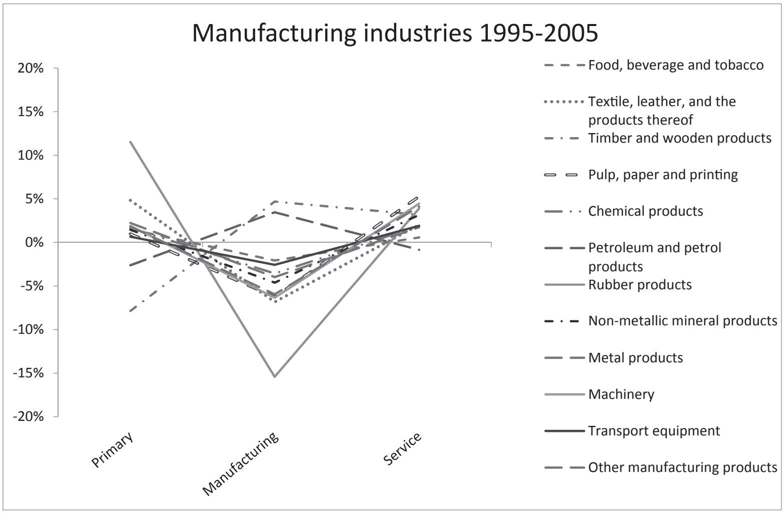

FIGURE 8 Smile curves by industry, 1995 to 2005
SOURCE: Authors' calculations on AIO database

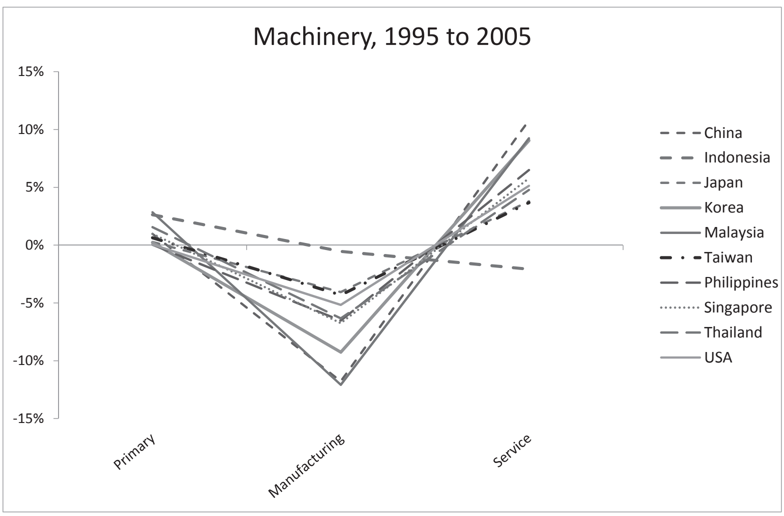

FIGURE 9 Machinery smile, by nation, 1995–2005
SOURCE: Authors' calculations on AIO database

forced by changes in technology, competition, relative prices, or corporate restructuring. For example, technological changes could raise or lower the amount of primary inputs necessary to produce a given product. Primary share could also fall if the price of primary goods rose by less than the price of the goods produced by the sectors using them.

3.1. Organizing framework: Firm-level smile curve

We start with the definition. Value added of a stage is the difference between the value of the stage's output and the cost of its intermediate inputs, namely,

$$\text{Value added} = \text{Price} \times \text{output} - (\text{per} - \text{unit cost of intermediates}) \times \text{output}. \tag{2}$$

To connect it to things that might be subject to policies, the first step is to relate the price to the costs of capital, labour and other primary factors, intermediate costs and the markup, namely

$$\begin{aligned}\text{Price} = {} & \text{per} - \text{unit factor payments} + \text{per} - \text{unit cost of intermediate inputs} \\ & + \text{markup},\end{aligned} \tag{3}$$

where factor payments represent wages, return to capital, technology, etc., and the markup is the premium of price over average cost. Using the price relationship, we get

$$\text{Value added} = (\text{per} - \text{unit factor payments} + \text{markup}) \times \text{output}. \tag{4}$$

Observe that the cost of intermediates is netted out. To compare value-added across links in the value chain, we normalize to get value-added per unit of output, namely

$$\text{Value added/output} = \text{per} - \text{unit factor payments} + \text{markup}. \tag{5}$$

This is a workable starting point. It tells us that value-added at each stage in a firm-level value chain consists of factor payments and profits. From this, it follows immediately that the only way to change the distribution of value-added per stage is to change relative factor payments or relative profit margins.

One clear source of such changes is offshoring. Imagine that firms in high-technology, high-wage nations offshore labour-intensive stages to low-technology, low-wage nations. The implied cost savings will mechanically reduce the offshored stage's share of total value, assuming that the profit margin does not change much. The reason is that a stage's value added is based on its costs.

This basic cost-accounting effect can be amplified by two additional effects. The first is relative market power. Offshored tasks tend to be things that can be done in many emerging nations, most of which are eager to attract such stages. The non-offshored stages, by contrast, tend to involve things where firms naturally have market power due to product differentiation, branding, etc. Basically, offshored tasks become commoditized, while the onshore tasks do not. The second is the combination of high-technology from the lead firm with low-wage labour in the offshoring recipient. Even if such firms pay local workers more than average (as is often the case), the combination of high labour productivity and low wages can massively reduce the unit cost of the offshored stage.

This provides one simple story for the smile curve. Some production stages are more readily offshored than others, and North–South offshoring is typically driven by cost-lowering motives. Thus, the value added in the offshored stages could be expected to fall. If the most offshore-able stages involve fabrication, the firm-level smile curve would be a natural outcome.

At the economy-wide level, the story is slightly different. Here, the key point is that if it is easier to offshore manufacturing activities than service activities, offshoring should be expected to produce an economy-wide smile curve.

3.2. "Servicification" of manufacturing

A very different sort of explanation could come from the "servicification" of manufacturing. In the 1970s, companies like Nestle would have most services performed by company employees. Because Nestle was classified as a manufacturing firm, the value added from its workers providing service inputs was classified as manufacturing value-added—regardless of the nature of the task performed. Employees in the marketing department would obviously be providing a service value-added input, but many of them would, in the value-added calculations, be counted as manufacturing workers. When Nestle started outsourcing much of its marketing work to marketing firms (which are classified as being in the service sector), the proportion of service value-added in Nestle products rose simply because of the reclassification or relabelling of the service tasks from the manufacturing to the service sector. That is, even if there were no changes in technology, costs, or prices, shifting jobs and tasks from manufacturing firms to service firms would make it look like less of a product's total value-added was coming from fabrication. The basic idea here is that manufacturing firms have outsourced many tasks such as marketing, accounting and cleaning. In most national accounting systems, such outsourcing would shift value-added from a manufacturing firm to service-sector firm and this would thus appear to be an increase in value that is added by the nation's service sectors. This would be true even if there were no changes at all in the production process.

The servicification of manufacturing has long been commented upon by economists tracking employment data. More recent work documents the trend more carefully (Falk and Fei 2011, Lodefalk 2010). An important paper by Bernard and Fort (2013) documents what they call "factory-less manufactures" as having reached the polar extreme of service separation from fabrication. A recent paper by Bloom et al. (2019) suggests that some of this reclassification of establishment activities has indeed been taking place in the US, i.e., with establishments whose primary activity used to be manufacturing now being reclassified as being in services.

3.3. Estimation analyses of the smile curve

This subsection investigates whether the above descriptive analyses are supported econometrically. We estimate the following equation using AIO 24 and AIO 76, respectively.

$$VAsharefromS_{cit} = \beta_0 + \beta_1 Dum2000 + \beta_2 Dum2005 + FixedEffects + \epsilon_{cit}, \quad (6)$$

where $VAsharefromS_{cit}$ denotes the value-added share in country c, industry i and year t that originates from the sector $S \in \{Primary, Manufacturing, Service\}$ and $Dum2000$ and $Dum2005$ are indicator variables equal to 1 if and only if the observation is, respectively, from 2000 and 2005. Three sets of regression results are yielded using, in turn, the share of value-added from primary, manufacturing and service sectors as the dependent variable. We expect to find negative and significant coefficients for β_1 and β_2 when S = manufacturing and positive and significant when S = service. Estimation results with various sets of fixed effects are in table 2 with AIO 24 industries.

For all the different sets of fixed effects, the coefficient estimates are negative and significant for manufacturing, positive and significant for service and generally insignificant for primary. Columns (1) to (3) with the country fixed effect only and columns (4) to (6) with the industry fixed effect only indicate that the smile curves are present both across industries within countries and across countries within industries. The results in the column (7) to (9) with the full set of fixed effects indicate that the smile curves are present over time within industry/country. The estimation results using AIO 76 in table 3 show very similar results as in table 2. The same estimation is done using WIOD. Table 4 shows the results. The period is each year from 1995 to 2011. The year 1995 is taken as the reference dummy. Year dummies from 2000 onwards tend to show negative and significant coefficients, with their magnitudes getting larger for manufacturing and positive and significant coefficients and with their magnitudes getting larger for service, indicating again the presence of the smile curves.

TABLE 2

Smile curve estimation: Asian Input–Output Table, 24 industries (1985, 1990, 1995, 2000, 2005)

Asian Input-Output table, 24 industries (1985, 1990, 1995, 2000, 2005): Smile curve estimation

Variables	(1) Primary ratio	(2) Manufacturing ratio	(3) Service ratio	(4) Primary ratio	(5) Manufacturing ratio	(6) Service ratio	(7) Primary ratio	(8) Manufacturing ratio	(9) Service ratio
yr2000	−0.00997	−0.0222*	0.0321***	−0.00997	−0.0222**	0.0321***	−0.00997	−0.0222**	0.0321***
	(0.0106)	(0.00913)	(0.00612)	(0.00879)	(0.00780)	(0.00667)	(0.00632)	(0.00681)	(0.00379)
yr2005	−0.00592	−0.0363***	0.0423***	−0.00592	−0.0363***	0.0423***	−0.00592	−0.0363***	0.0423***
	(0.0103)	(0.00980)	(0.00633)	(0.00856)	(0.00878)	(0.00708)	(0.00737)	(0.00878)	(0.00502)
Country fixed effects	✓	✓	✓						
Industry fixed effects				✓	✓	✓			
Country*Industry fixed effects							✓	✓	✓
R-squared	0.150	0.054	0.401	0.518	0.412	0.251	0.833	0.705	0.784
Number of observations	600	600	600	600	600	600	600	600	600

NOTES: Multi-way (production country * production industry) clustered robust standard errors in parentheses.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

TABLE 3

Smile curve estimation: Asian Input–Output Table, 76 industries (1990, 1995, 2000, 2005)

Variables	(1) Primary ratio	(2) Manufacturing ratio	(3) Service ratio	(4) Primary ratio	(5) Manufacturing ratio	(6) Service ratio	(7) Primary ratio	(8) Manufacturing ratio	(9) Service ratio
yr2000	−0.00580	−0.0181**	0.0239***	−0.00497	−0.0184***	0.0233***	−0.00559	−0.0179***	0.0235***
	(0.00692)	(0.00685)	(0.00402)	(0.00518)	(0.00450)	(0.00443)	(0.00358)	(0.00371)	(0.00276)
yr2005	0.00187	−0.0338***	0.0319***	0.00181	−0.0339***	0.0321***	0.00195	−0.0342***	0.0322***
	(0.00671)	(0.00711)	(0.00426)	(0.00518)	(0.00494)	(0.00469)	(0.00405)	(0.00458)	(0.00329)
Country fixed effects	✓	✓	✓						
Industry fixed effects				✓	✓	✓			
Country*Industry fixed effects							✓	✓	✓
R-squared	0.140	0.031	0.339	0.528	0.580	0.203	0.860	0.814	0.784
Number of observations	1,674	1,674	1,674	1,674	1,674	1,674	1,674	1,674	1,674

NOTES: Multi-way (production country * production industry) clustered robust standard errors in parentheses.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

TABLE 4

Smile curve estimation: World Input–Output Table (1995–2011)

World Input-Output Table: Smile curve estimation

Variables	(1) Primary ratio	(2) Manufacturing ratio	(3) Service ratio	(4) Primary ratio	(5) Manufacturing ratio	(6) Service ratio	(7) Primary ratio	(8) Manufacturing ratio	(9) Service ratio
yr1996	0.000644	−0.00226	0.00162	0.000618	−0.00212	0.00150	0.000722	−0.00228*	0.00156+
	(0.00491)	(0.00594)	(0.00353)	(0.00328)	(0.00436)	(0.00385)	(0.000815)	(0.00108)	(0.000935)
yr1997	−0.000193	−0.00496	0.00516	−0.000218	−0.00481	0.00503	−0.000115	−0.00498***	0.00509***
	(0.00489)	(0.00589)	(0.00349)	(0.00331)	(0.00438)	(0.00384)	(0.000904)	(0.00125)	(0.00115)
yr1998	−0.00401	−0.00582	0.00982**	−0.00386	−0.00577	0.00963*	−0.00375**	−0.00618***	0.00994***
	(0.00474)	(0.00575)	(0.00351)	(0.00338)	(0.00433)	(0.00395)	(0.00122)	(0.00157)	(0.00147)
yr1999	−0.00386	−0.00762	0.0115***	−0.00376	−0.00749+	0.0113**	−0.00365*	−0.00777***	0.0114***
	(0.00484)	(0.00585)	(0.00348)	(0.00340)	(0.00425)	(0.00396)	(0.00152)	(0.00186)	(0.00177)
yr2000	0.000302	−0.0121*	0.0118***	0.000373	−0.0120**	0.0116**	0.000483	−0.0123***	0.0118***
	(0.00509)	(0.00585)	(0.00336)	(0.00351)	(0.00419)	(0.00389)	(0.00204)	(0.00210)	(0.00211)
yr2001	−0.00150	−0.0193***	0.0208***	−0.000820	−0.0197***	0.0206***	−0.00103	−0.0203***	0.0214***
	(0.00497)	(0.00576)	(0.00338)	(0.00338)	(0.00412)	(0.00390)	(0.00186)	(0.00220)	(0.00220)
yr2002	−0.00389	−0.0223***	0.0262***	−0.00325	−0.0227***	0.0260***	−0.00346+	−0.0234***	0.0268***
	(0.00494)	(0.00575)	(0.00334)	(0.00337)	(0.00417)	(0.00390)	(0.00191)	(0.00231)	(0.00224)
yr2003	−0.00383	−0.0237***	0.0275***	−0.00322	−0.0240***	0.0273***	−0.00343+	−0.0246***	0.0281***
	(0.00488)	(0.00570)	(0.00334)	(0.00336)	(0.00416)	(0.00389)	(0.00193)	(0.00230)	(0.00221)
yr2004	0.000291	−0.0238***	0.0235***	0.00132	−0.0246***	0.0233***	0.000861	−0.0250***	0.0242***
	(0.00500)	(0.00567)	(0.00328)	(0.00343)	(0.00419)	(0.00389)	(0.00208)	(0.00248)	(0.00237)
yr2005	0.00254	−0.0266***	0.0241***	0.00318	−0.0270***	0.0238***	0.00304	−0.0272***	0.0242***
	(0.00500)	(0.00569)	(0.00326)	(0.00341)	(0.00416)	(0.00388)	(0.00223)	(0.00266)	(0.00244)
yr2006	0.00468	−0.0294***	0.0247***	0.00535	−0.0298***	0.0245***	0.00515*	−0.0304***	0.0253***
	(0.00506)	(0.00567)	(0.00326)	(0.00346)	(0.00418)	(0.00389)	(0.00235)	(0.00272)	(0.00257)
yr2007	0.00500	−0.0341***	0.0291***	0.00570+	−0.0346***	0.0289***	0.00544*	−0.0352***	0.0298***
	(0.00505)	(0.00574)	(0.00331)	(0.00346)	(0.00416)	(0.00391)	(0.00239)	(0.00281)	(0.00253)
yr2008	0.00443	−0.0420***	0.0375***	0.00511	−0.0424***	0.0373***	0.00490*	−0.0430***	0.0381***
	(0.00501)	(0.00581)	(0.00340)	(0.00343)	(0.00424)	(0.00406)	(0.00241)	(0.00302)	(0.00274)

(*continued*)

TABLE 4

(*Continued*)

World Input-Output Table: Smile curve estimation

Variables	(1) Primary ratio	(2) Manufacturing ratio	(3) Service ratio	(4) Primary ratio	(5) Manufacturing ratio	(6) Service ratio	(7) Primary ratio	(8) Manufacturing ratio	(9) Service ratio
yr2009	0.00311	−0.0485***	0.0454***	0.00375	−0.0489***	0.0451***	0.00352	−0.0495***	0.0459***
	(0.00500)	(0.00583)	(0.00352)	(0.00356)	(0.00434)	(0.00421)	(0.00236)	(0.00314)	(0.00277)
yr2010	0.00555	−0.0484***	0.0428***	0.00618+	−0.0488***	0.0426***	0.00596*	−0.0493***	0.0434***
	(0.00504)	(0.00585)	(0.00355)	(0.00356)	(0.00436)	(0.00423)	(0.00246)	(0.00316)	(0.00286)
yr2011	0.00942+	−0.0477***	0.0383***	0.0101**	−0.0480***	0.0380***	0.00983***	−0.0486***	0.0388***
	(0.00512)	(0.00584)	(0.00358)	(0.00358)	(0.00436)	(0.00426)	(0.00255)	(0.00317)	(0.00288)
Country fixed effects	✓	✓	✓						
Industry fixed effects				✓	✓	✓			
Country*Industry fixed effects							✓	✓	✓
R-squared	0.131	0.141	0.417	0.585	0.544	0.089	0.930	0.896	0.823
Number of observations	9,412	9,412	9,412	9,412	9,412	9,412	9,412	9,412	9,412

NOTES: Multi-way (production country * production industry) clustered robust standard errors in parentheses.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

3.4. Estimation analysis for the hypothesis of offshoring

In subsection 3.1, we argue that offshoring to low-wage, labour-abundant countries is one clearly potential source of the smile-curve phenomena. This section attempts to investigate such a possibility. We estimate the following equation, using WIOD:[4]

$$VAsharefromManuf_{cit} = \beta_0 + \beta_1 LowWageCountriesShareWithinManuf_{cit} + FixedEffects + \epsilon_{cit}, \quad (7)$$

where $VAsharefromManuf_{cit}$ denotes the value-added share of manufacturing sector as a source sector out of the total value-added in country c, industry i and year t and $LowWageCountriesShareWithinManuf_{cit}$ denotes the share of low-wage countries within the manufacturing source value-added. The offshoring hypothesis indicates that the coefficient estimate is negative because the value-added share of manufacturing sector (the left-hand side variable) falls when manufacturing jobs are offshored to low-wage countries (higher share of low-wage countries as a source of manufacturing value-added [the right-hand side variable]). The estimation results are in table 5. Columns (1) and (2) include all the export countries whereas columns (3) and (4) are confined to G7 countries. The definition for low-wage countries is based on the World Bank classification (for details, see the WIOD country list in the appendix). The coefficient estimates show the expected negative signs with high statistical significance, and the magnitudes are higher for rich countries as exporters, which goes well with our intuition as offshoring is done mostly by rich countries.

4. Deconstructing the value shift to services

This section takes a closer look at the prima facie evidence presented above. We start with the time dimension.

4.1. Smile curves 1985–1995 and 1995–2005

Unlike other multiregional IO tables that are available (notably WIOD and TiVa), the Asian IO table exists in electronic form dating back to 1985. This allows us to investigate whether the smile curve is a recent phenomenon or whether it also was present in the 1980s. Here, we take the first 10 years (1985–1995) and contrast it with the subsequent 10 years (1995–2005), which we have shown above—each time focusing on the changes rather than the levels. Specifically, we calculate the value-added in each nation's exports, fully tracing back service, manufacturing and primary inputs.

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4 We have done the same estimation analyses using AIO 24 and AIO 76 but found statistically insignificant coefficient estimates, which we believe arise from the small number of countries (10 countries) in AIO, out of which five countries are classified as "low-wage" countries.

TABLE 5

Estimation analysis for the hypothesis of offshoring using WIOD 1995–2011

Variables	Whole Manufacturing share as source sector	Whole Manufacturing share as source sector	G7 countries Manufacturing share as source sector	G7 countries Manufacturing share as source sector
Low-wage countries share within the manufacturing source	−0.188*** (0.0264)	−0.271*** (0.0423)	−1.038*** (0.159)	−1.103*** (0.0979)
Country fixed effects	✓		✓	
Industry fixed effects	✓		✓	
Year fixed effects	✓		✓	
Country–Industry fixed effects		✓		✓
Country–Year fixed effects		✓		✓
Industry–Year fixed effects		✓		✓
Observations	9,412	9,412	1,666	1,666
R-squared	0.653	0.933	0.740	0.972

NOTES: Robust standard errors in parentheses.
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

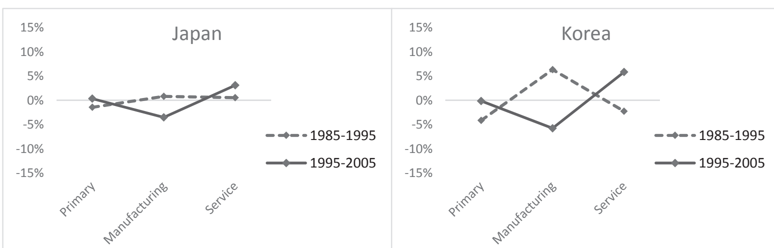


FIGURE 10 Smile curves for Japan and Korea, 1985–1995, 1995–2005
SOURCE: Authors' calculations on AIO database

The smile curve comes from plotting these changes. Figure 10 shows the facts for Japan and Korea. The figure plots on the vertical axis the change in value that was added in the three sectors (primary, manufacturing and services) to the nation's exports. The figure shows that between 1985 and 1995, the value-added originating in manufactured sectors rose slightly for Japan and clearly in Korea, while value-added to these nations exports in service sectors rose slightly for Japan but was unchanged for Korea. In summary, there was no smile-curve phenomenon in either of these nations in the decade leading up to 1995.

The smile appears clearly, however, during the decade following 1995. The value-added in the manufacturing sector fell for both nations whereas the value-added in the service sector rose.

Figure 11, which shows the cases for the remaining Asian nations in the AIO, indicates that except for in the Philippines and Indonesia, the smile curve is present in 1995–2005, but not in 1985–1995. We can apply this same temporal decomposition aggregating across the Asian nations in the AIO database but separately by industry. Figure 12 displays the result for exports in selected industries. Again, we observe high commonality in the patterns.

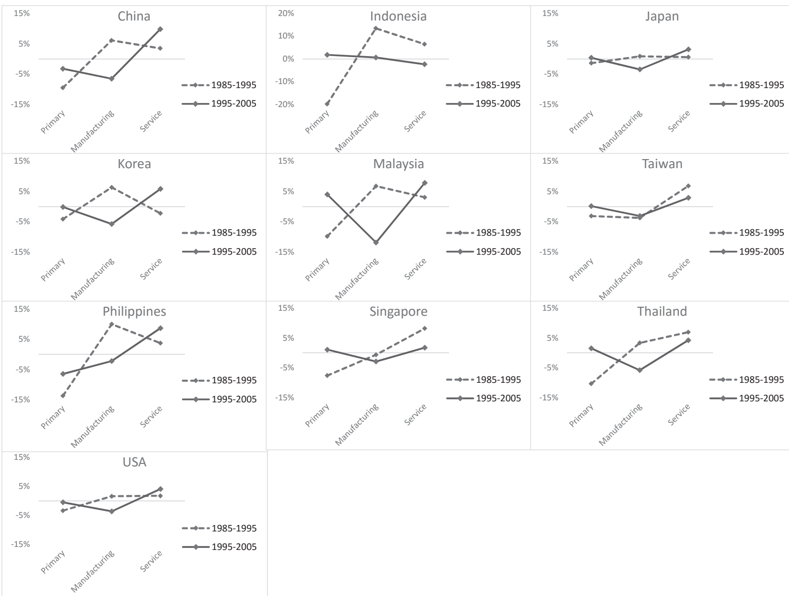


FIGURE 11 Aggregate smile curve by nation, 1985–1995 versus 1995–2005
SOURCE: Authors' calculations on AIO database

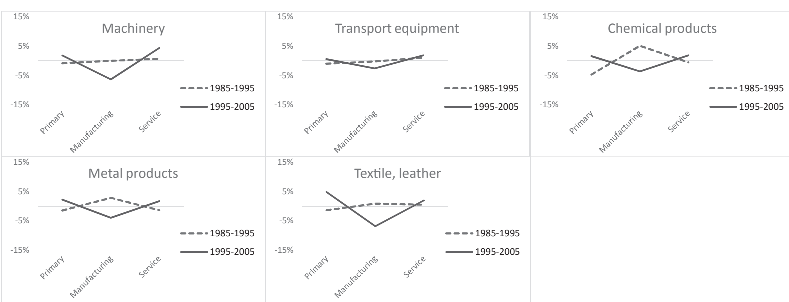


FIGURE 12 Aggregate smile curve by industry, 1985–1995 versus 1995–2005
SOURCE: Authors' calculations on AIO database

While this set of facts is striking, it does not immediately help us identify the drivers of the shift to services. Factory Asia started to develop rapidly from about 1985, but it accelerated substantially between 1990 and 2000 as China opened up and joined the WTO, and Asian nations unilaterally reformed following the Asian financial crisis in ways that were attractive to offshored factories. Other things equal, this might point to the second unbundling as a key driver. Unfortunately, the servicification of manufacturing was also booming post-1995 (Lodefalk 2010). The main point here is that the information and communication technology revolution fostered outsourcing and offshoring by making it easier and safer to organize complex interactions at a distance.

At the very least, the change over time alerts us about the fact that something changed in recent decades to produce this evolution in the service inputs into Asian exports. This is helpful in that it rules out many of the standard "structural change" explanations in the growth literature. Studies such as Ngai and Pissarides (2007), Acemoglu and Guerrieri (2008) and Foellmi and Zweimuller (2008) stress the secular rise in services share of GDP and employment. What we see with the contrast between 1985–1995 and 1995–2005 is that this cannot be the whole story.

4.2. Change in value-added in skill levels

An important caveat about the above analyses is that the service sector does not necessarily refer to high-skilled jobs, such as legal or medical services. It may include low-skilled jobs, such as cleaning or catering services. Whereas the AIO does not allow us to distinguish between the value-added generated by high-skilled and the one by low-skilled labour, the WIOD is useful for highlighting the issue.[5] The Social Economic Accounts of the WIOD provides information on the distributions of high-, medium- and low-skilled workers by country and industry. When computing the value-added trade, we divided the value-added of country/industry into the value-added yielded by these three types and then calculated the value-added trade following the methodology discussed above.

Figure 13 shows the decomposition of the change of value-added. Taking China as an example, the increased share of the service value-added was driven mainly by high-skilled labour. The 3.45% increase of the service value-added is composed of a 2.54% rise in high-skilled value-added, a 0.88% rise in medium-skilled value-added and a 0.03% rise in low-skilled value-added. On the other hand, the decrease of the value-added of the manufacturing sector is attributed mainly to the decrease of the low-skilled

5 Definition of low, middle and high-skilled labour differs across countries. Skills are defined on the basis of educational attainment levels. Broadly put, low-skills are primary education, middle-skill secondary education, high-skill tertiary education. The analysis is for 1995–2009 because the data on labour participation by skill levels are available only up to 2009. For more details, see WIOD Socio-Economic Accounts (SEA): Sources and Methods (2016).

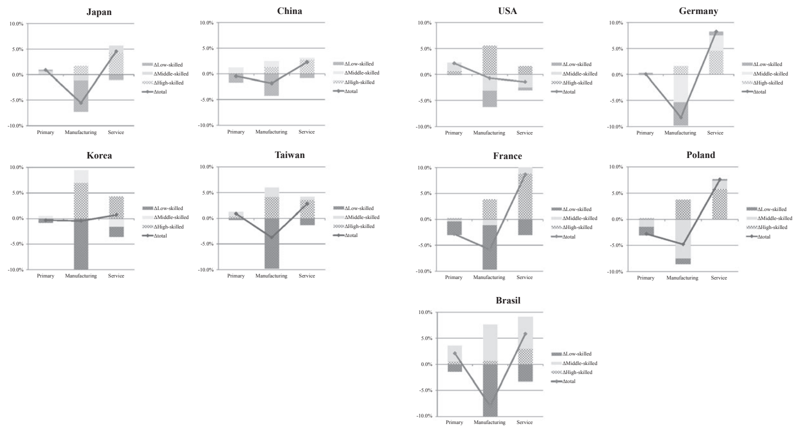


FIGURE 13 Change in value-added by skill levels, 1995–2009
SOURCE: Authors' calculations on WIOD database

value-added. The higher contribution of the high-skilled labour in the increased service-sector value-added is more prominent in the developed countries, such as Japan, Germany and France, although the US is somehow not such a case.

4.3. The geography of the shift to services value-added

The shift of the value-added source from the manufacturing to the service sector ignored the issue of national sources. Hereto, we have ignored the geographical dimension, i.e., which countries supplied the extra service-sector value-added. This misses a key part of the concern raised by the smile curve—that offshoring is sending the "bad" jobs to emerging markets while the "good" jobs are retained in the lead firms' home nations. The smile-curve fear is that high-productivity service-sector jobs are staying in or even moving to advanced nations while low-productivity fabrication jobs—especially assembling—are moving to developing nations.

Given the aggregation in our dataset, we cannot really address this good-versus-bad job dichotomy. We can, however, track the nations that provide the higher service-sector inputs, i.e., we look at the increase in service VA by *source* nation for each exporting nation/industry. Loosely speaking, we associate the service-sector inputs into nation's exports as "good" jobs.

To fix ideas and introduce concepts, we begin with a single export sector (machinery) and look at the nation-of-origin of service-sector inputs for Thailand and Japan. For example, the top panel of table 6 shows the case of the Thai exports of machinery, an industry known for its global supply chain and a large presence of Japanese firms. We see that Thailand's own share of service-sector inputs decreased from 74% in 1985 to 40% in 2005. The corresponding rise in foreign service-sector inputs came mainly from

TABLE 6

Value shift to service sectors: Machinery exports from Thailand and Japan

Exporter	Industry	Sector	Country	Share 1985	Share1990	Share 1995	Share 2000	Share 2005
Thailand	Machinery	service	Thailand	74.3%	49.0%	43.9%	46.5%	40.3%
Thailand	Machinery	service	Japan	16.5%	23.0%	26.0%	21.6%	21.4%
Thailand	Machinery	service	China	0.4%	0.6%	1.2%	4.1%	10.9%
Thailand	Machinery	service	USA	5.9%	16.9%	16.0%	13.5%	10.8%
Thailand	Machinery	service	Taiwan	0.8%	2.3%	2.8%	3.6%	4.9%
Thailand	Machinery	service	Malaysia	0.4%	1.3%	3.0%	2.6%	3.7%
Thailand	Machinery	service	Korea	0.6%	1.5%	1.6%	2.8%	3.6%
Thailand	Machinery	service	Singapore	0.7%	4.8%	3.2%	3.0%	1.6%
Thailand	Machinery	service	Indonesia	0.2%	0.3%	0.4%	1.2%	1.5%
Thailand	Machinery	service	Philippines	0.3%	0.4%	2.0%	1.0%	1.2%
Exporter	Industry	Sector	Country	Share 1985	Share1990	Share 1995	Share 2000	Share 2005
Japan	Machinery	service	Japan	96.6%	96.5%	95.5%	94.0%	90.2%
Japan	Machinery	service	USA	2.4%	2.2%	2.6%	2.7%	3.7%
Japan	Machinery	service	China	0.3%	0.2%	0.4%	0.7%	2.2%
Japan	Machinery	service	Taiwan	0.2%	0.3%	0.3%	0.9%	1.1%
Japan	Machinery	service	Korea	0.2%	0.3%	0.4%	0.6%	1.0%
Japan	Machinery	service	Malaysia	0.1%	0.1%	0.2%	0.3%	0.4%
Japan	Machinery	service	Thailand	0.0%	0.1%	0.2%	0.2%	0.4%
Japan	Machinery	service	Philippines	0.1%	0.1%	0.2%	0.2%	0.4%
Japan	Machinery	service	Indonesia	0.2%	0.1%	0.1%	0.2%	0.3%
Japan	Machinery	service	Singapore	0.1%	0.1%	0.1%	0.2%	0.3%

SOURCE: Authors' calculations on AIO database

Japan, the US and China—although it increased for every nation in our database.

This result is consistent with the firm-level smile-curve drivers discussed above. That is, if Japanese lead firms in the machinery sector are offshoring fabrication jobs to lower-cost countries but keeping pre- and post-fabrication service-sector jobs at home, we should expect the pattern in the top panel of table 6. The large increase of Thai export sourcing from US service sectors (the US share of service inputs rises from 5.9% to 10.8%) is also in line with the canonical smile curve thinking at the firm level.

An interesting twist, however, is that Thai exports are seeing more of the value-added by the service sectors in other Asian developing nations such as China, Taiwan and Malaysia. Of course, it is possible that the service-sector inputs from, say, the Philippines involves low-productivity service inputs into intermediate goods, while the service-sector inputs from, say, the US involves high-productivity service inputs such as marketing, design and innovation services.

The bottom panel of table 6 shows the same breakdown for Japanese machinery exports. The decrease in domestic service-sector sourcing is far less marked than it was for Thailand, with Japan's share falling only 6 percentage points. This fall was accompanied by modest rises in service-sector value-added from the US and China. Table 7 shows the own-sourcing service shares for all

TABLE 7

Reduction in own-nation service-sector sourcing shares (1985 to 2005)

Country	1985	1990	1995	2000	2005	Change 1985–2005
USA	98%	98%	97%	97%	97%	−1%
Japan	94%	95%	96%	95%	92%	−1%
China	92%	91%	86%	87%	85%	−6%
Korea	74%	79%	78%	80%	75%	1%
Indonesia	79%	83%	84%	74%	71%	−7%
Taiwan	74%	78%	72%	78%	70%	−4%
Malaysia	70%	71%	65%	57%	64%	−7%
Thailand	82%	74%	72%	71%	63%	−19%
Philippines	78%	63%	54%	61%	54%	−24%
Singapore	60%	61%	67%	64%	45%	−15%

SOURCE: Authors' calculations on AIO database

the countries averaged across industries. Notably, all the countries, except Korea (with one percentage point) experienced a decrease of their own-sourcing service shares. The US and Japan kept their high own-sourcing service shares even in 2005, whereas developing countries decreased their own-sourcing shares.

To see the general pattern of which countries supplied service value-added, we take five key export industries (textile, chemical, metal, machinery and transport equipment) and 10 exporter countries in the AIO database. For each of these 50 cases, we look at the change in service source shares for 10 supplies, namely Japan, the US, China, Singapore, Korea, Taiwan, Malaysia, Indonesia, Thailand and the Philippines. The basic data is displayed in a rather concentrated manner in figure 14. For each of the 50 cases we plot the change in the

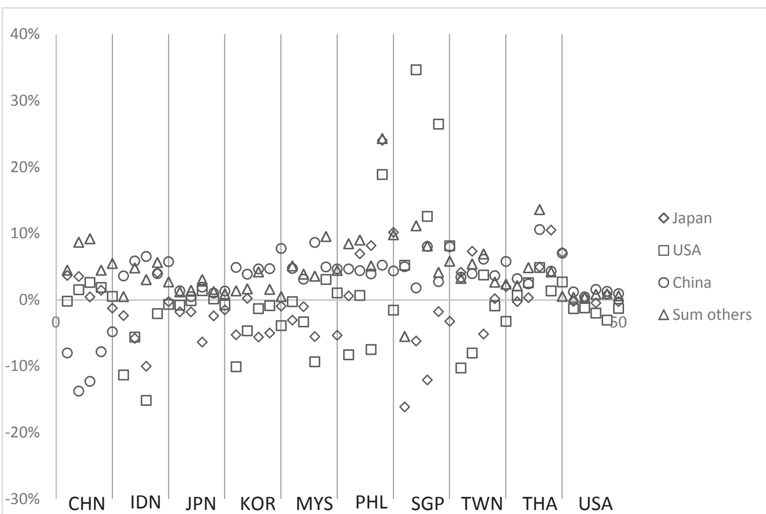


FIGURE 14 Service-input share changes: By national origin 1985–2005
SOURCE: Authors' calculations on AIO database

sourcing share for the main actors—Japan, the US and China. Take the first example denoted by CHN (China)—the five circles show that for each of the five industries' exports from China, China's own contribution decreased, whereas the US and Japan increased their shares slightly and the other countries (denoted "sum of others") increased their shares. The five circles in IDN (Indonesia) show percentage change of China-origin service value-added embedded in Indonesia's five industries' exports. The circles being located above zero, i.e., positive, means increased China-origin service value-added in Indonesia's exports. Overall, China increased its service value-added participation in the other nine countries, and the other countries ("sum of others") also increased their shares. The cases for Japan and the US are mixed. A general conclusion we can draw from this figure is that the developed countries did not necessarily increase their service value-added participation, but China in particular and the other Asian nations combined ("sum of others") increased their service participation. The next subsection discusses in which industry China increased its service value-added shares.

4.4. What kind of service industries?

This subsection investigates what kind of service industries increased their shares as the source of value-added. Figure 15 shows the value-added contribution of each service industry in Asian countries' exports in 1990, 1995, 2000, 2005, using AIO 76.[6] Wholesale and retail trade has large value-added and increased dramatically. Transportation has the third largest contribution as of 2005 and increased substantially. R&D is included in education and research, which also shows a steady increase.

We have seen in the last subsection that China increased its service value-added share participation in the other countries. Table 8 shows what percentage China increased its value-added participation from 1990 to 2005. In eight out of nine service-sector industries, China ranks first or second in its service share increase. We do not have information to investigate the reasons for the difference in the share changes by industries. However, we conjecture that the high share increase in transportation and wholesale and retail trade presumably comes from more involvement of Chinese transportation firms and wholesale firms in supply-chain networks, combined with increased Chinese outward FDI. The high shares also documented in telephone and telecommunication as well as electricity, gas and water supply indicate that Chinese intermediate manufacturing goods traded are energy- and communications-intensive.

6 Here we use AIO 76 instead of AIO 24 because AIO 24 has only four service industries, whereas AIO 76 has service industries at more disaggregated level. In particular, it includes some important service industries such as transportation and wholesale and retail trade, separately. For details, see the lists in the appendix.

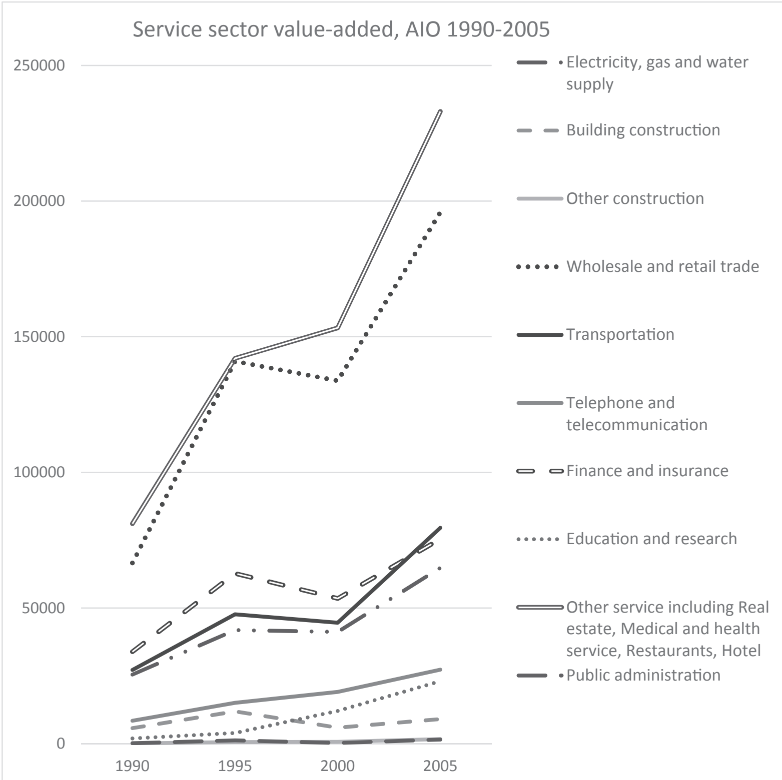


FIGURE 15 Service-sector value-added, AIO 1990–1995
SOURCE: Authors' calculations on AIO database

TABLE 8

China's service value-added share change in the other countries

Source country	Source industry	Share change 1990–2005	Ranking
China	Electricity, gas and water supply	18.90%	1
China	Building construction	7.01%	2
China	Other construction	9.62%	2
China	Wholesale and retail trade	11.47%	1
China	Transportation	11.89%	1
China	Telephone and telecommunication	19.36%	1
China	Finance and insurance	7.73%	1
China	Education and research	–0.97%	9
China	Other service including Real estate, Medical and health service, Restaurants, Hotel	6.13%	1

SOURCE: Authors' calculations on AIO database

5. Concluding remarks and testable hypotheses

This is, to our best knowledge, the first attempt to show what economy-wide smile curves look like for some major countries, especially Asian nations. Our use of the AIO allows us to show that the smile curve is more than just an international implication of the shift to services that has been stressed in the structural change literature. We find that inputs from manufacturing sectors provided rising shares of nations' export value-added from 1985 to 1995 but falling shares from 1995 to 2005. This pattern of little change in value-added via inputs from primary sectors teamed with shifts in value-added from inputs stemming from manufactured sectors to inputs coming from service sectors. We find this outcome for almost all industries and almost all nations.

One potential explanation for this shift is that fabrication has become commoditized. That is, the vast range of nations eager to welcome low-productivity manufacturing jobs has reduced the markups and labour costs in such stages. In this view, lead firms from high-technology, high-wage nations offshore labour-intensive manufacturing tasks while keeping high-skill service tasks at home. We find some evidence in support of this because the developing countries decreased their own-sourcing of service value-added while the developed countries kept their high share of own-sourcing of service value-added. We also find that decreased own-sourcing of service value-added is filled by increased service value-added share from China and the other countries.

In terms of our finding's implications for a broader literature of trade, evidence we find on the effect of offshoring on the input–output linkage may suggest that trade economists should adopt production functions that allow substitutability across inputs[7] when they construct models to understand cross-border production processes.

Supporting information

Supplementary material accompanies the online version of this article.

7 Caliendo and Parro (2015) construct a trade model that incorporates global production and trade in intermediates based on Cobb–Douglas (fixed input purchase shares) as their main model in the main text, whereas they show the model with CES (flexible input purchase shares) in the appendix. The CES-based model should probably be a model of choice given our check of correlation coefficients of input shares between 1995 and 2005 using WIOD shows that not only small countries such as Malta or Estonia but also large countries such as Poland (0.77), Turkey (0.69) and Indonesia (0.66) have correlation coefficients less than 0.8 and also our check using AIO 76 between 1995 and 2005 shows substantially low correlation coefficients (such as 0.68 for China, 0.53 for Malaysia, 0.46 for Philippines and 0.72 for Thailand).

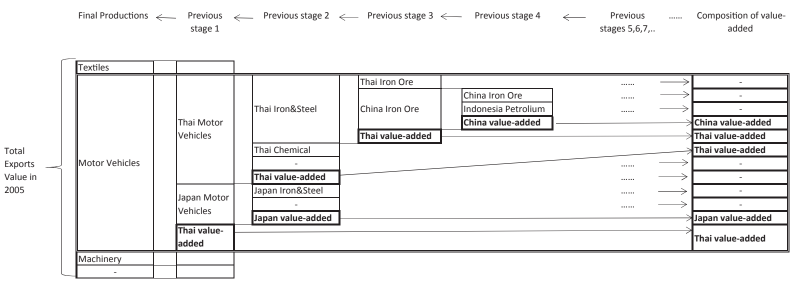
Appendix

Comparison between AIO and WIOD

Besides the coverage of periods, the other major difference between AIO and WIOD is country coverage. Whereas WIOD covers many more countries than AIO does, AIO covers several major Asian countries that WIOD does not include, such as Malaysia, Thailand and the Philippines. Another difference related to country coverage is the treatment of the ROW. In AIO, countries other than the 10 countries are aggregated into ROW and treated in the exogenous part of the IO table. On the contrary, WIOD includes ROW within the endogenous part of the IO table. To do this, WIOD relies on the proportionality assumptions.

TABLE A1

A sketch of the concept of the value-added computation



NOTES: Motor vehicle exports in Thailand are made from input values from motor vehicle industry of Thailand and of Japan and value-added within Thailand. Japan motor vehicles, in turn, are made from Japan's iron and steel industry and others combined, with value-added within Japan. And so on.

TABLE A2

Summary table of the main features of Asian Input–Output Table and World Input–Output Database

Data base	Institute		Year	Countries	Industries
World Input-Output Table	European Commission	Release 2013	each year from 1995 to 2011	41	35
	European Commission	Release 2016	each year from 2000 to 2014	44	56
Asian Input-Output Table	JETRO, Institute of Developing Economies		1985, 1990, 1995, 2000, 2005	10	24 (1985), 78 (1990, 1995), 76 (2000, 2005)

TABLE A3

List of industries AIO 24

Industry code	Industry name	Sector classification
001	Paddy	Primary
002	Other agricultural products	
003	Livestock	
004	Forestry	
005	Fishery	
006	Crude petroleum and natural gas	
007	Other mining	
008	Food, beverage and tobacco	Manufacturing
009	Textile, leather, and the products thereof	
010	Timber and wooden products	
011	Pulp, paper and printing	
012	Chemical products	
013	Petroleum and petrol products	
014	Rubber products	
015	Non-metallic mineral products	
016	Metal products	
017	Machinery	
018	Transport equipment	
019	Other manufacturing products	
020	Electricity, gas, and water supply	Service
021	Construction	
022	Trade and transport	
023	Services	
024	Public administration	

TABLE A4

List of industries AIO 76–AIO 78

Industry code	Industry description	Sector
001	Paddy	Primary sector
007A	Other grain	
002X	Cassava, Sugar cane and beet, Oil palm and coconuts, Other food crops	
003X	Natural rubber, Fiber crops, Other commercial crops	
009	Livestock and poultry	
010	Forestry	
011	Fishery	
012	Crude petroleum and natural gas	
015A	Iron ore	
010X	Copper ore, Tin ore, Other metallic ore	
016	Non-metallic ore and quarrying	
018X	Milled rice, Other milled grain and flour	Manufacturing sector
021A	Fish products	
021B	Slaughtering, meat and dairy products	
017X	Oil and fats, Sugar, Other food products	
022A	Beverage	
022B	Tobacco	
023	Spinning	
024	Weaving and dyeing	
025	Knitting	
026	Wearing apparel	
027	Other made-up textile products	
028	Leather and leather products	
029	Timber	
030A	Furniture	
030B	Other wooden products	
031	Pulp and paper	
032	Printing and publishing	
033A	Synthetic resins and fiber	
033B	Other basic industrial chemicals	
034	Chemical fertilizers and pesticides	
035A	Drugs and medicine	
035B	Other chemical products	
036	Refined petroleum and its products	
037	Tires and tubes	
038	Other rubber products	
039	Cement and cement products	
040	Glass and glass products	
041	Other non-metallic mineral products	
042	Iron and steel	
043	Non-ferrous metal	
044	Metal products	
045D	Heavy electric machinery	
045E	Engines and turbines	
045X	Ordinary industrial machinery, Specialized industrial machinery, Agricultural machinery	
046A	Electronics and electronic products	
046B	Other electric machinery and appliance	
047A	Motor vehicles	
048B	Shipbuilding	

(*continued*)

TABLE A4

(*Continued*)

Industry code	Industry description	Sector
048X	Motor cycles and bicycles (Motor cycles), Motor cycles and bicycles (Bicycles), Aircrafts, Other transport equipment	
049	Precision machines	
050A	Plastic products	
050B	Other manufacturing products	
051	Electricity, gas and water supply	Service sector
052A	Building construction	
052B	Other construction	
053A	Wholesale and retail trade	
053B	Transportation	
054A	Telephone and telecommunication	
054B	Finance and insurance	
054C	Education and research	
054D	Other service including Real estate, Medical and health service, Restaurants, Hotel	
056	Unclassified	
055	Public administration	

NOTE: Concordance between AIO 76 and AIO 78 is done by the authors.

TABLE A5

List of industries World Input–Output Database

Industry number	Industry name	Sector
1	Agriculture, Hunting, Forestry and Fishing	Primary
2	Mining and Quarrying	
3	Food, Beverages and Tobacco	Manufacturing
4	Textiles and Textile Products	
5	Leather, Leather and Footwear	
6	Wood and Products of Wood and Cork	
7	Pulp, Paper, Paper , Printing and Publishing	
8	Coke, Refined Petroleum and Nuclear Fuel	
9	Chemicals and Chemical Products	
10	Rubber and Plastics	
11	Other Non-Metallic Mineral	
12	Basic Metals and Fabricated Metal	
13	Machinery, Nec	
14	Electrical and Optical Equipment	
15	Transport Equipment	
16	Manufacturing, Nec; Recycling	
17	Electricity, Gas and Water Supply	Service
18	Construction	
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	
22	Hotels and Restaurants	
23	Inland Transport	
24	Water Transport	
25	Air Transport	
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	
27	Post and Telecommunications	
28	Financial Intermediation	
29	Real Estate Activities	
30	Renting of M&Eq and Other Business Activities	
31	Public Admin and Defence; Compulsory Social Security	
32	Education	
33	Health and Social Work	
34	Other Community, Social and Personal Services	
35	Private Households with Employed Persons	

TABLE A6

List of countries: World Input–Output Database, 1995–2011

Code	Country name
AUS	*Australia*
AUT	*Austria*
BEL	*Belgium*
BGR	Bulgaria
BRA	Brazil
CAN	*Canada*
CHN	China
CYP	*Cyprus*
CZE	*Czeck Republic*
DEU	*Germany*
DNK	*Denmark*
ESP	*Spain*
EST	*Estonia*
FIN	*Finland*
FRA	*France*
GBR	*United Kingdom*
GRC	*Greece*
HUN	*Hungary*
IDN	Indonesia
IND	India
IRL	*Ireland*
ITA	*Italy*
JPN	*Japan*
KOR	*Korea*
LTU	*Lithuania*
LUX	*Luxembourg*
LVA	*Latvia*
MEX	Mexico
MLT	*Malta*
NLD	*Netherlands*
POL	*Poland*
PRT	*Portugal*
ROU	Roumania
RUS	Russia
RoW	Rest of the World
SVK	*Slovakia*
SVN	*Slovenia*
SWE	*Sweden*
TUR	Turkey
TWN	*Taiwan*
USA	*United States of America*

NOTE: High income countries (italic) and middle/low income countries by World Bank country.

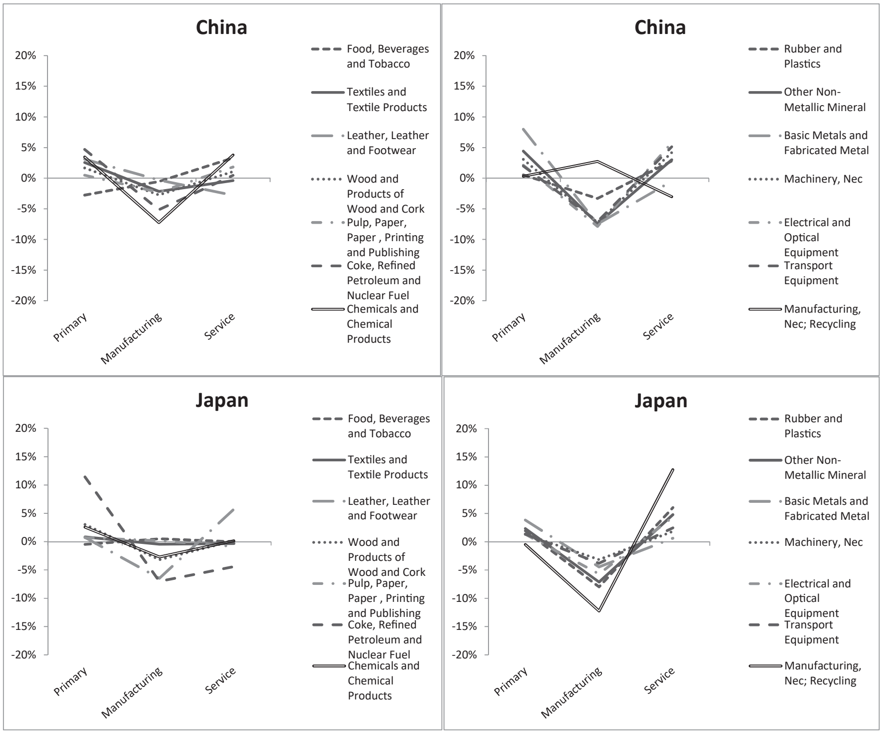


FIGURE A1 Smile curve by nation and industry using the World Input–Output Database, 1995–2011

(*continued next page*)

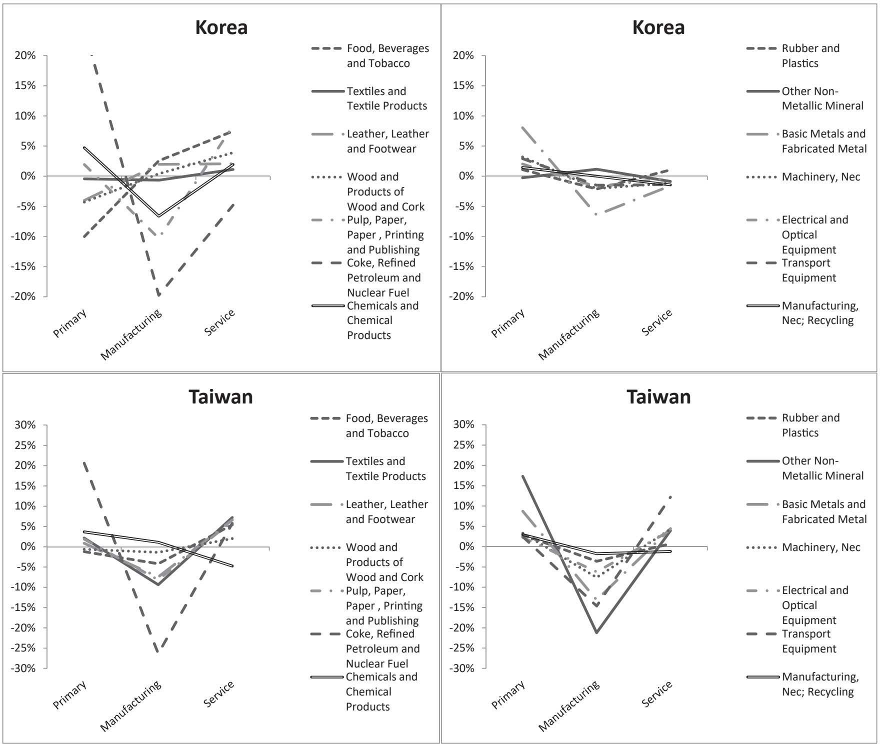


FIGURE A1 Smile curve by nation and industry using the World Input–Output Database, 1995–2011 (*continued*)

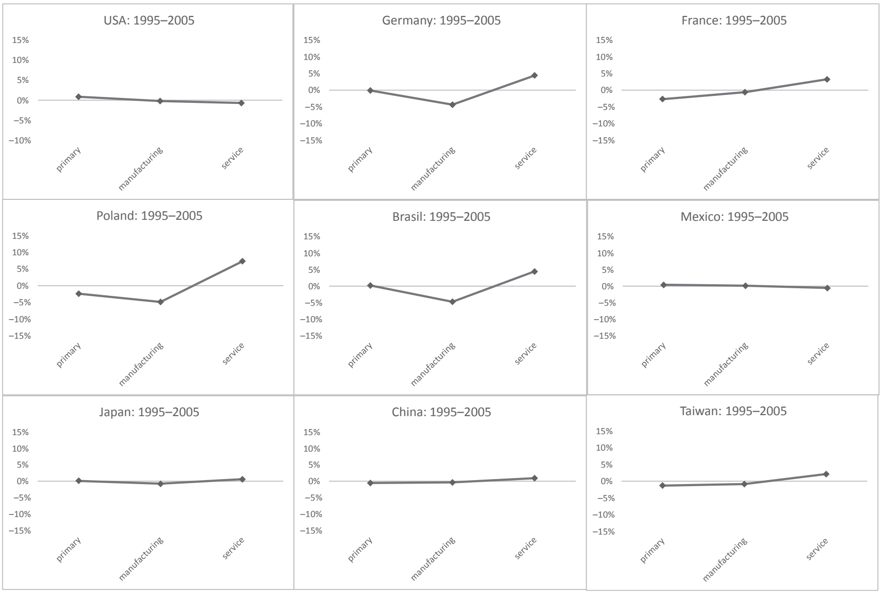


FIGURE A2 Smile curve by nation using the World Input–Output Database, 1995–2005

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