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Production fragmentation, upstreamness, and value added: Evidence from Factory Asia 1990–2005☆

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ABSTRACT

We exploit the recent release of the 2005 Asian Input-Output Matrix to dress a picture of the geographic fragmentation of value added in Factory Asia from 1990 to 2005. We document 3 stylized facts. The first is that the average share of foreign value added embedded in production rose by about 7 percentage points between 1990 and 2005, from 9% to 16%. The second is that, contrary to popular belief, China has emerged as a major source of value added to other Factory Asia countries' production. Third, we find empirical support for the smile-curve hypothesis. Country-industries at the upstream and downstream extremities of the supply chain embed a larger share of value added than those with intermediate levels of upstreamness.

1. Introduction

"A Barbie doll costs $20, but China only gets about 35 cents of that." – New York Times 2006

Two questions may come to mind when reading the above quote. First, is Chinese production really only about adding cents of value to intermediate inputs? Or, more generally, within the labyrinth of Factory Asia's value chains, where is value added? Second, is China adding so little value to Barbie dolls because its assembly stage is at the downstream end of the production chain? Or, broadly speaking, do we observe a relationship between value addition and the position of a production stage along a global value chain?

While economists have been studying production fragmentation since the 1990s (e.g. Jones and Kierzkowski, 1990), answering the above questions has been difficult due to lack of appropriate data. The recent release of international input-output tables has opened up new research avenues by making it possible to dissect ever-expanding global value chains. Yet, despite a recent spurt of interest in the economics of global value chains, or the second unbundling (Baldwin, 2011), economists have not yet scrutinized the geographic distribution of Factory Asia's production value added.

When it comes to China, the conventional wisdom is that it is not using Chinese factors of production for most of Chinese exports (Baldwin, 2011). Ma and Van Assche (2010) suggest that the Chinese content of its 'processing exports' is less than 20%, and processing exports accounted for more than 50% of the nation's boom in manufactured trade. These numbers are often translated in the policy sphere as China having to solve the value-added problem. When it comes to global value chains in general, economists have suggested that the relationship between value added and production stages may be u-shaped, i.e. a smile curve with upstream and downstream stages adding more value than intermediate stages (Baldwin et al., 2014; Mudambi, 2008). Is this the case in Factory Asia?

In this paper we use newly-released Input-Output data from the Institute of Developing Economies, part of the Japan External Trade Organization (IDE-JETRO), to dress a picture of value-added fragmentation in Factory Asia (China, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand) from 1990 to 2005 and in doing so shed new light on the questions above.

Our methodology is novel. Firstly, we do not only decompose the value-added content of exports but dissect all of Factory Asia's final production, whether exported or not. While Johnson and Noguera's (2012) estimate the value-added of exports using the

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GTAP Input-Output matrices, we trace out the origin of the value added embedded in all of a country's production of final goods. If we take Boeing' Dreamliner as an example. Let's assume it is made in the US and sold to American Airlines, and hence not exported. This does not mean that the aircraft is not part of an elaborate global value chain with parts and components imported from many countries. Our decomposition aims to capture the geographic extent of these value chains, even when the final product is not exported. This allows us to go beyond the analysis of trade economists, who were mostly concerned about measuring trade flows accurately, and get a clear depiction of how value added is split along global value chains.

Our decomposition allows us to establish two stylized facts. The first is that the share of foreign value added embedded in Factory Asia's final production rose by about 7 percentage points between 1990 and 2005, from 9% to 16%. The second is that, contrary to popular belief, China's production of final goods embeds a smaller share of foreign value added than that of other Factory Asia countries. The anecdotal evidence on Barbie dolls as an example of low-value-added exports from China may not be a good indicator of China's overall production. The data suggests otherwise across all industries. Between 1990 and 2005 among factory Asia countries China grew most as a source of value added to other countries' production.

Our second methodological contribution is the estimation of smile curves at the country-sector level. To do so we measure the upstreamness of each sector in each country in Factory Asia, using the index suggested by Antràs et al. (2012) and plot it against the industry's average value-added contribution to final demand. What we find is that, on average, country-industries at the upstream and downstream extremities of the supply chain do indeed embed a larger share of value added than those with intermediate levels of upstreamness. In doing so we provide the first confirmation of the smile-curve conjecture at the multi-sector international level.[1]

Our paper fits in the literature on production fragmentation pioneered by, among others, Jones and Kierzkowski (1990), Hummels et al. (2001), and in the context of Asia, Ando and Kimura (2005). Our contribution is to trace out the geographic and sectoral distribution of the value-added embedded in the production of final goods, whereas many previous studies focused instead on trade flows of intermediate goods. Our paper is similar to Baldwin and Lopez-Gonzales (2013) who present a portrait of global supply-chain trade and its evolution since 1995 using the recent World Input-Output Database. While they introduce import-to-produce and import-to-export measures of supply-chains taken directly from Input-Output tables, we trace out the origin of value-added through Input-Output structures through recursive computation. The relevance of our approach is also linked to the trade-and-growth debate, as highlighted by Baldwin and Lopez-Gonzales (2013) who argue that value-added is directly related to national income, especially wage, and Low (2014), who writes that knowing where the value is created by trade is absolutely crucial when jobs are at stake.

Finally, one unique contribution of our paper is to cover the period 1990–2005, hence starting earlier than previous studies and before the information and communication technology (ICT) revolution, which is considered to be the kick-starter of production fragmentation (Baldwin, 2011). This allows us to observe the rise of international production fragmentation in the Input-Output matrices.

The rest of our paper is structured as follows. In the next section we describe the data and our methodology to decompose value added. Section 3 presents descriptive statistics for production fragmentation patterns. Section 4 examines the relationship between upstreamness and value added and presents theoretical arguments behind the smile curve. The last section concludes.

2. Data

The data come from the Asian International Input-Output (AIO) Table. This international IO table has been constructed by IDE-JETRO every 5 years from 1985 to 2005. The 2005 table covers nine Asian nations (Indonesia, Malaysia, the Philippines, Singapore, Thailand, China, Taiwan, Korea, and Japan) plus the US and 76 sectors (the 1985 table covered 24 sectors). We focus on 42 manufacturing industries and thus on the period from 1990 to 2005.[2] It includes the US since it is a major trade partner of almost all Asian countries. Other countries are aggregated as the Rest of the World (ROW). While other datasets are now available for many nations, e.g. the OECD-WTO Trade in Value-Added (TiVA) initiative and the World Input-Output Database (WIOD), the AIO has the advantage of starting before the ICT revolution, i.e. in 1990 rather than in 1999, covering more Asian countries, and it also provides a higher disaggregation of industries.

By recursive use of information in the AIO table, we can determine the source of value added in every dollar of production of final goods. The key is the simple accounting identity that states that the sale value of a product equals to the cost of intermediate inputs plus value added. Here value added refers to payments to factors of production, i.e. wages as well as profits. The same identity applies to the intermediate goods used as inputs, so a recursive application can generate a full map of where the value was added. For example, if labor were the only productive factor, we could identify where all the workers behind a given final product were employed (by sector and by nation).

For example, the value added embedded in Thai auto production can be decomposed into countries involved in the international supply chain which sources motors from Japan and petrol from Indonesia, as well as other inputs from the chemical and metal industries, which themselves source their inputs from other industries in other countries. By tracking down the whole process until the output value equals the sum of value added, we can decompose the total value added by industry and country. To ease understanding of the calculation process, Fig. 1 provides a sketch of the scheme of the computation.

Decomposing value-added across input-output structures is straightforward using matrix algebra (see Johnson and Noguera, 2012):

$$VA = F[I - B]^{-1}X$$

where VA is value-added embodied in the final goods production of a given country (N countries and J sectors), F is a (NJ;NJ) diagonal matrix with the ratio of direct value-added to gross output for each country and sector on the diagonal, $(I\text{-}B)^{-1}$ is the (NJ;NJ) Leontief inverse – it estimates the amount of intermediates per US$ of final output after all rounds intermediate shipments across sectors and countries. X is the (NJ; 1) vector of final goods pro-

[1] In concurrent work Ye et al. (2015) also estimated smile curves at the country-industry level yet they focus on exports, use a different methodology to compute value added, and a different data source. Previous empirical studies of the smile curve focused on electronics (Shin et al., 2012) or on Japanese firms only (Kimura, 2003).

[2] Our analysis focuses on the value-added sources of manufacturing industries. The Asian Input-Output table (AIO) of 1985, which covers 24 industries, includes only 12 manufacturing industries, whereas the AIO tables from 1990 onwards include 42 manufacturing industries. The use of more disaggregated data allows us to avoid some aggregation bias and gives us a larger number of observations in our regression analysis. The covered industries are listed in Table A1 in the appendix.