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Abstract

This paper examines the evolution of Japan's inter-regional value chains using input-output tables from 1960 to 2005. We measure the degree of inter-regional production linkages based on various statistics including (1) the outsourcing index, (2) upstreamness, (3) downstreamness, and (4) empirical comparative advantages. The results show that, in most sectors, the expansion of inter-regional value chains slowed down after the 1990s, when imports from overseas started to increase rapidly. We also find that the value chains in the transport equipment sector have expanded exceptionally. This sectoral heterogeneity is confirmed by all the measures used in this study.

Keywords: production supply chains, intra-national trade, input-output analysis, Japan
JEL classification: D57, O18, P25

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1. Introduction

Global value chains have been shown to shape international trade flows across countries, affecting various aspects of the economy.[1] In addition, recent trade literature has recognized *intra*-national trade as a critical factor in influencing trade patterns.[2] The roles of these two factors in explaining international trade have been investigated independently in previous studies. However, very little is known about the interaction of these two factors–global value chains and intra-national trade–particularly how value chains operate within a country.

This paper fills this gap by examining a long-run transition of domestic value chains using Japan's inter-regional input-output table (hereafter IO table). There are several benefits to focusing on Japan in this context. First, due to its proximity to Asian countries, Japan has been deeply integrated into global value chains since the 1990s (Ando and Kimura, 2005; Baldwin, 2016). As a result, it provides us with a rare opportunity to examine how a country's integration with global value chains affects its domestic value chains. Second, due to the widespread use of IO analyses in Japan, the availability of the inter-regional IO table dates back to the year 1960. This makes it possible to examine long-run changes in the structure of domestic value chains during the 1960-2005 period. For these reasons, Japan is considered excellent for analyzing production value chains using IO tables.

This paper provides new insights into long-run changes in the spatial distribution of economic activities in Japan. To provide rough ideas, Panel A of Figure 1 describes the Gini coefficients based on the prefecture-level population and the number of manufacturing employees.[3] It shows that the population Gini coefficient continuously rises over the 1960-2005 period, suggesting an increasing spatial concentration of population over the period, caused by population growth in Greater Tokyo, as shown in Panel B.[4] In contrast, the manufacturing Gini coefficient continuously declines, suggesting an increasing spatial dispersion of manufacturing

[1] For example, global value chains have been shown to affect countries' skill structures (Timmer et al., 2014), employment (Lost et al., 2015a), and welfare (Eppinger et al., 2021).
[2] For example, Ramando et al. (2016) show that it is important to consider internal trade in explaining not too strong effect of country size on income levels. Albrecht and Tombe (2016) demonstrate that there are substantial gains from internal trade in Canada.
[3] The manufacturing Gini coefficient is the simple average of the twelve Gini coefficients shown in Panel C of Figure 1.
[4] This rise of the Gini coefficient comes from population concentration in Greater Tokyo as shown in Panel C. Greater Tokyo, including Metropolitan Tokyo, the largest city, increases population over time, while Greater Osaka, including Osaka city, the second largest city, sees a gradual decline over time and Aichi, including Nagoya city, the third largest, slightly increases.

employees, consistent with Tomiura (2003). Panel C presents twelve sectoral manufacturing Gini coefficients, indicating substantial heterogeneity across sectors. In particular, the transport equipment sector follows an exceptionally different pattern, staying nearly constant over time.

=== Insert Figure 1 here ===

We further investigate how these changes in the spatial distribution of manufacturers have shaped internal production networks within Japan. We employ the following statistics to measure Japan's domestic value chains: the outsourcing indices of Feenstra and Hanson (1996, 1997), the upstreamness and downstreamness of Miller and Temurshoev (2017), the 'value chain journey' diagrams of Baldwin and Okubo (2019), and internal trade in value-added estimated using the approach by Timmer et al. (2013, 2014) and Los et al. (2015b). All these measures show that the evolution of Japan's domestic value chains follows a hump-shaped pattern – domestic value chains have expanded in the first half of our sample period while the last half of the sample witnessed a shrink in domestic value chains.

Most sectors follow the same time-series patterns in the evolution of domestic value chains except the transport equipment sector, which experiences a continuous expansion of its value chains. All measures of production value chains that we employ show the uniqueness of the transport equipment sector. The substantial value chains of the transport equipment sector are consistent with tight manufacturer-supplier relationships documented in Asanuma (1989, 1992a, 1992b) and Aoki (1988).

This paper contributes to three different strands of literature. First, it is associated with the literature on production value chains. For example, Hummels et al. (2001) analyze IO tables from OECD countries to demonstrate that vertical specialization accounts for 30% of growth in trade flows between 1970 and 1990. Recent literature emphasizes the importance of considering trade in value-added because gross trade flows include a substantial amount of intermediate goods (e.g., Johnson and Noguera, 2012; Timmer et al., 2013, 2014). This paper is close to Tomiura (2009), which analyzed Japanese firm-level data from 1998 and found that R&D

intensive firms tend to prefer foreign outsourcing over domestic outsourcing in terms of regional focus.[5]

Second, we contribute to the literature on *internal* trade. For example, McCallum (1995) considers internal trade within Canada when estimating the border effect on trade. Ramando et al. (2016) and Albrecht and Tombe (2016) also emphasize the importance of considering internal trade in explaining the scale effect and gains from trade, respectively. In the context of Japan, Okubo (2004) finds that the border effect of Japan declined over the 1960-1990 period, meaning that internal trade within Japan (relative to international trade) had become significant during the period, consistent with our findings.

Lastly, this paper is related to the literature on the location choice and spatial reallocation of manufacturing, especially in the Japanese context. Fukao and Yue (1997) analyze the location choice of Japanese electronics firms during the 1978-1992 period, finding that rising labor costs in Japan increased offshoring to Asian countries.[6] Tomiura (2003) finds that manufacturing sectors had become spatially dispersed during the 1990s and the regional supply of non-tradable inputs was a key in explaining the reallocation. Theoretical works explaining these empirical observations include Krugman and Livas-Elizondo (1996) and Forslid and Wooton (2003).[7] Our paper differs from these prior studies because we measure spatial allocation of manufacturing through the lens of inter-regional trade.

The remainder of the paper is organized as follows. Section 2 describes data sources and the structure of the IO table. Section 3 conducts various analyses and discusses the results. Section 4 includes concluding remarks. The Appendix presents additional details, tables, and figures.

2. Data

[5] Kiyota (2021) shows that a decline of capital accumulation caused by foreign outsourcing explains the regional manufacturing value-added.

[6] Fukao (1996) extends the sectoral coverage by including textiles, general and precision machinery, and transport equipment. Yue (2000) extends the sample period to 1969-1993. These papers find similar results as Fukao and Yue (1997).

[7] Krugman and Livas-Elizondo (1996) show that, with backward and forward linkages, an increase in international trade raises the regional dispersion force of manufacturing within a country. Forslid and Wooton (2003) find that trade liberalization first leads to concentration and then leads to dispersion. They show that comparative advantage plays a key role in shaping this pattern.

2.1 Data sources and aggregation

We obtain Japan's inter-regional IO table from Japan's Ministry of Economy, Trade, and Industry.[8] Regional transactions of intermediate and final goods are constructed based on the Survey on Commercial Distribution (Shōhin Ryūtsu Cyōsa). As discussed in Arai and Kim (2017), output data are recorded based on the location of production rather than the location of headquarters.

It includes eight regions, Hokkaido, Tohoku, Kanto (including Greater Tokyo), Chubu (including Aichi), Kinki (including Greater Osaka), Chugoku, Shikoku, and Kyushu, for the period 1960-2005.[9] While the analysis is conducted with the eight regions, estimates for Hokkaido, Tohoku, Chugoku, Shikoku, and Kyushu are categorized as 'Periphery' for an illustrative purpose. In addition, Kanto, Chubu, and Kinki are renamed as 'Eastern Core', 'Central Core', and 'Western Core', respectively.

Sectoral aggregations of the IO table change over time; therefore, sectors are consistently aggregated into the same 21 sectors throughout the sample period. Out of the 21 sectors, we mainly focus on twelve manufacturing sectors: (1) food, (2) textiles, (3) lumber, (4) pulp and paper, (5) chemicals, (6) petroleum and coal products, (7) ceramic, clay, and stone products, (8) iron and steel products, (9) metal products, (10) machinery and electronics, (11) precision machinery, and (12) transport equipment.

Our IO analysis with the 21 sectors is carried out by considering sectoral linkages between non-manufacturing and manufacturing sectors. However, we discuss the results from the twelve manufacturing sectors only. In addition, for an illustrative purpose, the first four manufacturing sectors are categorized as light manufacturing sectors, and sectors 5-11 are categorized as heavy manufacturing sectors.[10] We keep the transport equipment sector (sector 12) separate because it is unique in various measures.

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[8] It is available at https://www.meti.go.jp/statistics/tyo/tiikiio/result/result_3.html. The inter-regional IO table from the year 2000 is not the official IO table by the METI, and it is the one constructed by Arai and Ogata (2007).

[9] Okinawa is not included in the IO table for the years 1960 and 1970 and it is included in the IO table for the years 1975-2005, because Okinawa was under American administration after World War II until 1972. To keep the IO analysis consistent throughout the sample period, Okinawa is entirely omitted from our analysis. In addition, the IO table from 1960 and 1970 separately include Tokai and Hokuriku, which constitute Chubu. However, only Chubu is available in the IO table from the years 1980-2005. Therefore, Tokai and Hokuriku are aggregated as one region for the years 1960 and 1970 as well. See Appendix A for more details.

[10] See Appendix B for more details regarding the sectoral aggregation.

All transactions in the IO table are expressed in nominal Japanese yen. Using the GDP deflators computed based on nominal and real prefectural GDPs, these nominal values are deflated to real values.[11] As a result, transactions' values are re-expressed as per the real 2000 prices. While different price changes across regions are adjusted, it is acknowledged that different price changes across sectors are not adjusted because the sectoral price data are not available from earlier periods of our sample.

2.2 Structure of the IO table

Japan's inter-regional IO table includes data on domestic transactions of intermediate inputs and final goods in Japanese yen values. Figure 2 shows a simplified 3-region 2-sector case. The left 6×6 matrix includes transactions in inputs. For example, $m_{(1,A),(2,B)}$ indicates intermediate goods produced by sector A of region 1 and used by sector B of region 2. The 6×3 matrix in the middle includes final goods transactions. For example, $f_{(1,A),(3)}$ indicates final goods produced in sector A of region 1 and purchased by region 3. In addition to these domestic transactions, international imports and exports are described in the last two columns of the table. $im_{(r,s)}$ denotes sector *s*' goods imported from abroad by region *r*. $ex_{(r,s)}$ denotes sector *s*' goods exported to abroad from region *r*.

While Figure 2 shows the 3-region 2-sector case, we assume the general *R*-region *S*-sector case in mathematical expressions. All variables are time-variant. However, we drop the time subscript to simplify notations throughout the paper. In the IO table, each horizontal sum is equal to gross output: $x_{(r,s)} = \sum_{r'=1}^{R} \sum_{s'=1}^{S} m_{(r,s),(r',s')} + \sum_{r'=1}^{R} f_{(r,s),r'} - im_{(r,s)} + ex_{(r,s)}$. Gross output $x_{(r,s)}$ and value-added $v_{(r,s)}$ are described at the bottom of the table. Because $m_{(r,s),(r',s')}$'s and $f_{(r,s),r'}$'s include imports from abroad, we construct an intermediate good matrix including domestically produced inputs only, as follows:

$$\widetilde{\mathbf{T}} = (\mathbf{I} - \mathbf{M})\mathbf{T}, \tag{1}$$

where tilde indicates that the corresponding variable is adjusted for international imports. **I** is an $(R \times S) \times (R \times S)$ identity matrix, and

[11] The nominal and real prefectural GDPs are obtained from the website of Japan's Cabinet Office, https://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/files_kenmin.html. Each region's GDP deflator is computed as 'each region's aggregate nominal GDP' divided by 'each region's aggregate real GDP'.

$$\underbrace{\mathbf{T}}_{(R\times S)\times(R\times S)} = \begin{bmatrix} m_{(1,1),(1,1)} & m_{(1,1),(1,2)} & \cdots & m_{(1,1),(R,S)} \\ m_{(1,2),(1,1)} & m_{(1,2),(1,2)} & \cdots & m_{(1,2),(R,S)} \\ \vdots & \vdots & \ddots & \vdots \\ m_{(R,S),(1,1)} & m_{(R,S),(1,2)} & \cdots & m_{(R,S),(R,S)} \end{bmatrix}$$

is a matrix including original intermediate goods flow. $\mathbf{M}$ indicates an $(R \times S) \times (R \times S)$ matrix including $im_{(r,s)}/da_{(r,s)}$ in diagonal entries and zeros in other entries where $da_{(r,s)} = \sum_{r'=1}^{R}\sum_{s'=1}^{S} m_{(r,s),(r\prime,s\prime)} + \sum_{r'=1}^{R} f_{(r,s),r\prime}$ denotes domestic absorption. A matrix of domestically produced final goods is also found by doing the same computation:

$$\tilde{\mathbf{F}} = (\mathbf{I} - \mathbf{M})\mathbf{F}, \tag{2}$$

where

$$\underbrace{\mathbf{F}}_{(R\times S)\times R} = \begin{bmatrix} f_{(1,1),(1)} & f_{(1,1),(2)} & \cdots & f_{(1,1),(R)} \\ f_{(1,2),(1)} & f_{(1,2),(2)} & \cdots & f_{(1,2),(R)} \\ \vdots & \vdots & \ddots & \vdots \\ f_{(R,S),(1)} & f_{(R,S),(2)} & \cdots & f_{(R,S),(R)} \end{bmatrix}.$$

=== Insert Figure 2 here ===

3. Analysis

3.1 Outsourcing indices

We begin our analysis by examining the prevalence of domestic and international outsourcing by computing several indices. Domestic outsourcing is defined as outsourcing input production to other regions (in the eight-region disaggregation), and international outsourcing is defined as outsourcing input production abroad.

As a result, domestic and international outsourcing can be measured by the following indices

$$Out_{(r,s)}^{d} = \frac{\sum_{s'}\sum_{r'\neq r}\widetilde{m}_{(r',s),(r,s')}}{\sum_{s'}\sum_{r'}\widetilde{m}_{(r',s),(r,s')} + im_{(r,s)}} \text{ and } Out_{(r,s)}^{i} = \frac{im_{(r,s)}}{\sum_{s'}\sum_{r'}\widetilde{m}_{(r',s),(r,s')} + im_{(r,s)}}, \tag{3}$$

respectively. Superscripts *d* and *i* indicate 'domestic' and 'international', respectively. The first term of the denominator $\sum_{s'}\sum_{r'}\widetilde{m}_{(r',s),(r,s')}$ is sector *s*' domestic inputs used by region *r*. The second term $im_{(r,s)}$ is sector *s*' imported inputs used by region *r*. Because the IO table does not provide imported imports and imported final goods separately, we impute imported inputs using total imports and the share of domestic input purchases in total domestic purchases in each sector in each region.[12] The numerator of $Out^d_{(r,s)}$ is the sum of domestically purchased inputs, excluding inputs produced in its region. As a result, $Out^d_{(r,s)}$ is seen as the prevalence of outsourcing sector s' inputs to other regions within Japan. $Out^i_{(r,s)}$ is a measure of the prevalence of outsourcing sector s' inputs abroad.

Panel A of Figure 3 displays aggregated outsourcing indices for the three broad manufacturing sectors.[13] The left panel shows domestic outsourcing indices and indicates that the light and heavy sectors follow a hump-shaped pattern: the domestic outsourcing index increased during the 1975-1990 period while decreasing around 1990. The transport equipment sector is an exception – its domestic outsourcing index is increasing throughout the sample period.

This sectoral heterogeneity in the domestic outsourcing index seems to be related to sectoral differences in the international index shown in the right chart of Figure 3's Panel A. While the international outsourcing index is rapidly increasing in the light and heavy sectors, it remains at a lower level in the transport equipment sector. Panel B of Figure 3 shows the correlation between the two variables using 12 manufacturing sector observations to investigate the link between the two indices further. The left scatterplot is based on long-run changes between 1960 and 2005, indicating a striking negative correlation. It implies that sectors that experienced a greater rise in international outsourcing, such as textiles, had a smaller increase (or a greater decrease) in domestic outsourcing.

Per previous studies, the rapid expansion of global value chains in Asia started in the 1990s (e.g., Baldwin, 2016).[14] Hence, we split our sample into two periods. The middle scatterplot is based on changes during 1960-1990, whereas the right scatterplot is based on the 1990-2005 period. These show that the negative correlation comes from the 1990-2005 period and not from the 1960-1990 period. This backs up our argument that the expansion of global

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[12] Specifically, international imports of inputs are imputed as $im^t_{(r,s)} = im_{(r,s)}\, \theta_{(r,s)}$ where $\theta_{(r,s)} = \frac{\sum_{s'} \sum_{r' \neq r} \widetilde{m}_{(r',s),(r,s')}}{\sum_{s'} \sum_{r' \neq r} \widetilde{m}_{(r',s),(r,s')} + \sum_{r' \neq r} \tilde{f}_{(r',s),(r)}}$.

[13] We first compute disaggregated outsourcing indices for the 12 manufacturing sectors (for each of the domestic and international ones). Then, four indices from the light sectors (and seven indices from the heavy sectors) are aggregated into one index by taking the weighted average where weights are total input usage in each sector.

[14] See Ando and Kimura (2005) and Kimura and Ando (2003, 2005).

value chains since the 1990s is related to the decline of domestic value chains of the same sectors. Our results are consistent with Fukao and Yue (1997), showing that an increase in Japan's labor costs increased offshoring to Asian countries after 1986.

=== Insert Figure 3 here ===

The outsourcing indices described in equation (3) include all inputs produced by a particular sector and used by either of *all* sectors in each region. However, these indices may not capture production value chains well, including inputs used by *all* sectors. Therefore, following Feenstra and Hanson (1996, 1997), we also compute the 'narrow' domestic outsourcing index as follows[15]:

$$Out_{(r,s)}^{Narrow} = \frac{\sum_{r' \neq r} \widetilde{m}_{(r',s),(r,\,s)}}{x_{(r,s)}}, \tag{4}$$

where the denominator is gross production in sector *s* of region *r*, and the numerator is intermediate goods used by that sector of that region and purchased from the same sector of the other regions. The left chart of Figure 4 Panel A shows that the 'narrow' domestic outsourcing is increasing in the transport equipment sector but not in the other sectors, similar to domestic outsourcing measured by equation (3).

To examine the level of insourcing (sourcing of inputs into its region) and the overall input share in gross output, we compute the following two indices[16]:

$$In_{(r,s)}^{Narrow} = \frac{\sum_{r' \neq r} \widetilde{m}_{(r',s),(r,\,s)}}{x_{(r,s)}} \quad \text{and} \quad Inputs_{(r,s)}^{Narrow} = \frac{\sum_{r'} \widetilde{m}_{(r',s),(r,\,s)}}{x_{(r,s)}},$$

which are shown in the middle and right charts of Figure 4 Panel A, respectively. It indicates that insourcing is also rising in the transport equipment sector but not in the other sectors. The overall input shares in gross production follow the same pattern. These observations suggest that domestic value chains have become longer only in the transport equipment sector.

Lastly, Panel B of Figure 4 represents changes in the international outsourcing index of equation (3) on the horizontal axis and changes in the 'narrow' domestic outsourcing index of

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[15] We are unable to compute the 'narrow' definition of *international* outsourcing because the IO table does not provide us with flows of internationally imported inputs into each sector.
[16] Obviously, $Out_{(r,s)}^{Narrow} + In_{(r,s)}^{Narrow} = Inputs_{(r,s)}^{Narrow}$.

equation (4) on the vertical axis. The figure shows that two variables are negatively related during the 1960-2005 period and the first half and the second half of the period. These results again suggest that international and domestic sourcing seem to be substitutes rather than complements.

=== Insert Figure 4 here ===

3.2 Upstreamness and downstreamness

We also employ the upstreamness and downstreamness of Miller and Temurshoev (2017) to measure domestic value chains.[17] The upstreamness measures the strengthness and complexity of value chains that *input suppliers* face. It is defined as follows:

$$u_{(r,s)} = \frac{\tilde{f}_{(r,s)}}{x_{(r,s)}} + 2\frac{\sum_{r'}\sum_{s'}\tilde{a}_{(r,s),(r',s')}\tilde{f}_{(r',s')}}{x_{(r,s)}} + 3\frac{\sum_{r'}\sum_{s'}\sum_{r''}\sum_{s''}\tilde{a}_{(r,s),(r',s')}\tilde{a}_{(r',s'),(r'',s'')}\tilde{f}_{(r'',s'')}}{x_{(r,s)}} + \cdots$$

where $\tilde{f}_{(r,s)} = \sum_{s'}\tilde{f}_{(r,s),s'}$ and $\tilde{a}_{(r,s),(r',s')} = \tilde{m}_{(r,s),(r',s')}/x_{(r',s')}$ denotes 'input' coefficient (net of international imports). $\tilde{m}_{(r,s),(r',s')}$ and $\tilde{f}_{(r,s),s'}$ come from equations (3) and (4), respectively. The first term is final goods divided by the gross output produced by sector *s* of region *r*. The second term is sector *s* of region *r*'s intermediate goods used to produce $\sum_{r'}\sum_{s'}\tilde{f}_{(r',s')}$ divided by gross output in the same sector of the same region. Intermediate goods required to produce intermediate goods in the second term are considered in the third term. The sequence continues infinitely.

Using the inter-regional IO table, the upstreamness is computed as follows:

$$\mathbf{u} = \left(\mathbf{I} - \hat{\mathbf{x}}^{-1}\tilde{\mathbf{T}}\right)^{-1}\mathbf{i}$$

where $\hat{\mathbf{x}}$ is an $(R \times S) \times (R \times S)$ matrix including gross output $x_{(r,s)}$ as diagonal elements and zeros in other entries, and $\mathbf{i}$ is an $(R \times S) \times 1$ vector of ones. The resulted uptreamness $\mathbf{u}$ is an $(R \times S) \times 1$ vector, available at the sector-region level. We find sector *s*' upstreamness by taking weighted averages of each region's upstreamness of that sector where the weights are gross output.[18]

[17] These measures are used to quantify the strengthness and the complexity of global value chains (e.g., Antràs and Chor, 2018; Ito and Vézina, 2016).
[18] See Appendix C for the sectoral gross output shares in each region.

To measure the strengthness and complexity of value chains that *input buyers* face, we also compute the downstreamness, which is defined as follows:

$$d_{(r,s)} = \frac{v_{(r,s)}}{x_{(r,s)}} + 2\frac{\sum_{r'}\sum_{s'} v_{(r,s)}\tilde{b}_{(r,s),(r',s')}}{x_{(r,s)}} + 3\frac{\sum_{r'}\sum_{s'}\sum_{r''}\sum_{s''} v_{(r,s)}\tilde{b}_{(r,s),(r',s')}\tilde{b}_{(r',s'),(r'',s'')}}{x_{(r,s)}} + \cdots$$

where $v_{(r,s)}$ denotes value-added and $\tilde{b}_{(r,s),(r',s')} = \tilde{m}_{(r,s),(r',s')}/x_{(r,s)}$ denotes 'output' coefficients (net of international imports). While the upstreamness measures the share of 'intermediate goods *sold*' to gross output, the downstreamness measures the share of 'intermediate goods *purchased*' to gross output. In matrix notation, it is expressed as

$$\mathbf{d}' = \boldsymbol{i}'\hat{\mathbf{x}}\left(\mathbf{I} - \hat{\mathbf{x}}^{-1}\tilde{\mathbf{T}}\right)^{-1}\hat{\mathbf{x}}^{-1},$$

which is a $(R \times S) \times 1$ vector. The sector-region level downstreamness is aggregated to the sector level by taking weighted averages where the weights are gross output. As we use the data on inter-regional trade within Japan to measure upstreamness and downsreamness, these indices capture the relative position of the sector-region pair (*s, r*) within Japan, not taking the relative potion in global value chains into consideration.

Panel A of Figure 5 displays the computed upstreamness in the left chart and the downstreamness in the right chart. It shows sectoral differences in the time-series changes in these measures. In the heavy sectors, both the upstreamness and downstreamness were higher in 1960 and substantially decreased by 2005. In the light sectors, the upstreamness stayed almost constant throughout the 1960-2005 period while the downstreamness decreased from 2.5 to 2.0. These results suggest that domestic value chains are either shrinking or not expanding in these sectors.

The transport equipment sector is an exception as it experienced an almost continuous increase in the upstreamness during the 1960-2005 period. Although the downstreamness declined from 1960 to 1975, unlike other sectors, it increased between 1975 and 2005. These suggest that domestic value chains are expanding, especially after 1975 in this sector, which can be explained by the solid manufacturer-supplier relationships described in Asanuma (1989, 1992a, 1992b) and Aoki (1988).

Panel B of Figure 5 represents the relationship between the upstreamness/downstreamness and international outsourcing using the sample of the 12 manufacturing sectors. It shows correlations between changes in these measures from 1960 to 1990 at the top and from 1990 to 2005 at the bottom. These scatter plots show negative correlations between international outsourcing and upstreamness/downstreamness. In particular, the negative correlation is more apparent for the 1990-2005 sample for the downstreamness. These observations are consistent with our findings using the domestic outsourcing indices.

=== Insert Figure 5 here ===

3.3 Empirical comparative advantages and 'value chain journeys'

The previous measures – the outsourcing indices, upstreamness, and downstreamness – are useful for knowing the overall trends in domestic value chains. However, we have aggregated these measures at the sector level, making it difficult to see the trade patterns of each region. Therefore, this section employs measures that work well to examine inter-regional trade.

First, we compute a measure of Empirical Comparative Advantages (hereafter ECA)[19]:

$$ECA_{(r,s)} = \frac{EX_{(r,s)} - IM_{(r,s)}}{EX_{(r,s)} + IM_{(r,s)}}$$

where $EX_{(r,s)}$ denotes exports of sector *s*'s goods by region *r* and $IM_{(r,s)}$ denotes imports of sector *s*'s goods by region *r*. Therefore, the numerator is net exports. The denominator is the sum of exports and imports, making an ECA ranging from -1 to 1. A positive value means that (*r*, *s*) has a comparative advantage, and a negative value means a comparative *dis*advantage.

Applying this concept to the final goods flows of the IO table leads to the following measure of comparative advantages:

$$ECAF^{Gross}_{(r,s)} = \frac{\sum_{r' \neq r} \tilde{f}_{(r,s),r'} - \sum_{r' \neq r} \tilde{f}_{(r',s),\, r}}{\sum_{r' \neq r} \tilde{f}_{(r,s),r'} + \sum_{r' \neq r} \tilde{f}_{(r',s),\, r}}, \quad (5)$$

where $\sum_{r' \neq r} \tilde{f}_{(r,s),r'}$ denotes exports of sector *s*' final goods from region *r* to the rest of Japan, and $\sum_{r' \neq r} \tilde{f}_{(r',s),\, r}$ denotes imports of sector *s*' final goods from the rest of Japan to region *r*. Superscript *Gross* is added because we introduce the concept based on trade in value-added in the next section. Second, ECAs based on trade in intermediate goods are computed as follows:

[19] This measure is similar to the 'revealed comparative advantage' proposed by Balassa (1965) in spirit as it measures the region's comparative advantage based on observed trade flows. However, our ECA is different from his ECA. While the ECA of Balassa (1965) is constructed as the "country's exports from a sector relative to that country's overall exports" divided by that variable of the world. Our ECA is the same as Baldwin and Okubo (2019)'s ECA, and it is convenience because it ranges from zero to one.

$$ECAI_{(r,s)}^{Gross} = \frac{\sum_{r'\neq r}\sum_{s'}\widetilde{m}_{(r,s),(r',s')} - \sum_{r'\neq r}\sum_{s'}\widetilde{m}_{(r',s),\,(r,s')}}{\sum_{r'\neq r}\sum_{s'}\widetilde{m}_{(r,s),(r',s')} + \sum_{r'\neq r}\sum_{s'}\widetilde{m}_{(r',s),\,(r,s')}}$$

where $\sum_{r'\neq r}\sum_{s'}\widetilde{m}_{(r,s),(r',s')}$ denotes exports of sector *s*' intermediate goods from region *r* to the rest of Japan, and $\sum_{r'\neq r}\sum_{s'}\widetilde{m}_{(r',s),\,(r,s')}$ denotes imports of sector *s*' intermediate goods from the rest of Japan to region *r*. The same interpretation as $ECAF_{(r,s)}^{Gross}$ applies.

Following Baldwin and Okubo (2019), we plot $ECAF_{(r,s)}^{Gross}$ in the vertical axis and $ECAI_{(r,s)}^{Gross}$ in the horizontal axis, as shown in Figure 6, which they call a 'value chain journey' diagram. If an observation (*r*, *s*) is in the first quadrant of the figure, it means that (*r*, *s*) has comparative advantages in both final goods and intermediate goods. On the other hand, the third quadrant means that (*r*, *s*) has comparative disadvantages in both goods. Therefore, if observations are concentrated around the 45-degree line, roughly speaking, it implies that the production of final goods and intermediate goods are done in the same location, suggesting a shorter value chain.

On the other hand, if observations are off the 45-degree line and scattered in the second and fourth quadrants, production value chains are longer. An observation in the second quadrant implies that it has comparative advantages in final goods and comparative *dis*advantage in intermediate goods. It means that it buys more intermediate goods than it sells and sells more final goods than it buys, suggesting an assembler. In contrast, an observation in the fourth quadrant implies a comparative advantage in intermediate goods and a comparative *dis*advantage in final goods. It means that it sells more intermediate goods than buys more final goods than it sells, suggesting that it is an input supplier.

=== Insert Figure 6 here ===

Figure 7 presents the 'value chain journeys' diagrams for eleven manufacturing sectors.[20] The eleven sectors are classified into three based on the patterns of time-series evolutions of Periphery. Part I summarizes the sectors where Periphery moved from the fourth quadrant to the center, including (1) lumber and wooden products, (2) pulp, paper, and paper products, (3)

[20] Because we do not observe much inter-regional trade in petroleum and coals, we do not report the diagram for that sector.

ceramic, clay, and stone products, and (4) iron and steel.[21] Periphery had stronger comparative advantages in inputs and comparative *dis*advantage in final goods in these sectors in earlier periods. However, it gradually gained comparative advantages in final goods and lost its comparative advantages in inputs. This pattern suggests that, while Periphery was an input supplier in these sectors in the 1960s and the 1970s, it started producing both final goods and inputs, making domestic value chains shorter.

Part II of Figure 7 summarizes sectors where Periphery moved from the third quadrant to the center, including (1) metal products, (2) textiles and leather products, (3) machinery and electronics, and (4) precision machinery. Periphery had stronger comparative *dis*advantages in both final goods and inputs in the earlier periods in these sectors. However, it gained comparative advantages in both goods over time. Although it is difficult to relate these changes with the length of value chains, it shows that Periphery had developed its comparative advantages in these sectors, consistent with existing studies documenting the effects of Japan's infrastructure development, regional industrial subsidies, and cluster policies favoring Periphery (e.g., Fujita and Tabuchi, 1996; Okubo and Tomiura, 2012).

As the last category, Part II includes sectors where Periphery is not moving to the center, (1) food and kindred products, (2) chemicals, and (3) transport equipment. In the food sector, Periphery moved from the second quadrant to the first quadrant, meaning that it gained comparative advantages in inputs, keeping its comparative advantages in final goods at almost the same level during the sample period. On the other hand, the chemical sector follows an opposite pattern. Periphery lost its comparative advantage in inputs, keeping its comparative *dis*advantage at almost the same level during the sample period. These two patterns are similar because the Periphery moved near the 45-degree line, suggesting a shrink in domestic value chains.

Lastly, again, an exception is observed from the transport equipment sector. In almost all regions, the degree of comparative advantages and disadvantages stay relatively the same during the sample period compared with other sectors.[22] Western Core moved from the third quadrant to

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[21] The 'pulp, paper, and paper products' was in the first quadrant (instead of the fourth quadrant) in the year 1960. However, it moves to the fourth quadrant in 1970 and stays in that quadrant till 2000. Therefore, we classify this sector in this group.

[22] Central Core keeps its comparative advantages and Periphery also keeps its comparative disadvantages. Eastern Core moves from the first quadrant to the third quadrant, losing its comparative advantages in both final goods and inputs.

the fourth quadrant, gaining its comparative advantages in inputs, keeping its comparative *dis*advantages in final goods at almost the same level, potentially contributing to make domestic value chains longer for this sector.

=== Insert Figure 7 here ===

3.4 Gross trade and value-added trade

The last sub-section estimates regional trade in value-added contents following the international trade literature (e.g., Johnson and Noguera, 2012; Johnson, 2018). We then examine how regional comparative advantages differ between value-added and gross trade. We compute ECAs based on value-added trade using the following formula:

$$ECAF_{(r,s)}^{VA} = \frac{vax_{(r,s)|(\forall r',s),(\forall r' \neq r)} - \sum_{r' \neq r} vax_{(r',s)|(\forall r',s),(r)}}{vax_{(r,s)|(\forall r',s),(\forall r' \neq r)} + \sum_{r' \neq r} vax_{(r',s)|(\forall r',s),(r)}}, \quad (6)$$

where $vax_{(r,s)|(\forall r',s),(\forall r' \neq r)}$ denotes region *r*'s exports of sector *s*' value-added embedded in sector *s*' final goods exported from all regions to regions than region r.[23] $\sum_{r' \neq r} vax_{(r',s)|(\forall r',s),(r)}$ denotes region *r*'s imports of sector *s*'s value-added embedded in region *r*'s consumption of sector *s*'s final goods.[24] We employ the approach used by Timmer et al. (2013, 2014) and Los et al. (2015b).[25] See Appendix D for more details on estimates of value-added trade.

To examine how ECAs based on gross trade differ from ECAs based on value-added trade, in Figure 8, $ECAF_{(r,s)}^{Gross}$ (equation 5) and $ECAF_{(r,s)}^{VA}$ (equation 6) are plotted on the same chart for each of the three broad sectors. It shows that, in the light sectors of Periphery, $ECAF^{Gross}$ suggest weaker comparative advantages than $ECAF^{VA}$, suggesting that more inputs produced elsewhere are included in Periphery's final goods exports.[26] In the heavy sectors,

[23] $(\forall r', s)$ of $vax_{(r,s)|(\forall r',s),(\forall r' \neq r)}$ indicates that it is exported from sector *s* of either region of all regions $(\forall r')$. $(\forall r' \neq r)$ indicates that it is imported by either region other than itself *r*.
[24] $vax_{(r',s)|(\forall r',s),(r)}$ indicates region *r*'s imports of sector *s*' value-added embedded in sector *s*' final goods exported from region r' to region *r*. $(\forall r', s)$ indicates that it is exported from sector *s* of either region of all regions $(\forall r')$. (r) indicates that it is imported by region *r*.
[25] This approach is called the 'global value chain income' by Johnson (2018).
[26] A weaker comparative advantage in Periphery's light sectors comes trade deficit in inputs in textiles. In addition, although the ECA measured by inputs is rising in Periphery's food sector, value-added trade still implies a weaker comparative advantage than gross trade because more inputs from Western Core are circulated through value chains than inputs from Periphery. See Appendix E for ECAs based on gross trade and value-added trade for separate eleven manufacturing sectors.

Periphery experienced a greater increase in $ECAF^{VA}$ than $ECAF^{Gross}$, which is consistent with a substantial rise in ECAs in inputs in the 'metal products' sector, the 'machinery and electronics' sector, and the 'precision machinery' sector.

The gaps between $ECAF_{(r,s)}^{Gross}$ and $ECAF_{(r,s)}^{VA}$ in the transport equipment sector are consistent with the 'value chain journey' diagram in Part III of Figure 7. A smaller ECA in value-added than in gross trade in Periphery is consistent with a negative ECA in inputs of that region. A greater ECA in value-added than gross trade in Central Core in 2000 and 2005 is consistent with a positive ECA in inputs in these years in that region (a similar pattern is observed from Western Core as well).

=== Insert Figure 8 here ===

4. Conclusions

We have examined the long-run evolutions of Japan's domestic value chains using the inter-regional IO table during the 1960-2005 period. Our analysis has shown that Japan's domestic value chains had expanded during the first half of the focused period and shrunk during the last half of the period. While most manufacturing sectors follow similar time-series patterns, the transport equipment sector is found to be exceptional as it has been continuously expanding its domestic value chains. This sectoral heterogeneity seems to be related to different patterns of integration of Japan into global value chains since the 1990s.

Our analysis has also shown long-run changes in regional production structure indicated by gross regional trade and value-added regional trade. We have found that Periphery has continuously increased its comparative advantages in all sectors except the transport equipment sector. Each region's comparative advantages remain almost constant for the transport equipment sector, another evidence of the uniqueness of that sector. The continuous expansion of domestic value chains in the sector may come from relation-specific transactions between manufacturers and input suppliers, as described in Asanuma (1989, 1992a, 1992b) and Aoki (1988).

Our paper is the first to show Japan's domestic value chains and regional production structures through the lens of regional trade for the long-run period from 1960 to 2005. The analysis conducted in this paper has provided us with new insights into these changes and the interactions between internal and global value chains.

References

[1]. Albrecht, Lukas, and Trevor Tombe (2016) "Internal trade, productivity and interconnected industries: a quantitative analysis." *Canadian Journal of Economics*, 49(1): 237-263.

[2]. Ando, Mitsuyo and Fukunari Kimura (2005) "The formation of international production and distribution networks in East Asia." In: *International Trade in East Asia, NBER-East Asia Seminar on Economics*, Vol. 14, edited by T. Ito and A. K. Rose, University of Chicago Press.

[3]. Antràs, Pol and Davin Chor (2018) "On the measurement of upstreamness and downstreamness in global value chains." In: *World Trade Evolution Growth, Productivity and Employment*, edited by Lili Yan Ing and Miaojie Yu, Routledge: London.

[4]. Aoki, Masahiko (1988) *Information, Incentives and Bargaining in the Japanese Economy*, Cambridge University Press: Cambridge.

[5]. Arai, Sonoe and Masayuki Ogata (2007) "An overview of an estimate of the inter-regional input-output table of the year 2000 (Heisei 12 nen shisan chiikikan sangyō renkan hyō no gaiyō)." Available at https://www.meti.go.jp/statistics/tyo/tiikiio/result/result_s1.html. (Written in Japanese)

[6]. Arai, Sonoe and Young Gak Kim (2017) "Estimating and evaluating headquarter services trade across regions (Chiiki wo matagu honshā sābisu tonyū no suikei to eikyō hyōka)." RIETI Discussion Paper 17-J-013. (Written in Japanese)

[7]. Asanuma, Banri (1989) "Manufacturer-supplier relationships in Japan and the concept of relation-specific skill." *Journal of the Japanese and International Economies*, 3(1): 1-30.

[8]. Asanuma, Banri (1992a) "Risk absorption in Japanese subcontracting: a microeconometric study of the automobile industry." *Journal of the Japanese and International Economies*, 6(1): 1-29.

[9]. Asanuma, Banri (1992b) "Japan's manufacturer-supplier relationships in the global economy (Kokusai teki tenbou no naka de mita nihon no mēkā to sapuraiyā tono kankei)" *The Journal of the Kyoto University Economic Society* (*Keizai Ronsō*), 149(4, 5, 6): 214-254.

[10]. Balassa, Bela (1965) "Trade liberalisation and "revealed" comparative advantage." *The Manchester School*, 33(2): 99-123.

[11]. Baldwin, Richard (2016) *The Great Convergence: Information Technology and the New Globalization*, Harvard University Press.

[12]. Baldwin, Richard, and Toshihiro Okubo (2019) “GVC journeys: industrialisation and deindustrialisation in the age of the second unbundling.” *Journal of the Japanese and International Economies,* 52(June): 53-67.

[13]. Eppinger, Peter, Gabriel J. Felbermayr, Oliver Krebs, and Bohdan Kukharskyy (2021) “Decoupling global value chains.” CESifo Working Paper No. 9079.

[14]. Feenstra, Robert C. and Gordon H. Hanson (1996) “Globalization, outsourcing, and wage inequality.” *American Economic Review Papers and Proceedings*, 86(2): 240-245.

[15]. Feenstra, Robert C. and Gordon H. Hanson (1999) “The impact of outsourcing and high-technology capital on wages: estimates for the United States, 1979–1990.” *Quarterly Journal of Economics*, 114(3): 907-940.

[16]. Forslid, Rikard and Ian Wooton (2003) “Comparative advantage and the location of production.” *Review of International Economics*, 11(4): 588-603.

[17]. Fujita, Masahisa and Takatoshi Tabuchi (1997) “Regional growth in postwar Japan.” *Regional Science and Urban Economics*, 27(6): 643-670.

[18]. Fukao, Kyoji (1996) “Domestic relocation or oversea relocation? an empirical analysis on location choices by Japanese manufacturers (Kokunai ka kaigaika? Wagakuni seizougyo no ricchi sentaku ni kansuru jisshō bunseki).” *The Journal of Japan Economic Research* (*Nihon Keizai Kenkyū*), 47(1): 47-63. (Written in Japanese)

[19]. Fukao, Kyoji and Ximing Yue (Kimei Gaku) (1997) “Location choices of electronics firms (Denki mēkā no ricchi sentaku).” *Mita Journal of Economics* (*Mita Gakkai Zasshi*), 90(2): 209-237. (Written in Japanese)

[20]. Hummels, David, Jun Ishii, and Kei-Mu Yi (2001) “The nature and growth of vertical specialization in world trade.” *Journal of International Economics*, 54(1): 75-96.

[21]. Ito, Tadashi, and Pierre-Louis Vézina (2016) “Production fragmentation, upstreamness, and value added: evidence from Factory Asia 1990–2005.” *Journal of the Japanese and International Economies,* 42(December): 1-9.

[22]. Johnson, Robert C., and Guillermo Noguera (2012) “Accounting for intermediates: production sharing and trade in value added.” *Journal of International Economics*, 86(2): 224-236.

[23]. Johnson, Robert C. (2018) “Measuring global value chains.” *Annual Review of Economics*, 10: 207-236.

[24]. Kimura, Fukunari and Mitsuyo Ando (2003) “Fragmentation and agglomeration matter: Japanese multinationals in Latin America and East Asia.” *North American Journal of Economics and Finance*, 14(3): 287-317.

[25]. Kimura, Fukunari and Mitsuyo Ando (2005) “Two-dimensional fragmentation in East Asia: conceptual framework and empirics.” *International Review of Economics and Finance*, 14(3): 317-348.

[26]. Kiyota, Kozo (2021) “Spatially uneven pace of deindustrialization within a country.” Unpublished manuscript, Keio University.

[27]. Krugman, Paul, and Raul Livas Elizondo (1996) “Trade policy and the third world metropolis.” *Journal of Development Economics*, 49(1): 137-150.

[28]. McCallum, John (1995) “National borders matter: Canada-U.S. regional trade patterns.” *American Economic Review*, 85(3): 615-623.

[29]. Miller, Ronald E., and Umed Temurshoev (2017) “Output upstreamness and input downstreamness of industries/countries in world production.” *International Regional Science Review*, 40(5): 443-475.

[30]. Okubo, Toshihiro (2004) “The border effect in the Japanese market: a gravity model analysis.” *Journal of the Japanese and International Economies*, 18(1): 1-11.

[31]. Okubo, Toshihiro, and Eiichi Tomiura (2012) “Industrial relocation policy, productivity and heterogeneous plants: evidence from Japan.” *Regional Science and Urban Economics*, 42(1-2): 230-239.

[32]. Los, Bart, Marcel P. Timmer, and Gaaitzen J. de Vries (2015a) “How important are exports for job growth in China? a demand side analysis.” *Journal of Comparative Economics*, 43(1): 19-32.

[33]. Los, Bart, Marcel P. Timmer, and Gaaitzen J. de Vries (2015b) “How global are global value chains? a new approach to measure fragmentation.” *Journal of Regional Science*, 55(1): 66-92.

[34]. Ramondo, Natalia, Andrés Rodríguez-Clare, and Milagro Saborío-Rodríguez (2016) “Trade, domestic frictions, and scale effects.” *American Economic Review*, 106(10): 3159-3184.

[35]. Timmer, Marcel P., Bart Los, Robert Stehrer, and Gaaitzen J. de Vries (2013) "Fragmentation, incomes, and jobs: an analysis of European competitiveness." *Economic Policy*, 28(76): 613-661.

[36]. Timmer, Marcel P., Abdul Azeez Erumban, Bart Los, Robert Stehrer, and Gaaitzen J. de Vries (2014) "Slicing up global value chains." *Journal of Economic Perspectives*, 28(2): 99-118.

[37]. Tomiura, Eiichi (2003) "Changing economic geography and vertical linkages in Japan." *Journal of the Japanese and International Economies*, 17(4): 561-581.

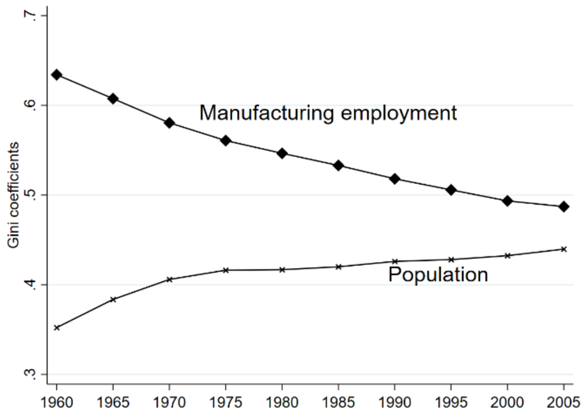
[38]. Tomiura, Eiichi (2009) "Foreign versus domestic outsourcing: firm-level evidence on the role of technology." *International Review of Economics & Finance*, 18(2): 219-226.

[39]. Yue, Ximing (Gaku, Kimei) (2000) "The determinants of manufacturing plants' location choices: an empirical analysis on Japan's inter-regional relocations (Kojyō ricchi sentaku no kettei yōin: nihon ni okeru chiikikan no jisshō kenkyū)." *The Journal of Japan Economic Research* (*Nihon Keizai Kenkyū*), 41: 92-109. (Written in Japanese)

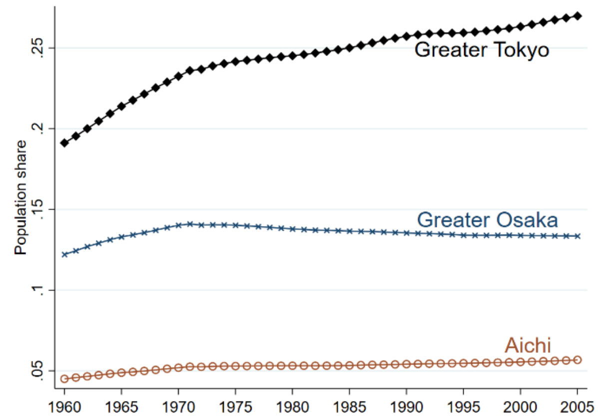
Tables and figures

Figure 1: Gini coefficients of population and manufacturing employment

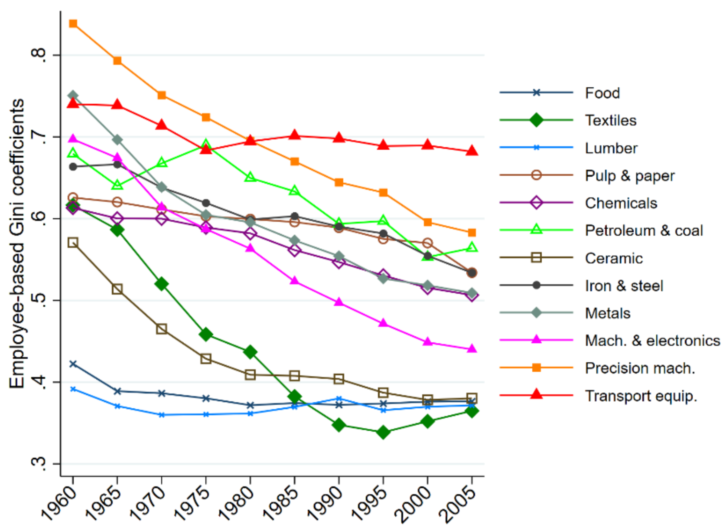
Panel A: Gini coefficients



Panel B: Urban population share



Panel C: Gini coefficients based on manufacturing employment by sectors



Note: The population data come from the Statistics Bureau of Japan, Ministry of Internal Affairs and Communications. The manufacturing employment data come from the Census of Manufacture (Kogyo Toukei Chosa) of the METI. The Gini coefficients are based on the prefecture-level data. Okinawa is not included in the Gini coefficients before 1975, but it is included in 1975-2005.

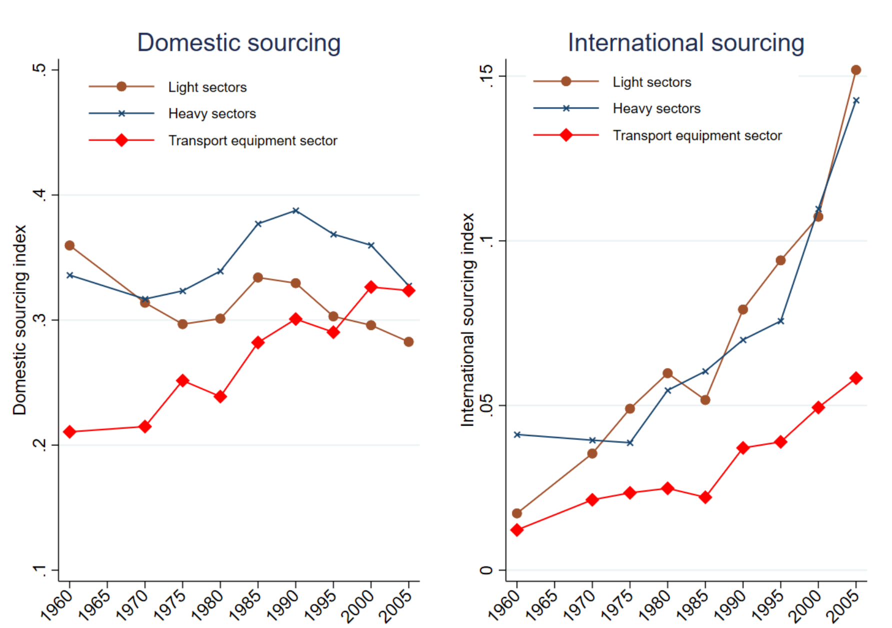
Figure 2: Structure of the inter-regional IO table, the 3-region 2-sector case

		Region 1		Region 2		Region 3						
		A	B	A	B	A	B	Region 1	Region 2	Region 3	IM	Ex
Region 1	Sector A	$m_{(1, A), (1, A)}$	$m_{(1, A), (1, B)}$	$m_{(1, A), (2, A)}$	$m_{(1, A), (2, B)}$	$m_{(1, A), (3, A)}$	$m_{(1, A), (3, B)}$	$f_{(1, A), (1)}$	$f_{(1, A), (2)}$	$f_{(1, A), (3)}$	$-im_{(1, A)}$	$ex_{(1, A)}$
	Sector B	$m_{(1, B), (1, A)}$	$m_{(1, B), (1, B)}$	$m_{(1, B), (2, A)}$	$m_{(1, B), (2, B)}$	$m_{(1, B), (3, A)}$	$m_{(1, B), (3, B)}$	$f_{(1, B), (1)}$	$f_{(1, B), (2)}$	$f_{(1, B), (3)}$	$-im_{(1, B)}$	$ex_{(1, B)}$
Region 2	Sector A	$m_{(2, A), (1, A)}$	$m_{(2, A), (1, B)}$	$m_{(2, A), (2, A)}$	$m_{(2, A), (2, B)}$	$m_{(2, A), (3, A)}$	$m_{(2, A), (3, B)}$	$f_{(2, A), (1)}$	$f_{(2, A), (2)}$	$f_{(2, A), (3)}$	$-im_{(2, A)}$	$ex_{(2, A)}$
	Sector B	$m_{(2, B), (1, A)}$	$m_{(2, B), (1, B)}$	$m_{(2, B), (2, A)}$	$m_{(2, B), (2, B)}$	$m_{(2, B), (3, A)}$	$m_{(2, B), (3, B)}$	$f_{(2, B), (1)}$	$f_{(2, B), (2)}$	$f_{(2, B), (3)}$	$-im_{(2, B)}$	$ex_{(2, B)}$
Region 3	Sector A	$m_{(3, A), (1, A)}$	$m_{(3, A), (1, B)}$	$m_{(3, A), (2, A)}$	$m_{(3, A), (2, B)}$	$m_{(3, A), (3, A)}$	$m_{(3, A), (3, B)}$	$f_{(3, A), (1)}$	$f_{(3, A), (2)}$	$f_{(3, A), (3)}$	$-im_{(3, A)}$	$ex_{(3, A)}$
	Sector B	$m_{(3, B), (1, A)}$	$m_{(3, B), (1, B)}$	$m_{(3, B), (2, A)}$	$m_{(3, B), (2, B)}$	$m_{(3, B), (3, A)}$	$m_{(3, B), (3, B)}$	$f_{(3, B), (1)}$	$f_{(3, B), (2)}$	$f_{(3, B), (3)}$	$-im_{(3, B)}$	$ex_{(3, B)}$
		$x_{(1, A)}$	$x_{(1, B)}$	$x_{(2, A)}$	$x_{(2, B)}$	$x_{(3, A)}$	$x_{(3, B)}$					
		$v_{(1, A)}$	$v_{(1, B)}$	$v_{(2, A)}$	$v_{(2, B)}$	$v_{(3, A)}$	$v_{(3, B)}$					

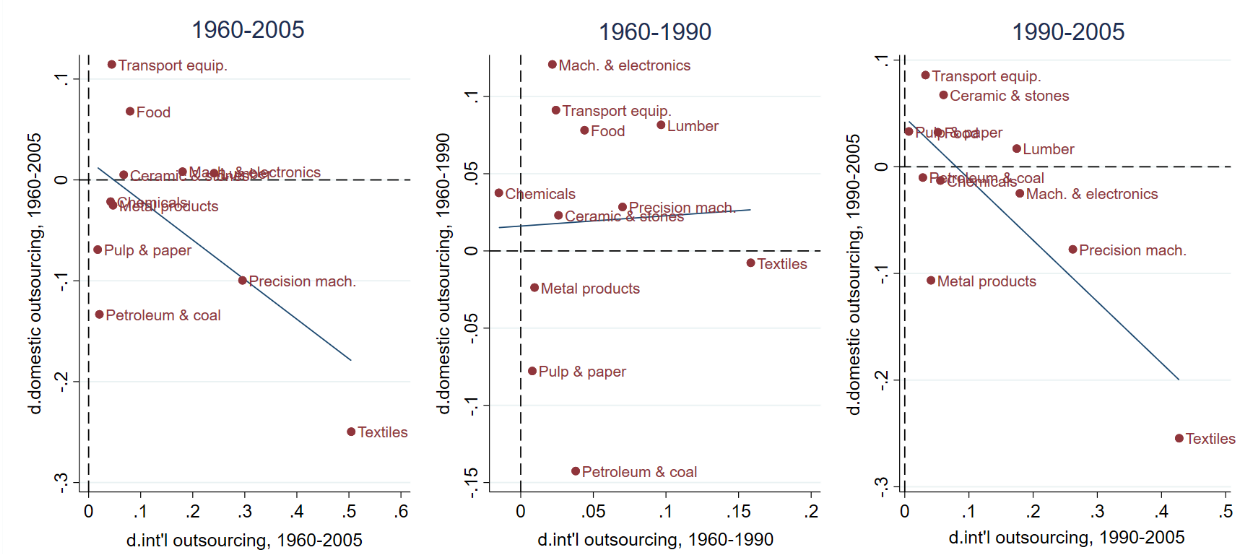
Note: Authors' description based on Japan's inter-regional IO table from METI.

Figure 3: Domestic and international outsourcing indices

Panel A: Outsourcing indices of three broad manufacturing sectors



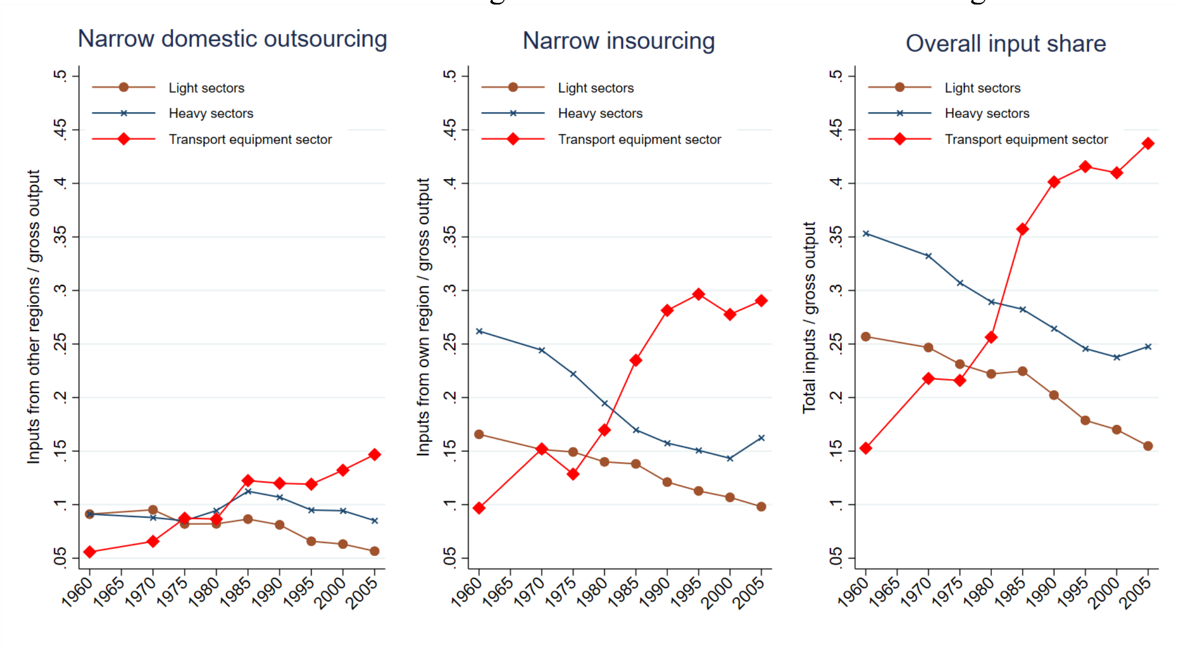
Panel B: Changes in domestic and international outsourcing indices



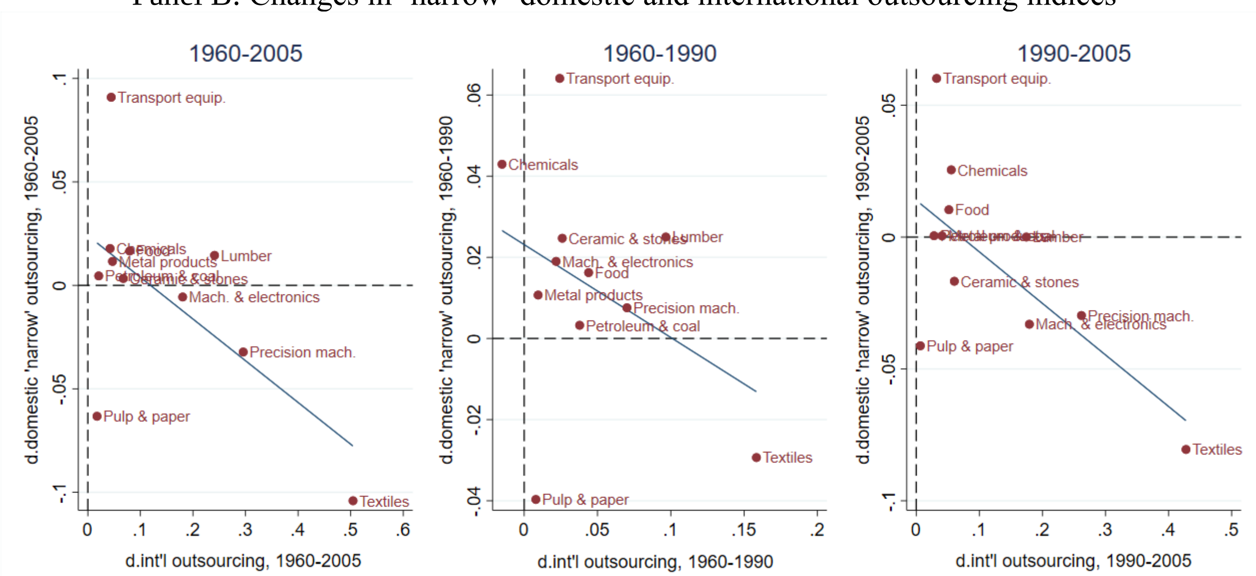
Note: Authors' estimation based on the inter-regional IO table from METI. The sector-region level indices are aggregated to the sector level by taking weighted average where weights are input usage.

Figure 4: ‘Narrow’ domestic and international outsourcing indices

Panel A: ‘Narrow’ outsourcing indices of three broad manufacturing sectors



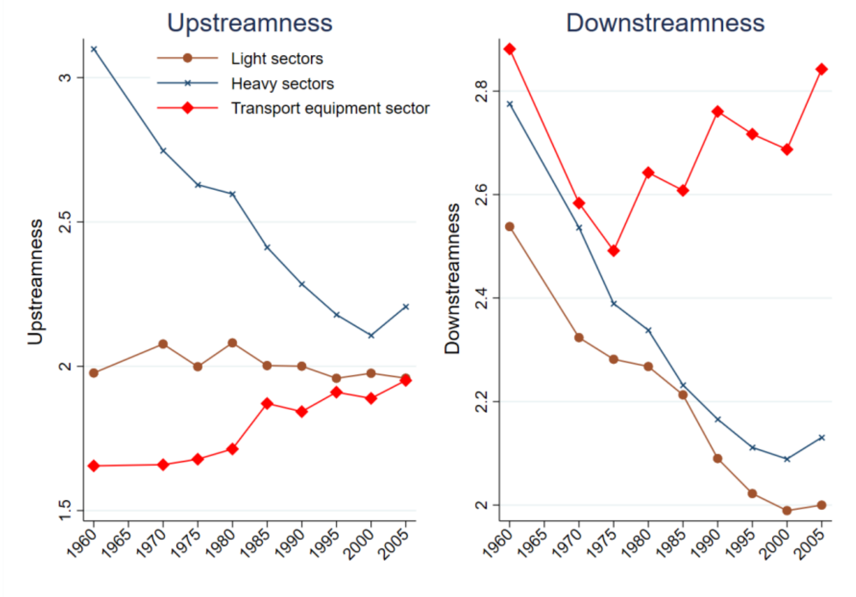
Panel B: Changes in ‘narrow’ domestic and international outsourcing indices



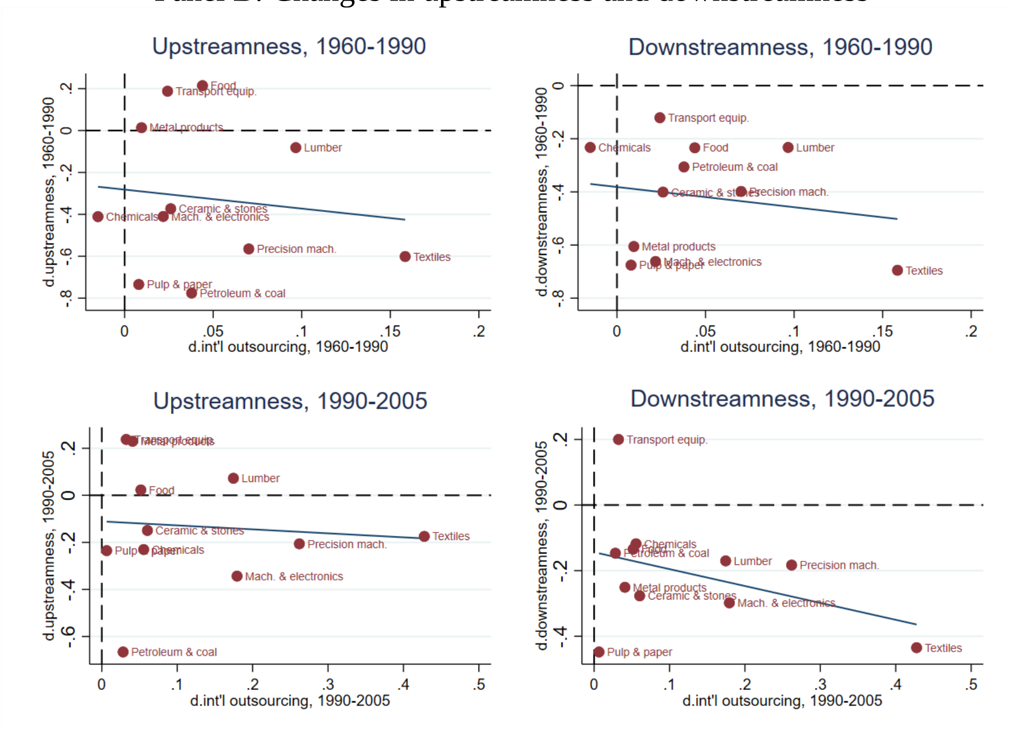
Note: Authors’ estimation based on the inter-regional IO table from METI. The sector-region level indices are aggregated to the sector level by taking weighted average where weights are input usage.

Figure 5: Upstreamness and downstreamness

Panel A: Upstreamness and downstreamness of three broad manufacturing sectors

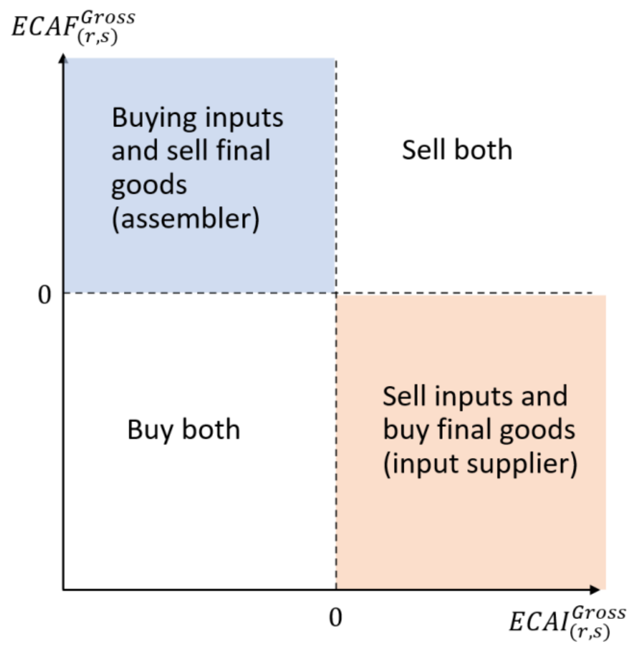


Panel B: Changes in upstreamness and downstreamness



Note: Authors' estimation based on the inter-regional IO table from METI. The sector-region level indices are aggregated to the sector level by taking a weighted average where weights are input usage. Note that these indices measure the upsreamness and downstreamness within Japan, not taking the positions in global value chains into consideration.

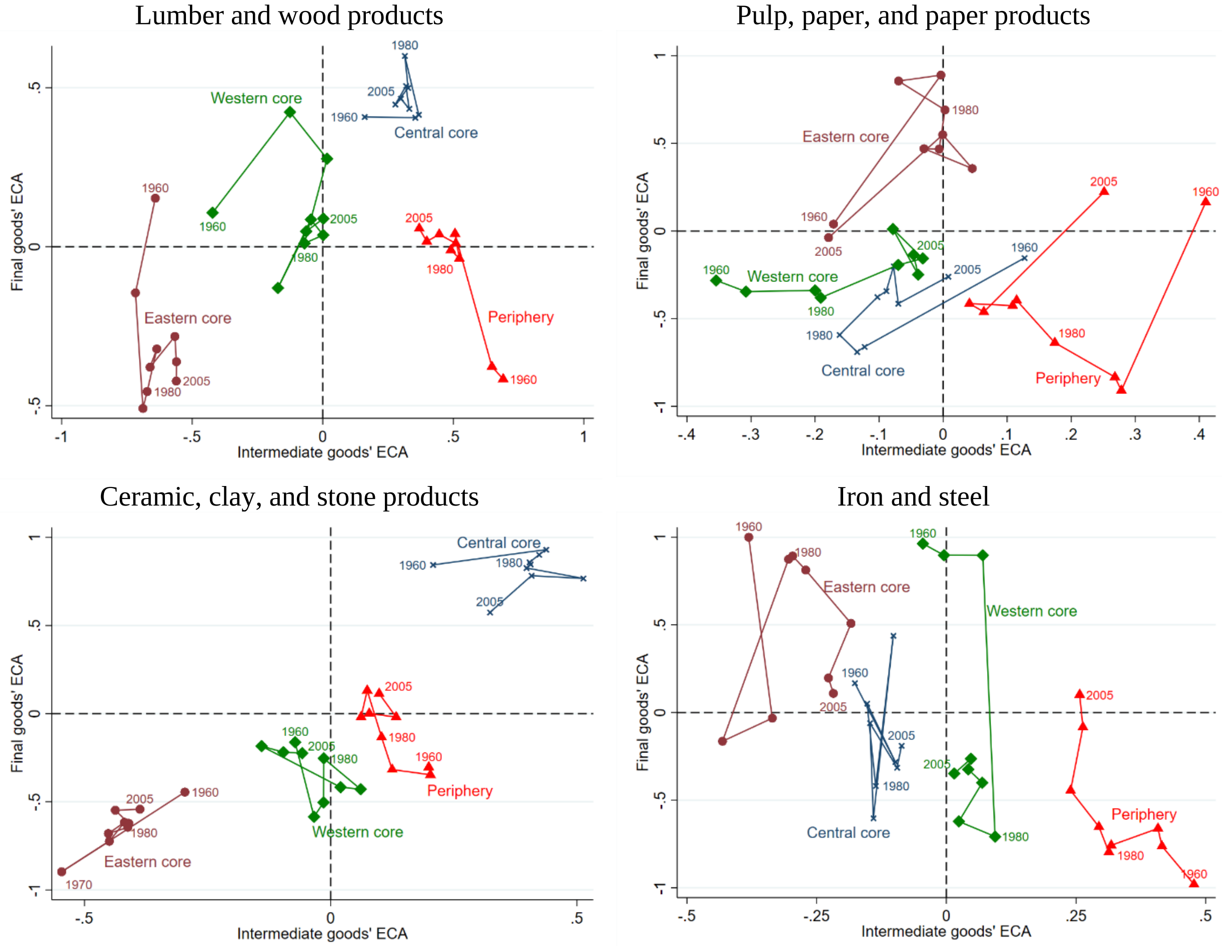
Figure 6: Conceptual framework of the 'value chain journey' diagram



Note: Authors' illustration. The original idea of the diagram comes from Baldwin and Okubo (2019).

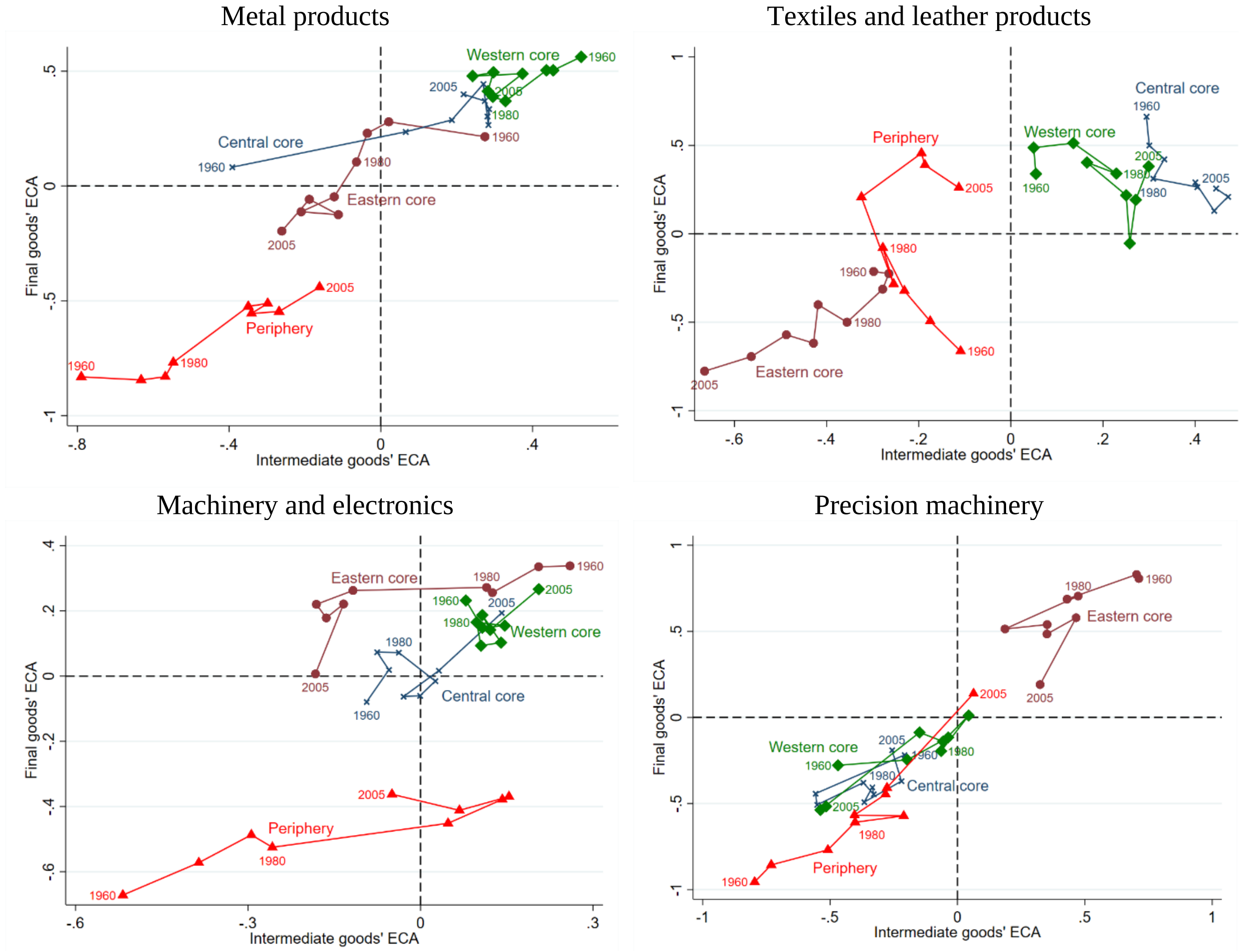
Figure 7: ‘Value chain journey’ diagrams

Part I: Periphery moving from the fourth quadrant to the center



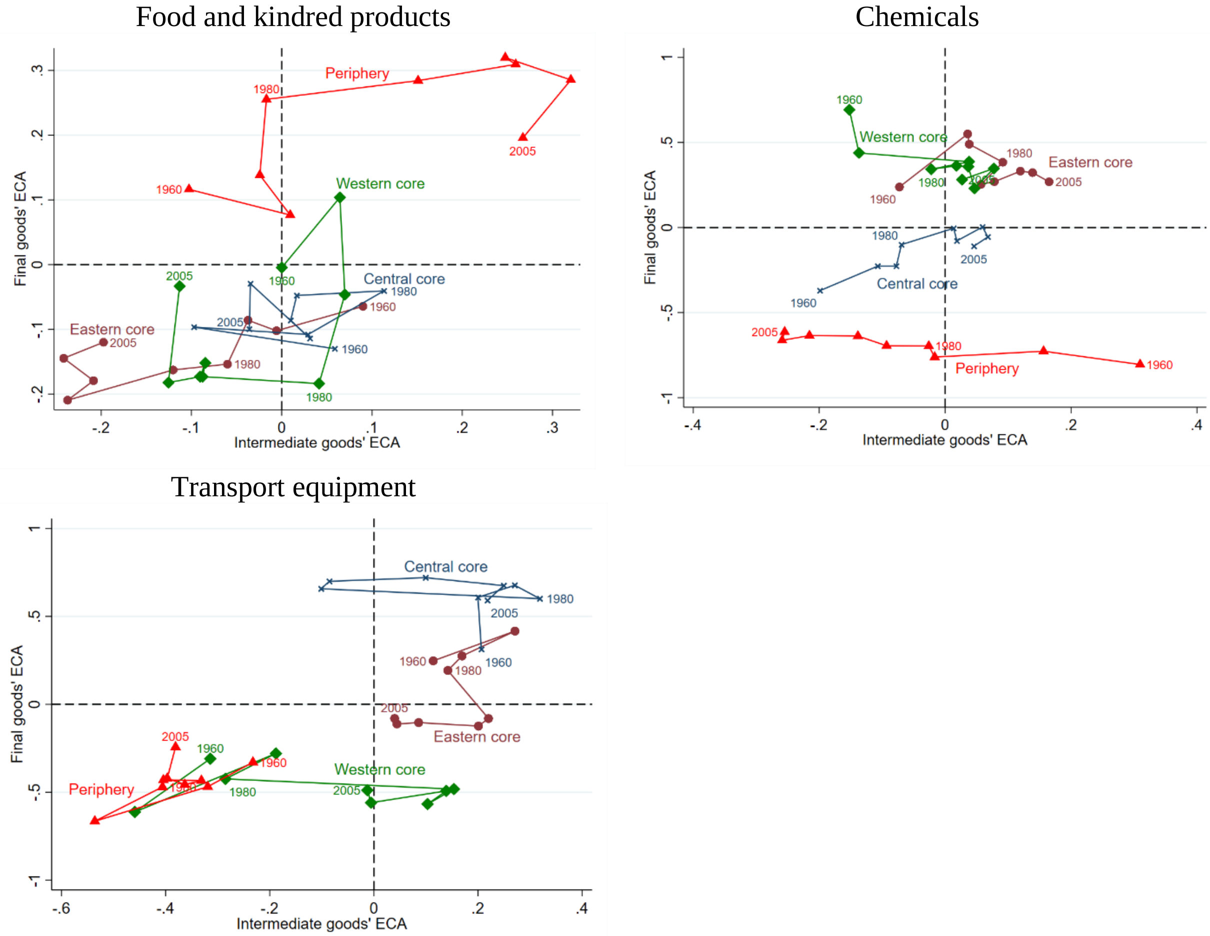
Note: Authors’ estimation based on the inter-regional IO table from METI.

Part II: Periphery moving from the third quadrant to the center



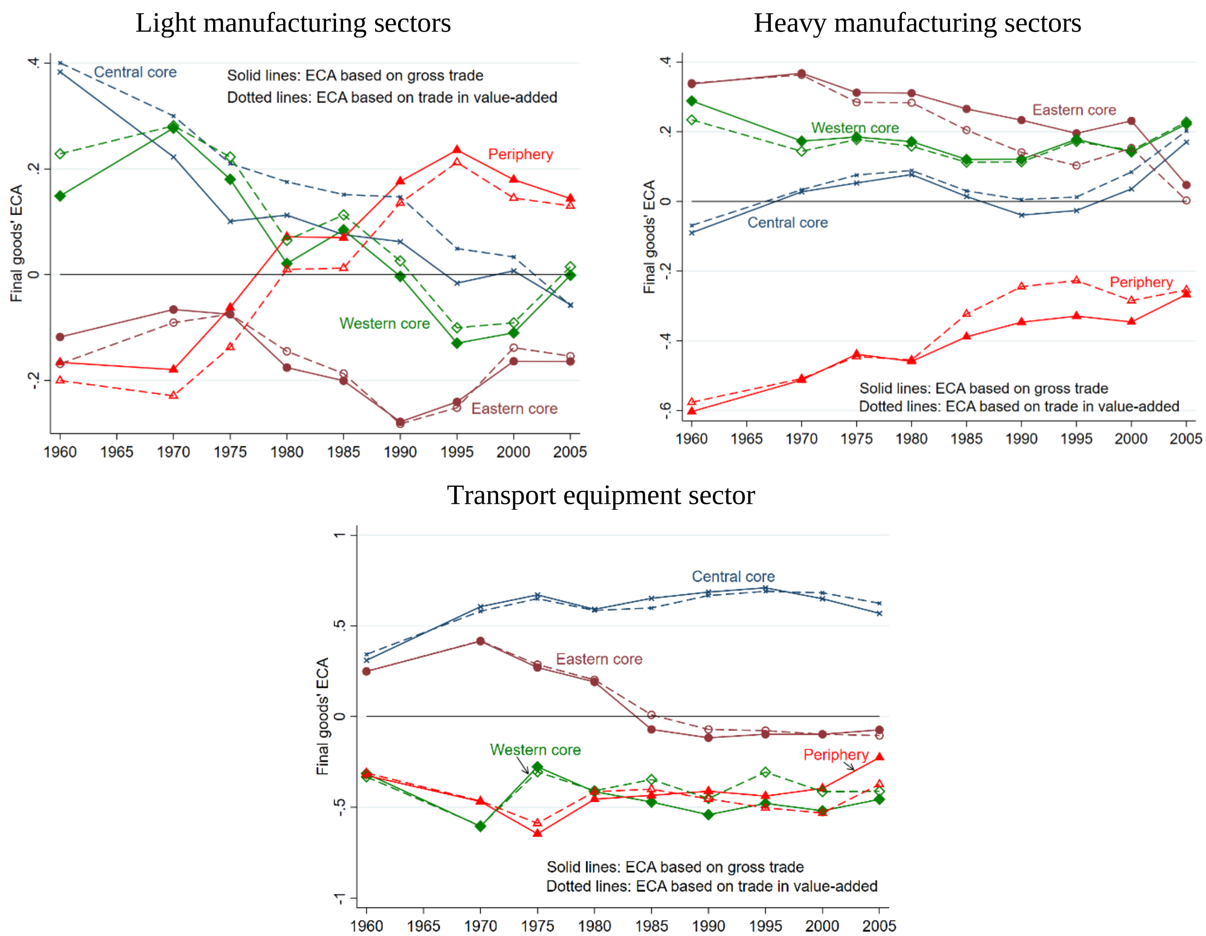
Note: Authors' estimation based on the inter-regional IO table from METI.

Part III: Periphery not moving to the center



Note: Authors' estimation based on the inter-regional IO table from METI.

Figure 8: Empirical comparative advantage measured by gross trade and value-added trade in final goods



Note: Authors' estimation based on the inter-regional IO table from METI.

Online Appendix for “A long-run transition of Japan’s domestic value chains”

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Keio University

April 2022

Appendix A. Inter-regional input-output table

Table A.1 shows regional disaggregation in each original IO table. The IO table from 1960 and 1970 does not include Okinawa, while those from 1975 to 2005 include the region. Therefore, to make our analysis consistent throughout the sample period, Okinawa is entirely omitted from our analysis. In addition, Chubu is disaggregated into Tokai and Hokuriku only in the IO table from 1960 and 1970. Therefore, these are aggregated as one region to make our analysis consistent throughout the sample period.

Table A.1 Regions in the IO table

	1960	1970	1975	1980	…	2005
1	Hokkaido	Hokkaido	Hokkaido	Hokkaido	…	Hokkaido
2	Tohoku	Tohoku	Tohoku	Tohoku	…	Tohoku
3	Kanto	Kanto	Kanto	Kanto	…	Kanto
4	Tokai	Tokai	Cubu	Cubu	…	Cubu
	Hokuriku	Hokuriku				
5	Kinki	Kinki	Kinki	Kinki	…	Kinki
6	Chugoku	Chugoku	Chugoku	Chugoku	…	Chugoku
7	Shikoku	Shikoku	Shikoku	Shikoku	…	Shikoku
8	Kyushu	Kyushu	Kyushu	Kyushu	…	Kyushu
			Okinawa	Okinawa	…	Okinawa

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Appendix B. Inter-regional input-output table

Table A.2 shows the 21 sectors consistently included in the IO table throughout the sample period. The shaded sectors are the 12 manufacturing sectors we focus. As indicated, in some figures, (3) food, (4) textiles, and (5) lumber are categorized as 'light sectors.' In addition, (6) chemicals, (7) petroleum and coal, (8) ceramic, clay, and stone products, (9) iron and steel products, (10) metal products, (11) machinery and electronics, and (12) precision machinery are categorized as 'heavy sectors'.

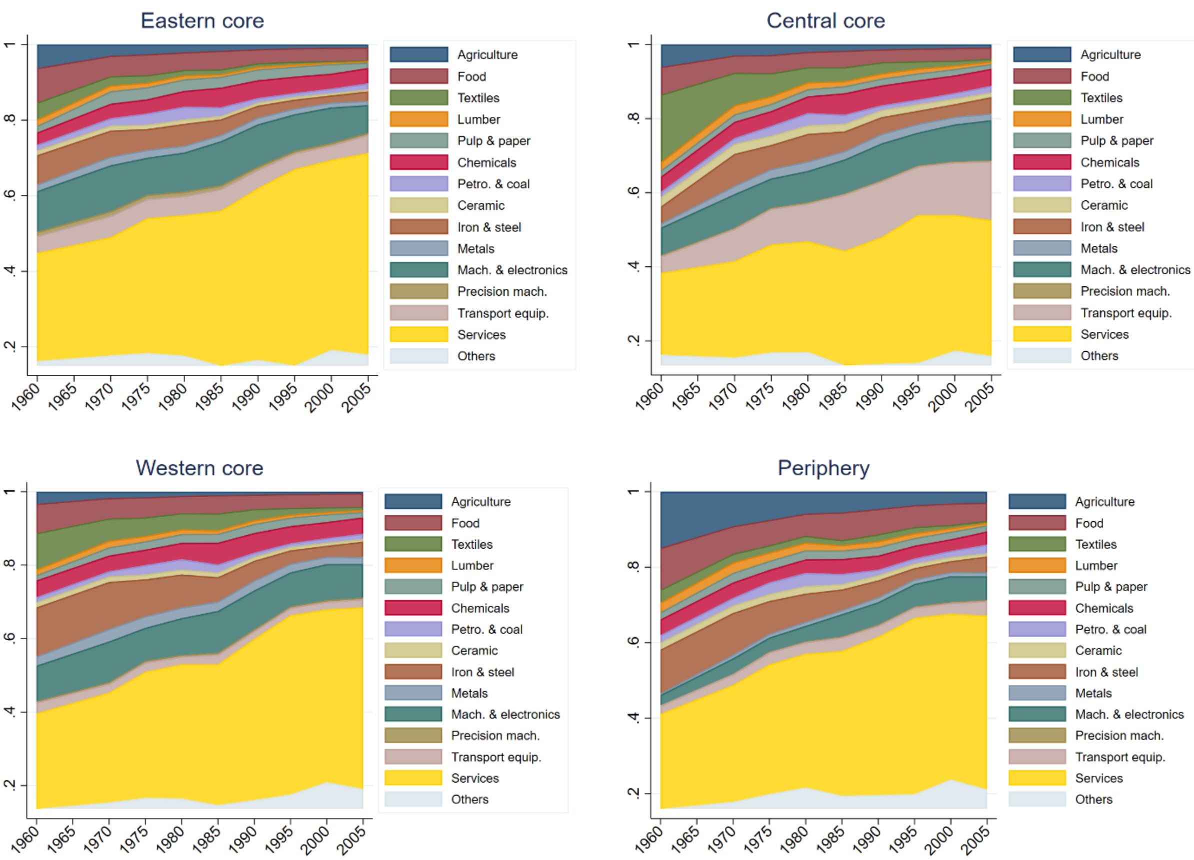
Table A.2 Sectors in the IO table

1	Agriculture, forestry, and fisheries	
2	Coal and mining	
3	Food	Light sectors
4	Textiles	
5	Lumber	
6	Pulp & paper	
7	Chemicals	Heavy sectors
8	Petroleum & coal	
9	Ceramic, clay & stones	
10	Iron & steel	
11	Metal products	
12	Machinery & electronics	
13	Precision machinery	
14	Transport equipment	
15	Miscellaneaous maunfacturing	
16	Construction	
17	Utility	
18	Wholesale and retail trade	
19	Finance, real estate, and other services	
20	Transportation and warehousing	
21	Unallocated	

Appendix C. Sectoral shares in gross output

Some sector-region level observations are aggregated at the sector level by taking weighted averages. The weights are gross output for the upstreamness and the downstreamness. Therefore, to overview regional differences in sectoral gross output shares, this section shows area charts of gross output from the four aggregated regions, Eastern Core, Central Core, Wester Core, and Periphery. The sectoral aggregations are done using more disaggregated output from the eight regions.

Figure A.1 Sectoral gross output shares



Note: Authors' estimation based on the inter-regional IO table from METI.

Appendix D. Estimating value-added contents

Export-side: To estimate inter-regional trade in value-added contents, we employ the approach used by Timmer et al. (2013, 2014) and Los et al. (2015b). We use the three-region (regions 1, 2, and 3) and two-sector (sectors A and B) case to simplify equations. Value-added contents embodied in region 1's (direct and indirect) exports of sector A's final goods sold to elsewhere, $vax_{(1,A)|(\forall r,A),(\forall r\neq 1)}$, are estimated using the following equation:

$$\begin{bmatrix} vax_{(1,A)|(\forall r,A),(\forall r\neq 1)} \\ vax_{(1,B)|(\forall r,A),(\forall r\neq 1)} \\ vax_{(2,A)|(\forall r,A),(\forall r\neq 1)} \\ vax_{(2,B)|(\forall r,A),(\forall r\neq 1)} \\ vax_{(3,A)|(\forall r,A),(\forall r\neq 1)} \\ vax_{(3,B)|(\forall r,A),(\forall r\neq 1)} \end{bmatrix} = \hat{\mathbf{v}}(\mathbf{I}-\widetilde{\mathbf{T}})^{-1} \begin{bmatrix} \sum_{r'\neq 1} \tilde{f}_{(1,A),r'} \\ 0 \\ \sum_{r'\neq 1} \tilde{f}_{(2,A),r'} \\ 0 \\ \sum_{r'\neq 1} \tilde{f}_{(3,A),r'} \\ 0 \end{bmatrix},$$

where $\hat{\mathbf{v}}$ denotes a $(2\times 3)\times(2\times 3)$ matrix, including the 'value-added to gross output' ratio in the diagonal entries and zeros in the other entries. The last term of the right-hand side includes sector A's final goods purchased by all regions other than region 1.

Regarding the notation $vax_{(1,A)|(\forall r,A),(\forall r\neq 1)}$, subscript $(1, A)$ means that it is value-added exports from region 1's sector A. Subscript $(\forall r, A)$ means that value-added is embodied in gross exports from sector A of either one region or all regions. Subscript $(\forall r \neq 1)$ means that those gross exports are purchased by either region of all regions except region 1. Although value-added contents available at the region-sector level, we use $vax_{(1,A)|(\forall r,A),(\forall r\neq 1)}$ only. To clarify how other observations of value-added exports are estimated, the following equation describes how value-added contents embodied in region 2's (direct and indirect) exports of sector B's final goods sold elsewhere, $vax_{(2,B)|(\forall r,B),(\forall r\neq 2)}$, are estimated.

$$\begin{bmatrix} vax_{(1,A)|(\forall r,B),(\forall r\neq 2)} \\ vax_{(1,B)|(\forall r,B),(\forall r\neq 2)} \\ vax_{(2,A)|(\forall r,B),(\forall r\neq 2)} \\ vax_{(2,B)|(\forall r,B),(\forall r\neq 2)} \\ vax_{(3,A)|(\forall r,B),(\forall r\neq 2)} \\ vax_{(3,B)|(\forall r,B),(\forall r\neq 2)} \end{bmatrix} = \hat{\mathbf{v}}(\mathbf{I}-\widetilde{\mathbf{T}})^{-1} \begin{bmatrix} 0 \\ \sum_{r'\neq 2} \tilde{f}_{(1,B),r'} \\ 0 \\ \sum_{r'\neq 2} \tilde{f}_{(2,B),r'} \\ 0 \\ \sum_{r'\neq 2} \tilde{f}_{(3,B),r'} \end{bmatrix},$$

where only the fourth entry of the left-hand side of the equation is used.

Import-side: Value-added imports are estimated symmetrically. For example, value-added contents embedded in region 1's imports of sector A's final goods purchased from elsewhere, $\sum_{\forall r'\neq 1} vax_{(r',A)|(\forall r,A),(1)}$, are estimated using the following equation:

$$\begin{bmatrix} vax_{(1,A)|(\forall r,A),(1)} \\ vax_{(1,B)|(\forall r,A),(1)} \\ vax_{(2,A)|(\forall r,A),(1)} \\ vax_{(2,B)|(\forall r,A),(1)} \\ vax_{(3,A)|(\forall r,A),(1)} \\ vax_{(3,B)|(\forall r,A),(1)} \end{bmatrix} = \hat{\mathbf{v}}(\mathbf{I} - \widetilde{\mathbf{T}})^{-1} \begin{bmatrix} \tilde{f}_{(1,A),1} \\ 0 \\ \tilde{f}_{(2,A),1} \\ 0 \\ \tilde{f}_{(3,A),1} \\ 0 \end{bmatrix},$$

where the last term of the right-hand side of the equation includes sector A's final goods purchased by region 1. Because we are interested in region 1's imports of value-added contents produced by sector A of elsewhere, the sum of $vax_{(2,A)|(\forall r,A),(1)}$ and $vax_{(3,A)|(\forall r,A),(1)}$ is used in our analysis.

To clarify how other observations of value-added imports are estimated, the following equation describes how value-added contents embodied in region 2's (direct and indirect) imports of sector B's final goods purchased from elsewhere, $\sum_{\forall r' \neq 2} vax_{\left(r',A\right)|(\forall r,B),(2)}$, are estimated.

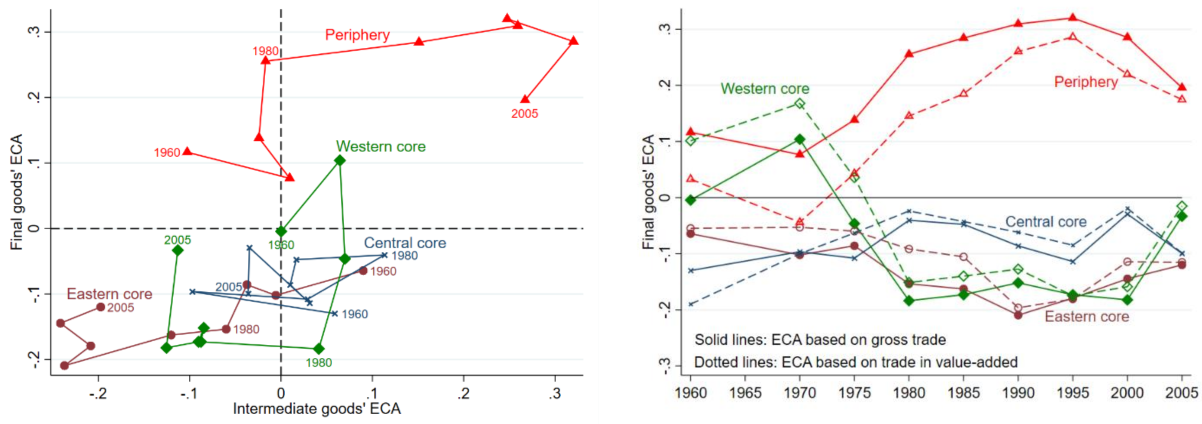
$$\begin{bmatrix} vax_{(1,A)|(\forall r,B),(2)} \\ vax_{(1,B)|(\forall r,B),(2)} \\ vax_{(2,A)|(\forall r,B),(2)} \\ vax_{(2,B)|(\forall r,B),(2)} \\ vax_{(3,A)|(\forall r,B),(2)} \\ vax_{(3,B)|(\forall r,B),(2)} \end{bmatrix} = \hat{\mathbf{v}}(\mathbf{I} - \widetilde{\mathbf{T}})^{-1} \begin{bmatrix} 0 \\ \tilde{f}_{(1,B),2} \\ 0 \\ \tilde{f}_{(2,B),2} \\ 0 \\ \tilde{f}_{(3,B),2} \end{bmatrix},$$

where the last term of the right-hand side of the equation includes sector B's final goods purchased by region 2. Because we are interested in region 2's imports of value-added contents produced by sector B elsewhere, the sum of $vax_{(1,B)|(\forall r,B),(2)}$ and $vax_{(3,B)|(\forall r,B),(2)}$ is used in our analysis.

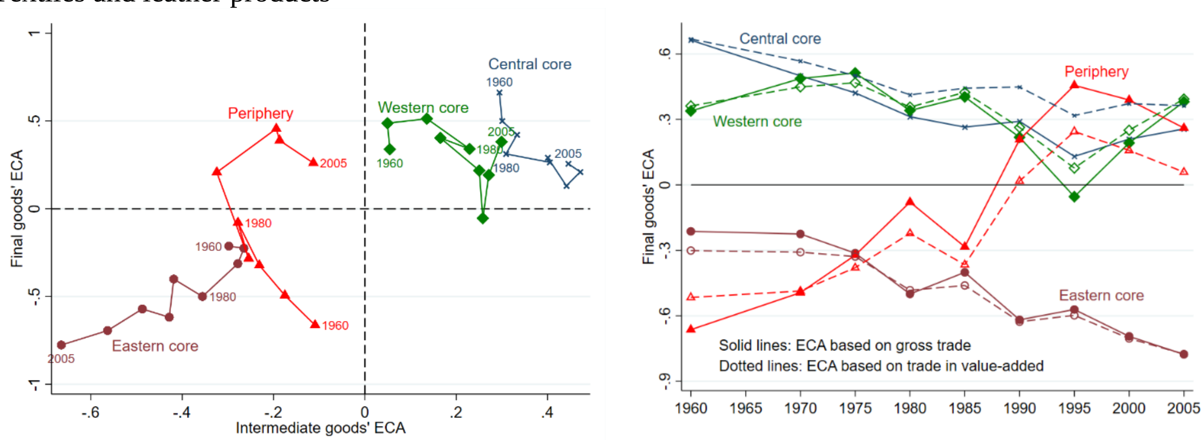
Appendix E. Empirical comparative advantages (ECAs) based on gross trade and value-added trade for separate eleven sectors

Figure A.2 'Value chain journey' diagrams and ECAs based on gross trade and value-added trade

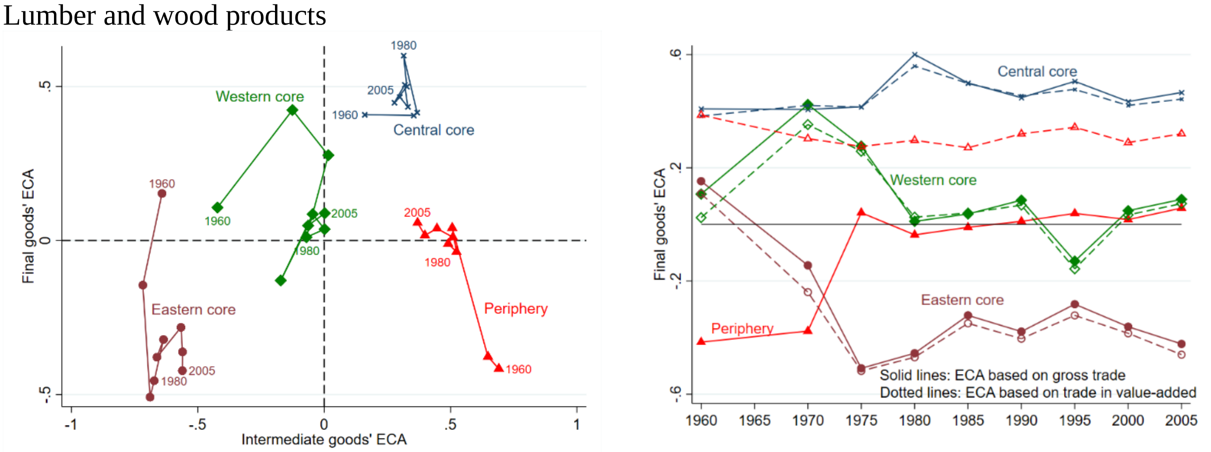
Food and kindred products



Textiles and leather products

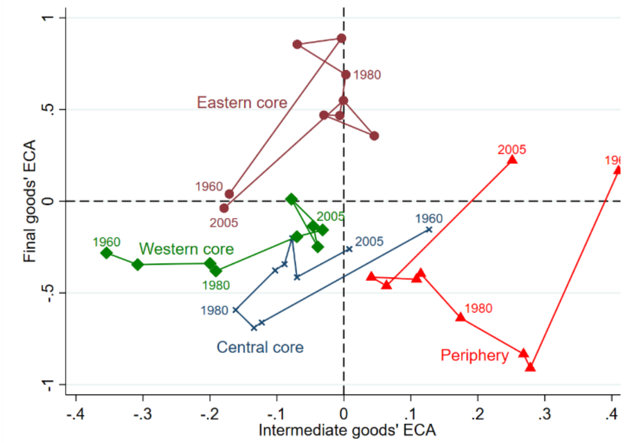


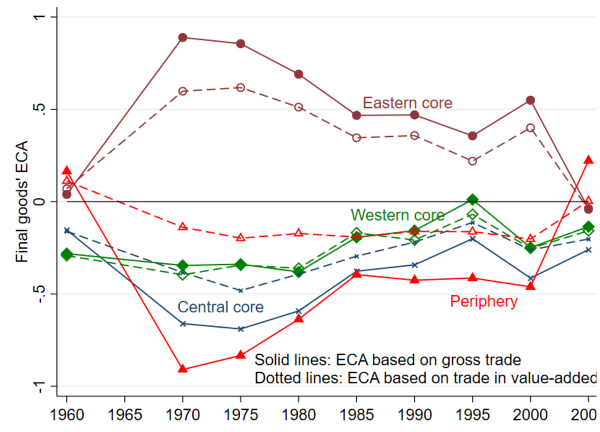
Lumber and wood products



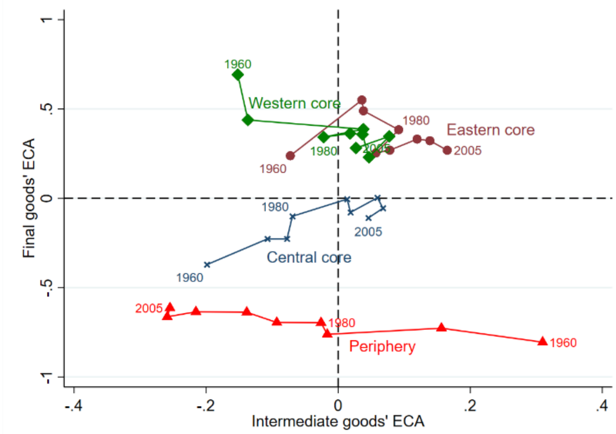
Note: Authors' estimation based on the inter-regional IO table from METI.

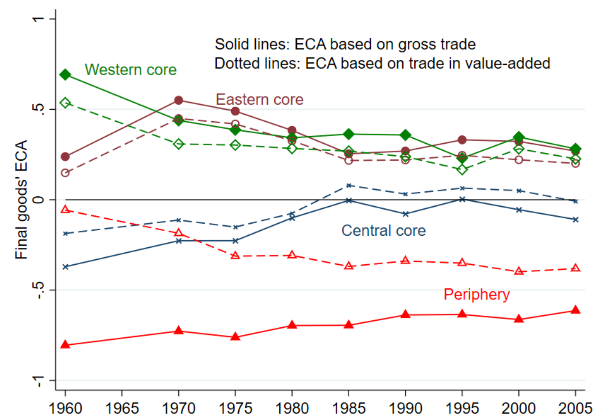
Pulp, paper, and paper products



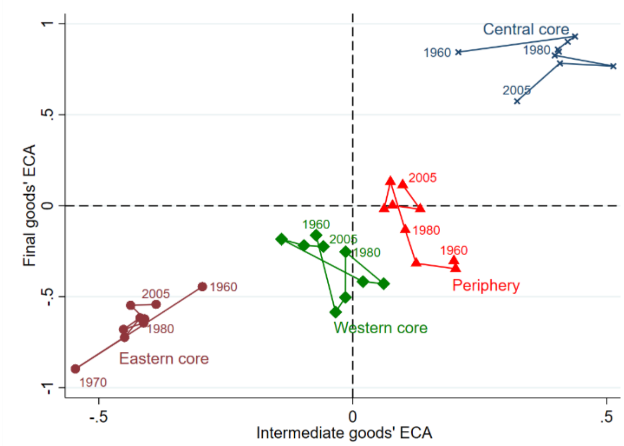


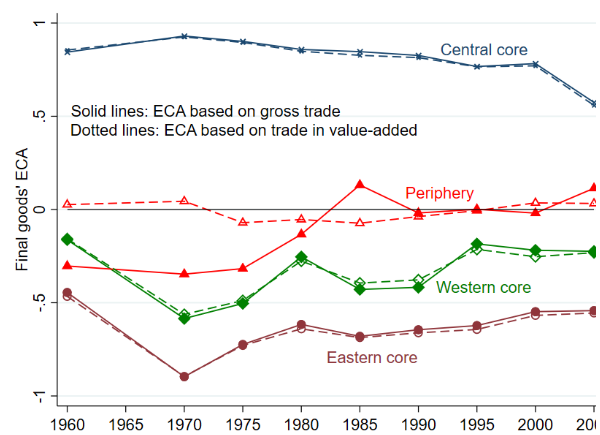
Chemicals



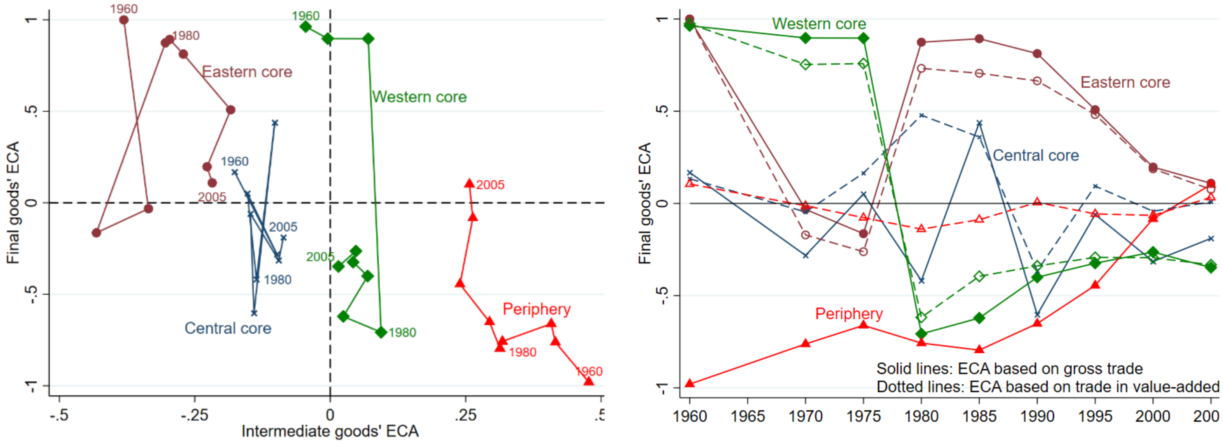


Ceramic, clay, and stones

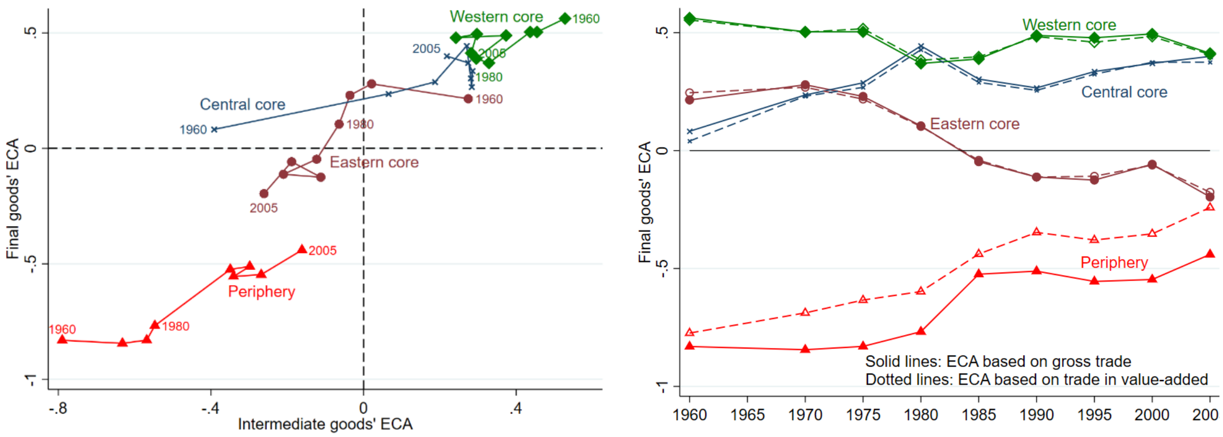




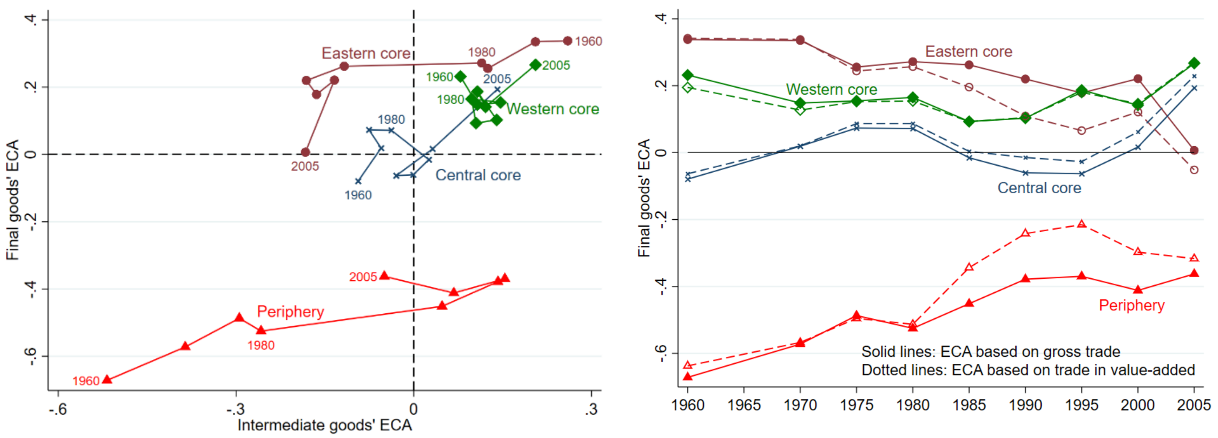
Iron and steel products



Metal products

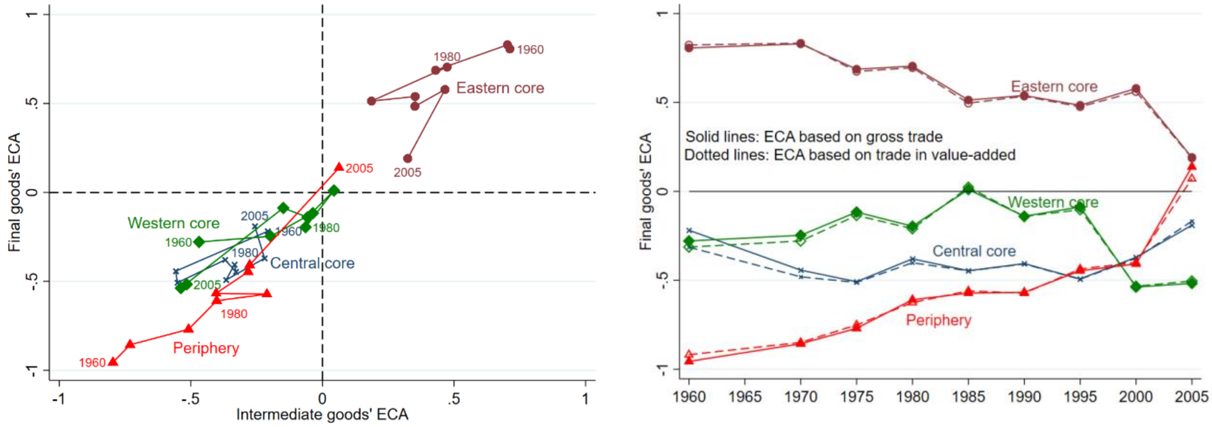


Machinery and electronics

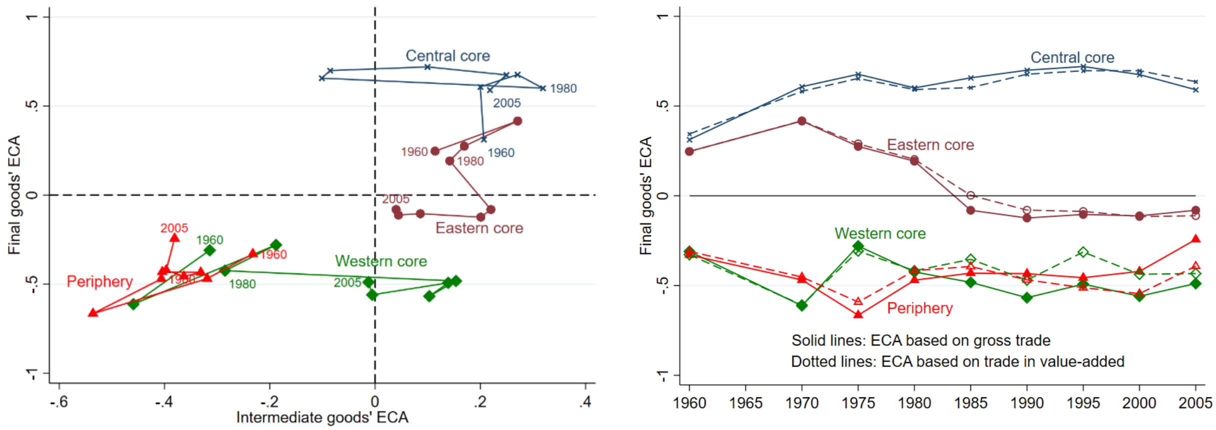


Note: Authors' estimation based on the inter-regional IO table from METI.

Precision machinery



Transport equipment



Note: Authors' estimation based on the inter-regional IO table from METI.