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Input Structure, International Trade of Intermediate Goods, and International Competitiveness

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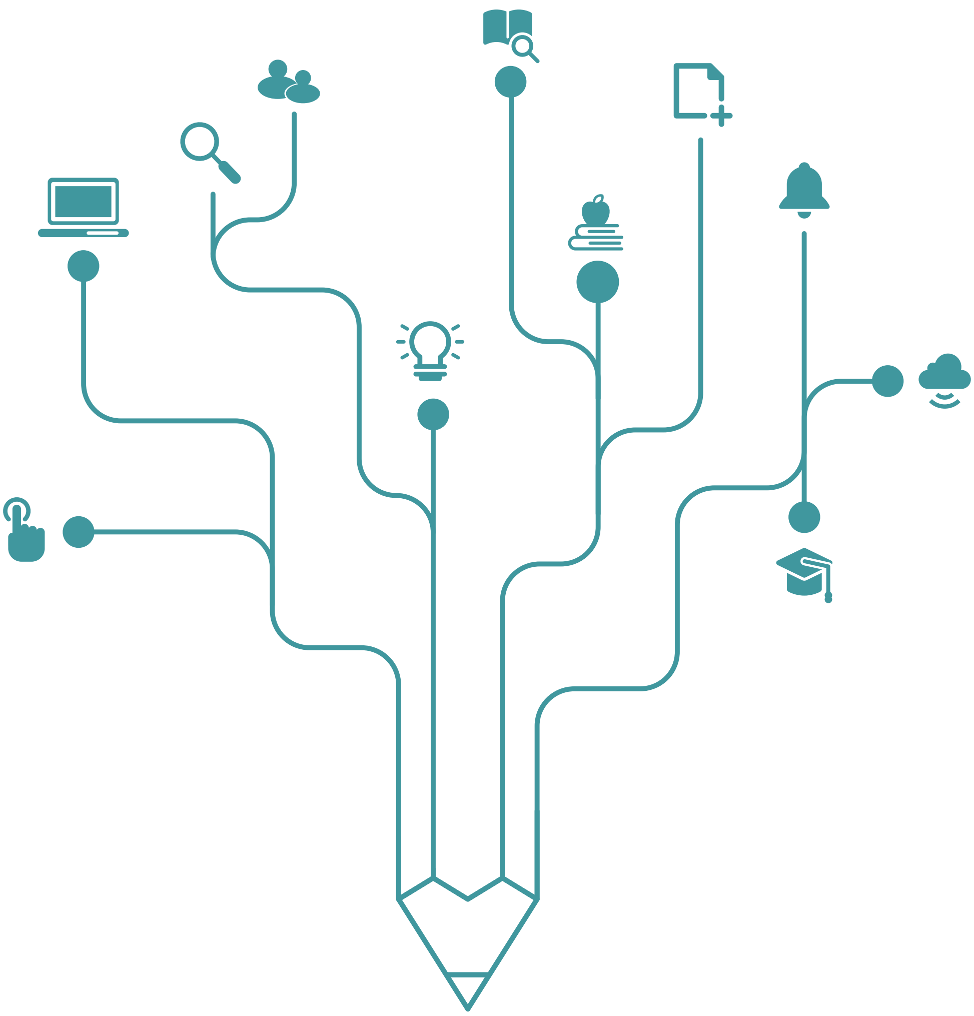

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Abstract

The purpose of this paper is to examine the relationship among input structure, international trade of intermediate goods, and international competitiveness at aggregate and sector levels using input-output (IO) tables and IO analysis. We used the IO tables of 66 countries included in the 2021 Edition of OECD's Input-Output Database (IO-DB, and we observed that IO tables and IO analysis can be useful in understanding the above-mentioned relationships. We found that IO analysis, in particular input structures and impact of final demand on value-added, provides useful hints and intuition about recent trend in international trade and the way countries' utilize the global production network.

Keywords: Input Structure, International Trade of Intermediate Goods, Value-Added Multiplier, International Competitiveness

JEL Classification: D57, F13, F14

1. Introduction

The purpose of this paper is to examine the relationship among input structure, international trade of intermediate goods, and international competitiveness at aggregate and sector levels using input-output (IO) analysis. While 'input structure' can be used in a wide variety of contexts, meaning the composition of production factors, it refers to the composition of total cost in terms of the expenditures on various domestic and imported raw materials, or 'intermediate input,' and primary production factors such as labor and capital.

Input structures at industry level play the central role in IO analysis, especially in computing the impact of final demand shocks on the supply side. Specifically, the shares of expenditures on various intermediate goods and primary production factors out of total production cost are the key determinants of the impact of final demand on the supply side variables such as gross output, value added and employment. In this paper, we will briefly review the relationship between the input structure and the impact of final demand shock on GDP at aggregate and industry levels.

Input structure also has a close relationship with the international trade not only of intermediate goods but also of final goods. Imported intermediate goods play an important role in various areas. We cannot imagine the world economy without employing imported intermediate goods as its importance has been ever increasing, in technology transfer and in global trade pattern as well as in production.

In this paper we will use the 2021 Edition of OECD's Input-Output Database (OECD IO-DB) to examine the relationship among input structure, international trade of intermediate goods, and value-added multiplier, the most frequently used measure of the impact of final demand shock on the supply side.

The paper is organized as follows. Section 2 provides a review of the literature. A simple analytical exposition of the relationship between input structure and value-added multiplier is given in Section 3. Section 4 introduces the data and presents the empirical results. Section 5 concludes the paper.

2. Literature

As explained earlier, 'input structure' implies the composition of total production cost, called 'total input' in IO analysis, expressed as the shares of the costs spent on domestically produced and imported intermediate inputs and on primary production factors. While the format of input structure depends on the layout of IO tables, the latter has been standardized considerably. Miller et al. (2009) is the most widely used reference for IO analysis, where the standard layout of IO tables and input structure can be found. Also, the manuals and guidelines accompanying individual countries' IO tables or the databases of IO tables are recommended for this purpose. Bank of Korea (2014) and Yamano and Ahmad (2006) are good examples.

Studying input structure also helps understand the pattern of and trend in international trade of final and intermediate products immensely. This is not surprising because the input structures of a national economy and of individual industries can be understood as snapshots of production functions, and thus can be said to reflect, if indirectly, the comparative advantage systems of countries and industries. In that sense, input structure provides much clue to understanding the changes in the international trade pattern.

For instance, one of the most notable trends in the international trade in recent decades is the 'international fragmentation' of global production. The world economy has witnessed many changes in the environment of international trade such as the rapid decrease in transportation cost, rapid improvement of information and communication technology, decrease in piracy, to name a few.

These changes made it possible to extend the comparative advantage system to 'product module' and even 'parts and components' levels, causing the increase of international trade of intermediate goods rapidly. These phenomena have been given various names, such as global outsourcing, international fragmentation of production stages, offshoring, vertical specialization, integration of global production network, global market integration, and bazaar economy, among others. See Kim (2004), Hummels et al. (2001), Loschky and Ritter (2006), Backer and Yamano (2008), Breda et al. (2009), Kim (2021a), Kim (2021b), etc. We will use OECD IO-DB to empirically confirm these patterns.

We will investigate the effect of input structure on the impact of final demand on value-added using elementary IO analysis, and any textbook or manuals of IO tables can be helpful such as Miller et al. (2009) and Bank of Korea (2014). We will investigate the relationship in both one-product and multi-product cases.

3. Input Structure and Value-Added Multiplier

3-1. Input Structure

Assume, as in usual IO analysis, that each industry produces only one product, and let n be the number of industries/products. Define x_{ij} as the amount of i th product used as an intermediate input in j th industry, $i=1,2,\ldots,n$, $j=1,2,\ldots,n$. We decompose x_{ij} into x_{ij}^d and x_{ij}^m, i.e., $x_{ij}=x_{ij}^d+x_{ij}^m$, where x_{ij}^d and x_{ij}^m represent domestically produced and imported intermediate input, respectively.

Define $x_{i.}=\sum_{j=1}^{n}x_{ij}$, $x_{i.}^{d}=\sum_{j=1}^{n}x_{ij}^{d}$, and $x_{i.}^{m}=\sum_{j=1}^{n}x_{ij}^{m}$ as total, domestic and imported intermediate demand for i th product, respectively, and $x_{.j}=\sum_{i=1}^{n}x_{ij}$, $x_{.j}^{d}=\sum_{i=1}^{n}x_{ij}^{d}$, and $x_{.j}^{m}=\sum_{i=1}^{n}x_{ij}^{m}$ as total, domestic and imported intermediate input in j th industry, respectively. Finally, $x_{..}=\sum_{j=1}^{n}\sum_{i=1}^{n}x_{ij}$ is defined as the total intermediate demand and the total intermediate input of the entire economy. Finally, define $x_{..}^{d}=\sum_{j=1}^{n}\sum_{i=1}^{n}x_{ij}^{d}$ and $x_{..}^{m}=\sum_{j=1}^{n}\sum_{i=1}^{n}x_{ij}^{m}$ accordingly.

Let x_j and v_j be the gross output and value-added of the j th industry and e_i and m_i be the exports and imports of i th product, respectively.[1] According to the System of National Accounts (SNA), the accounting system for national financial statements, total production cost, or 'total input,' equals firms' total revenue, or 'gross output' x_j .

We now define various input coefficients, the expenditures on production factors for one unit of gross output.

$a_{ij}^{d}=x_{ij}^{d}/x_j$ (domestic input coefficient),

$a_{ij}^{m}=x_{ij}^{m}/x_j$ (imported input coefficient),

$a_{j}^{v}=v_j/x_j$ (value-added coefficient).

We also define various input coefficient matrices as follows[2];

$\mathbf{A}^{d}=[a_{ij}^{d}]=[x_{ij}^{d}/x_j]$ (domestic input coefficient matrix),

$\mathbf{A}^{m}=[a_{ij}^{m}]=[x_{ij}^{m}/x_j]$ (imported input coefficient matrix),

$\hat{\mathbf{V}}=\mathrm{diag}(a_{j}^{v})=\mathrm{diag}(v_j/x_j)$ (value-added coefficient matrix)[3],

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[1] Gross outputs and intermediate inputs can be easily identified by the number of subscripts, i.e., the former has single subscripts while the latter has double subscripts.

[2] The size of all input coefficient matrices is $n\times n$.

[3] diag(c_j) denotes the $n\times n$ diagonal matrix with c_j being the j th diagonal element.

Total input consists of the expenditures on domestic and intermediate inputs and primary production factors, that is, $x_j = \sum_{i=1}^{n} x_{ij}^d + \sum_{i=1}^{n} x_{ij}^m + v_j$. Dividing both sides by x_j, we get

$$(1) \qquad 1 = \sum_{i=1}^{n} a_{ij}^d + \sum_{i=1}^{n} a_{ij}^m + a_j^v .$$

We call the $1 \times (2n+1)$ vector $(a_{1j}^d, \ldots, a_{nj}^d, a_{1j}^m, \ldots, a_{nj}^m, a_j^v)$ as the input structure of the j th industry.

Let $n = 1$, in other words, suppose there is only one product and one industry. It implies that we regard all products as a single product and all industries as a single industry. Then $x = \sum_{j=1}^{n} x_j$ and $v = \sum_{j=1}^{n} v_j$ represent the gross output and the value-added of the entire economy. Then the total input of the economy is decomposed into total domestic input, total imported input and value added,

$$x = \sum_{j=1}^{n}\sum_{i=1}^{n} x_{ij}^d + \sum_{j=1}^{n}\sum_{i=1}^{n} x_{ij}^m + \sum_{j=1}^{n} v_j = x_{..}^d + x_{..}^m + v ,$$

and (1) can be rewritten as

$$(2) \qquad a^d + a^m + a^v = 1, \qquad \text{where } a^d = x_{..}^d / x, \ a^m = x_{..}^m / x, \text{ and } a^v = v / x .$$

Note that (a^d, a^m, a^v) represents the input structure of the national economy with $n = 1$. Also note that

$$a^d = \sum_{j=1}^{n}\sum_{i=1}^{n} a_{ij}^d, \ a^m = \sum_{j=1}^{n}\sum_{i=1}^{n} a_{ij}^m, \ a^v = \sum_{j=1}^{n} a_j^v .$$

3-2. Impact of Final Demand Shock on the Supply-Side Variables

Let f_i^d denote the final demand for domestic product i, and let $f^d = \sum_{i=1}^{n} f_i^d$. The demand for domestically produced products consists of intermediate demand, $x_{..}^d$, and final demand, f^d, while gross output x is the only supply of domestic products. Hence the market clearing condition for domestic products can be expressed as $x = x_{..}^d + f^d$, or $x = a^d x + f^d$ where the second expression follows from $a^d = x_{..}^d / x$. Solving this for x, we get $x = f^d / (1 - a^d)$. When f^d increases by Δf^d, x increases by $\Delta x = \Delta f^d / (1 - a^d)$, hence

(3) $$\frac{\Delta x}{\Delta f^d} = \frac{1}{1 - a^d}.$$

The expression in (3) implies the increase in gross output when the domestic final demand increases by one unit and is called the gross output multiplier of domestic final demand.

This can be obtained in an alternative way. One of the assumptions in input-output analysis is that supply side is infinitely elastic, that is, supply adjusts to demand perfectly whenever demand changes. Assume $\Delta f^d = 1$. Then $\Delta x = 1$ due to the assumption of infinitely elastic supply. In order to increase gross output by one unit, we need to increase the inputs of production factors, and specifically, $x_{..}^d$, $x_{..}^m$ and v need to increase by a^d, a^m and a^v, respectively, of which (i) $\Delta x_{..}^d = a^d$ is satisfied by domestic firms, i.e., $\Delta x = \Delta x_{..}^d = a^d$, (ii) $\Delta x_{..}^m = a^m$ by increasing import, and (iii) $\Delta v = a^v$ by households. This is the adjustment in the second round.

The increase in gross output in the second round, $\Delta x = a^d$ is satisfied by $\Delta x = a^d a^d$, $\Delta x_{..}^m = a^d a^m$ and $\Delta v = a^d a^v$. In other words, Δx in each round requires Δx, $\Delta x_{..}^m$ and Δv

and their respective shares are a^d, a^m and a^v. In conclusion, the total increase in gross output in all rounds is $\Delta x = \Delta x / \Delta f^d = 1 + a^d + (a^d)^2 + (a^d)^3 + \cdots = 1/(1-a^d)$ when $|a^d| < 1$.

Substituting $a^v = v/x$, or equivalently $v = a^v x$, into (3), we obtain the impact of domestic final demand on the value-added of a country as follows;

$$(4) \qquad f(a^d, a^v) = \frac{\Delta v}{\Delta f^d} = \frac{a^v}{1-a^d} .$$

Equation (4) measures the increase in aggregate value-added when domestic final demand increases by one unit and is called the value-added multiplier of final demand (VAMF).

Strictly speaking, the VAMF cannot be regarded as an objective function of an optimization problem. Instead, the net present value of the flow of GDP in the future might be a more proper objective function. However, it is true that a higher value of VAMF might result in a bigger amount of GDP for given values of a^d and a^v with other conditions being equal. In that sense, we will regard the VAMF as a function of the input structure (a^d, a^m, a^v) and will study the function in more detail in this subsection.

Let's first examine the domain of VAMF as a function of the input structure (a^d, a^m, a^v). (i) Remembering that a^d, a^m and a^v are the shares of domestic and imported intermediate inputs and value-added out of total input, respectively, and that these amounts are nonnegative, these shares are also nonnegative, i.e., $0 \le a^d, a^m, a^v \le 1$. (ii) Any input structure (a^d, a^m, a^v) must satisfy the constraint $a^d + a^m + a^v = 1$, so we have only to consider two independent variables. We choose a^d and a^v. (iii) Substituting $0 \le a^m \le 1$ into $a^d + a^m + a^v = 1$, we get $0 \le a^d + a^v \le 1$. In conclusion, the domain of VAMF is $\{(a^d, a^v) \mid 0 \le a^d, a^v \le 1, a^d + a^v \le 1\}$, as depicted as the unit isosceles right triangle in Figure 1.

Note that the bivariate function (4) seems undefined when $a^d = 1$. We know, however, that when $a^d = 1$, the increase in gross output equals the initial increase in final demand in every round, hence the increase in value-added is zero in each round infinitely. For this reason, we have $f(a^d, a^v) = \Delta v / \Delta f^d = 0$ when $a^d = 1$. In conclusion, the VAMF function can be written as follows, and it is not continuous at $(a^d, a^v) = (1, 0)$.

$$(5) \qquad f(a^d, a^v) = \begin{cases} \dfrac{a^v}{1-a^d}, & 0 \le a^d,\ a^v \le 1,\ a^d + a^v \le 1, \\ 0, & a^d = 1,\ a^v = 0. \end{cases}$$

The graph of $f(a^d, a^v)$ is sketched in Figure 2. The surface of $f(a^d, a^v)$ is the curved twisted face connecting the four points (0,0,0), (1,0,0), (1,0,1) and (0,1,1). The function $f(a^d, a^v)$ attains the maximum value 1 over the constraint $a^d + a^v = 1$. This implies that the ridge connecting (0,1,1) and (1,0,1) forms the set of maximized values of $f(a^d, a^v)$. Note that $f(a^d, a^v)$ is maximized when $a^d + a^v = 1$, or $a^m = 0$, i.e., when the economy does not depend on imported intermediate input.

Figure 3 gives the same picture of the graph of $f(a^d, a^v)$ with contour lines at 0.1 intervals. It is interesting to observe that while the surface of $f(a^d, a^v)$ is a curved face, any contour line and any straight line parallel with the a^v axis drawn on the surface are straight lines.

The contour map of the VAMF function $f(a^d, a^v)$ is obtained by projecting the equation $f(a^d, a^v) = a^v / (1 - a^d) = k$ for various values of $k \in [0, 1]$ on the $a^d - a^v$ plane. Solving $f(a^d, a^v) = a^v / (1 - a^d) = k$ for a^v, we obtain the equation of the contour line with height k, $a^v = k(1 - a^d)$. It passes (1,0) in the $a^d - a^v$ plane and its slope is $-k$. The contour map of $f(a^d, a^v)$ is showed in Figure 4 with contour lines with heights $k \in [0, 1]$ at 0.1 intervals. In Figure 4, the curved arrow represents the direction in which the function value increases.

We now investigate the effect of the change in input structure on the impact of final demand on value-added, that is, on $f(a^d, a^v) = a^v / (1 - a^d)$. In this argument, we will assume that three shares (a^d, a^m, a^v) do not change simultaneously, that is, one of the three shares is fixed while the other two change by the same amount in the opposite direction so that the constraint $a^d + a^m + a^v = 1$ is maintained. This assumption is made to examine the impact of pairwise changes more easily and clearly. The general case where all three shares change simultaneously can be understood as the combinations of the following three cases. These three cases are depicted in Figure 5.

[**Case 1**: a^v fixed] When a^v is fixed, the constraint $a^d + a^m + a^v = 1$ requires that a^d and a^m change by the same amount in the opposite direction, i.e., $\Delta a^d + \Delta a^m = 0$. This refers to the import substitution ($a^d \uparrow$ and $a^m \downarrow$) or the negative import substitution ($a^d \downarrow$ and $a^m \uparrow$) of intermediate inputs, and the input structure (a^d, a^v) moves horizontally, i.e., to the left ($a^d \downarrow$, a^v fixed) or to the right ($a^d \uparrow$, a^v fixed), respectively. The VAMF $f(a^d, a^v) = a^v / (1 - a^d)$ increases (decreases) when the input structure (a^d, a^v) moves to the right (left), which can be easily confirmed from the contour map in Figure 5.

[**Case 2**: a^d fixed] When a^d is fixed, we have $\Delta a^m + \Delta a^v = 0$. This refers to the off-shoring ($a^v \downarrow$ and $a^m \uparrow$) or the on-shoring ($a^v \uparrow$ and $a^m \downarrow$) of intermediate inputs, and the input structure (a^d, a^v) moves vertically, i.e., up ($a^v \uparrow$, a^d fixed) or down ($a^v \downarrow$, a^d fixed), respectively. The VAMF $f(a^d, a^v) = a^v / (1 - a^d)$ increases (decreases) when the input structure (a^d, a^v) moves up (down).

[**Case 3**: a^m fixed] We have $\Delta a^d + \Delta a^v = 0$ when a^m is fixed. This refers to the domestic out-sourcing ($a^v \downarrow$ and $a^d \uparrow$) or the domestic in-housing ($a^v \uparrow$ and $a^d \downarrow$) of intermediate inputs, and the input structure (a^d, a^v) moves along the $-45°$ line, i.e., to the northwest ($a^v \uparrow$ and $a^d \downarrow$) or to the southeast ($a^v \downarrow$ and $a^d \uparrow$), respectively. The VAMF

$f(a^d,a^v)=a^v/(1-a^d)$ increases (decreases) when the input structure (a^d,a^v) moves to the northwest (southeast).

Observe that at low levels of $f(a^d,a^v)$, the slope of the contour is small and the fastest path up the surface is to move up vertically, while decrease in a^m becomes more valuable in moving up the surface as the economy is located higher on the surface.

Equation (5) cannot be used for computing the impact of the final demand on value-added at industry level. Let a_j^d and a_j^v be the domestic input and value-added coefficients in sector j, respectively. When the domestic final demand for j th product increases by one unit, the amounts of value-added in all industries change due to the inter-industry relationships involving intermediate inputs, and their amounts are computed as the n elements in the j th column of the $n\times n$ matrix $\mathbf{R}^v=\hat{\mathbf{V}}(\mathbf{I}-\mathbf{A}^d)^{-1}$, thus the increase in the aggregate GDP is the j th element of the $1\times n$ vector $\mathbf{o}'\mathbf{R}^v$ where $\mathbf{o}$ is the $n\times 1$ vector of 1s. $\mathbf{R}^v=\hat{\mathbf{V}}(\mathbf{I}-\mathbf{A}^d)^{-1}$ is called the value-added multiplier matrix, and it reduces to $f(a^d,a^v)=a^v/(1-a^d)$ when $n=1$.

4. Empirical Results

OECD has published several Editions of input-output databases in the past decades, while the 2021 Edition of OECD IO-DB was used in this paper for inter-country comparison. The 2021 Edition, released in 2021 and 2022, is the latest edition of the OECD IO-DB and contains the IO tables of 66 countries for 24 years (1995-2018), along with the Inter-Country Input-Output (ICIO) Tables. According to the World Bank's World Development Indicator statistics, these 66 countries represent 92.2%, 90.2%, 90.2%, and 70.7% of the world economy in terms of GDP, exports of goods and services, imports of goods and services, and population, respectively.

OECD IO-DB has two prominent advantages for the purpose of this paper. First, the IO tables of all countries in all years are compiled according to the common 45-industry classification system based on the International Standard Industry Classification (ISIC) Revision 4. Second, the unit of transaction amounts in all IO tables in OECD IO-DB is standardized in US dollars.

Figure 6 shows the input structure of the 66 countries combined as a single country during 1995-2018[4], that is, obtained by adding domestic and imported intermediate inputs, value-added and gross outputs of the 66 countries contained in the OECD IO-DB and computing input shares (a^d, a^v).[5] Considering that these 66 countries represent around 90% of the world economy, it is expected that the input structure of the world economy would be close to the input structure given in Figure 6.

Observe that the share of domestic intermediate input (a^d) has increased while the share of value-added (a^v) has decreased. Also observe that the decrease in a^v is bigger than the increase in a^d, thus resulting in the increasing distance between the input structure (a^d, a^v) and the $-45°$ line $a^d + a^v = 1$, implying that a^m increased in the same period. In summary, the input structure of the 66 countries changed, on average, in such a way that the share of value-added decreased while the shares of both domestic and imported intermediate inputs increased.

On the other hand, however, the computed input structures seem to imply that this trend is coming to an end considering that the yearly changes in the input shares are decreasing in magnitudes and the input shares are converging. This trend is observed clearly in Figure 7. We conclude that the world economy experienced both domestic outsourcing and offshoring in the production side in the past several decades but that the trend is coming to an end.

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[4] Trend lines in all figures in this chapter are based on the Hodrick-Prescott filtering.

[5] Rigorously speaking, it is the weighted average of the input structures of 66 countries with gross output amounts used as weights.

Input structures (a^d, a^v) of seven countries – United States, China, Japan, Germany, United Kingdom, France and Korea – are given in Figure 8. While the general trends comply with that of the world economy depicted in Figure 6, we observe considerable variation among the patterns of these countries. More specifically, the input structures of traditional developed countries – United States, Japan, Germany, United Kingdom and France are similar with one another in both location and in trend, while China depends more on domestic intermediate input and Korea is located somewhat between China and other five countries.

Figure 9 shows the dependence on imported intermediate input a^m, in both original and HP-filtered time-series, of the world economy[6] and the seven countries.[7] We conclude from these graphs that (i) the countries in the graph show similar trends, (ii) the share of imported intermediate input (a^m) out of total production cost has increased but the trend has weakened in many countries in recent years, (iii) a^m passed the saturation level and has been decreasing in Korea and China, and (iv) a^m experienced a sharp decrease in 2009, probably due to the economic crisis in 2009.

Figure 10 presents the sectoral input structures (a^d, a^v) of the 66 countries combined into one economy. Figure 10 graphically shows that (i) we find a considerable variation among the input structures by sector, (ii) the share of value-added out of total production cost is lowest in manufacturing sector while it is the highest in service sector, and (iii) the input structure (a^d, a^v) of all industries moved to the southeast and off the $-45°$ line $a^d + a^v = 1$ slightly, confirming the deepening global trend of domestic outsourcing and international offshoring in all industries.

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[6] Again, 'world economy' means the 66 countries in the OECD IO-DB combined into a virtual single country.

[7] The dependence on imported intermediate input a^m can also be measured by the distance, either horizontal or vertical, between an input structure (a^d, a^v) and the $-45°$ line $a^d + a^v = 1$.

Figure 11 shows the shares of imported intermediate input (a^m) by sector of the 66 countries combined as a single economy, from which we observe that (i) the sectoral levels of a^m show the similar trend, (ii) the level of a^m is the highest in the manufacturing sector and the lowest in the service sector, and (iii) the level of a^m in the manufacturing sector reached the peak around 2010 and has declined afterwards while the level of a^m in the service sector is still rising if slowly.

The imported intermediate input used in the manufacturing sector of the 66 countries was about 1.8 and 6.5 trillion US dollars in 1995 and 2018, respectively, and in 2018, it occupied 54.1% of total imported intermediate input used in the 66 countries, and 32.4% of total imports of 66 countries. Considering the important position taken by the manufacturing sector in the input structure and in the international trade, the trend of a^m should be given much attention.

We now turn our attention to the relationship between the input structure and the impact of domestic final demand on value-added measured by the value-added multiplier (VAMF). Figure 12 shows the graph of a^d , a^v and VAMF of the 66 countries during 1995-2018 period. The share of domestic intermediate input (a^d) decreased steadily until early 2010s and the share of value-added (a^v) decreased steadily during the same period, and VAMF decreased from around 0.91 in 1995 to 0.86 in 2012, about 5.0% decrease. This trend slowed down rapidly since then, and, in addition, the share of imported intermediate input (a^m) began declining since early 2010s (Figure 11), and VAMF began recovering since early 2010s.

We observe considerable variations in VAMF levels among industries and among countries as can be seen in Figure 13 and Figure 14. We observe that the level of VAMF is the lowest in the manufacturing sector and the highest in the service sector. This is directly related with the input structures and particularly the share of imported intermediate input (a^m) in the total production cost (Figure 11 and Figure 13.). The recovery of VAMF since early 2010s can be partially attributed to the decline of a^m since early 2010s, which could be called 'onshoring of the manufacturing sector.'

Figure 15 is the scatter plot of the VAMF levels against the share of exports as percentage of the national GDP of the seven countries that we are considering in this paper. The scatter plot shows that the bigger the share of exports as percentage of GDP the lower the VAMF. The correlation coefficient was -0.9507, and was almost the same when we use HP filtered series and when computed in other years. This result is not surprising because total exports mostly consist of manufactured products, and the share of imported intermediate inputs (a^m) is the highest (Figure 11) and the level of VAMF is the lowest (Figure 13) in the manufacturing sector.

We will finally examine the usefulness of the information that can be obtained from IO tables and input structure in understanding the recent trend in international trade. One of the most important event in the trend of the world economy is the surprisingly rapid increase in international trade. Maddison (2001) estimated that the world exports volume was 4~5% of world GDP in late 19th century, rose up to 8% in early 20th century, but declined back to lower than 6% in early 1950s due to the World Wars and the Korea War. However, the world trade began leaping afterwards, recording around 17% of world GDP around 2000 and then 24% in 2910. See Figure 16.

This result is almost identical with the estimates obtained from the OECD IO-DB. The ratio of the exports to GDP of the 66 countries in the OECD IO-DB is depicted in Figure 17, which is almost identical with the estimate by Maddison for the period 1995-2010 in Figure 16. Surprisingly, however, we find that the increasing trend of the exports of goods and service as a percentage of GDP significantly decelerates in early 2010s and then begins declining afterwards. While it could be early to decide that the ratio reached the peak and will decline, it appears evident that the increasing trend has at least slowed down.

Input structure can also help understand the trend in international trade. Juxtaposing the share of imported intermediate input in total cost (a^m) in Figure 18 with the ratio of exports to GDP in Figure 17, we find that these two time-series variables show surprisingly similar trends, even though the latter seems to precede the former slightly.

Intermediate products occupy a substantial portion in international trade, so it is obvious that these two series reveal similar trends. If we decompose a^m into two factors, however, then we can better understand the high correlation. Let m denote total imports, then we can decompose a^m as follows;

$$(6) \qquad a^m = \frac{x_{\cdot\cdot}^m}{x} = \frac{x_{\cdot\cdot}^m}{m} \times \frac{m}{x}.$$

The first term on the right-hand side is the ratio of imported intermediate input ($x_{\cdot\cdot}^m$) to total import, that is, the share of raw material in total imports. The second term is the ratio of total imports to gross output, called 'import coefficient,' which can be interpreted as the amount of foreign products to produce one unit of domestic product, or equivalently, the degree to which an economy depends on the foreign sector to maintain the domestic production base.

These two variables are depicted in Figures 19 and 20, and they show very similar patterns, which is why the product of the two shows the trend depicted in Figure 18. We can conclude from this observation that the recent remarkable change in the trend of international trade, say 'reaching the peak of the ratio of exports to GDP,' can be attributed to the changes in the global production framework. The changes are two-fold. First, it is possible that the countries' dependence on imported intermediate goods has reached the peak in early 2010s and has begun declining. At the same time, it is also possible that the countries' dependence on imports is going through the same trend.

6. Concluding Remark

As claimed at the beginning, the purpose of this paper is to investigate the relationship among input structure, international trade of intermediate goods, and international competitiveness at aggregate and sector levels using input-output analysis. We used the input-output tables of 66 countries contained in the 2021 Edition of OECD's Input-Output Database (IO-DB) for this purpose, and we observed that IO tables and basic IO analysis can be useful in understanding the above-mentioned relationships. The purpose of the paper is not to provide a rigorous proof or analysis as to the relationship among the above topics, but instead to show the usefulness of input-output tables and basic input-output analysis in understanding the recent trend in international trade.

The paper showed that the evidence obtained from the 2021 Edition of OECD IO-DB and basic IO analysis is highly compatible with and provides useful hints and intuition about recent trend in international trade and countries' production behavior. It is expected that further research will provide better understanding and potential policy implications for the issues.

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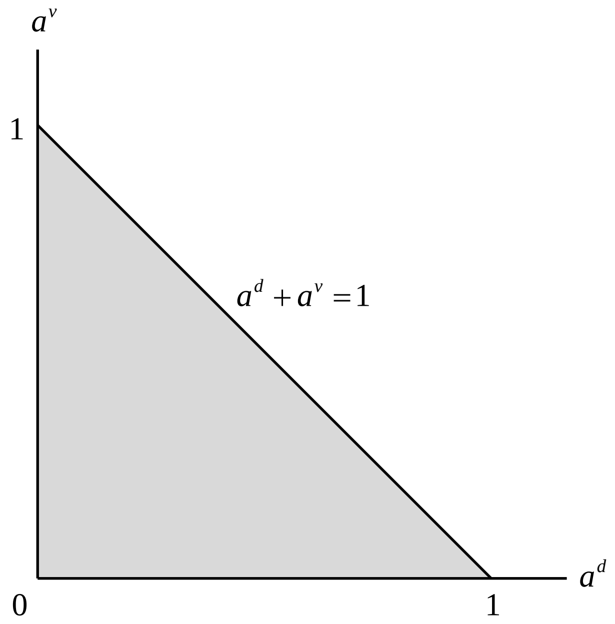


Figure 1. Domain of $f(a^d, a^v) = \frac{a^v}{1-a^d}$

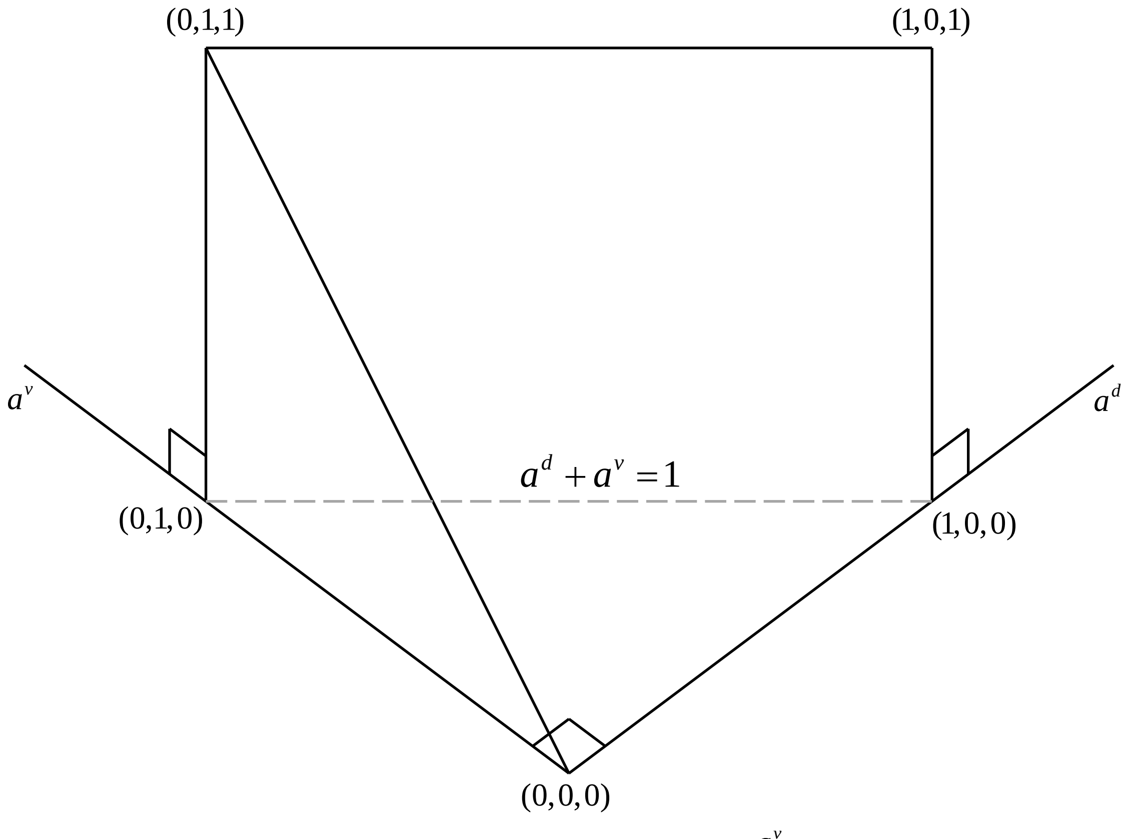


Figure 2. Sketch of $f(a^d, a^v) = \frac{a^v}{1-a^d}$

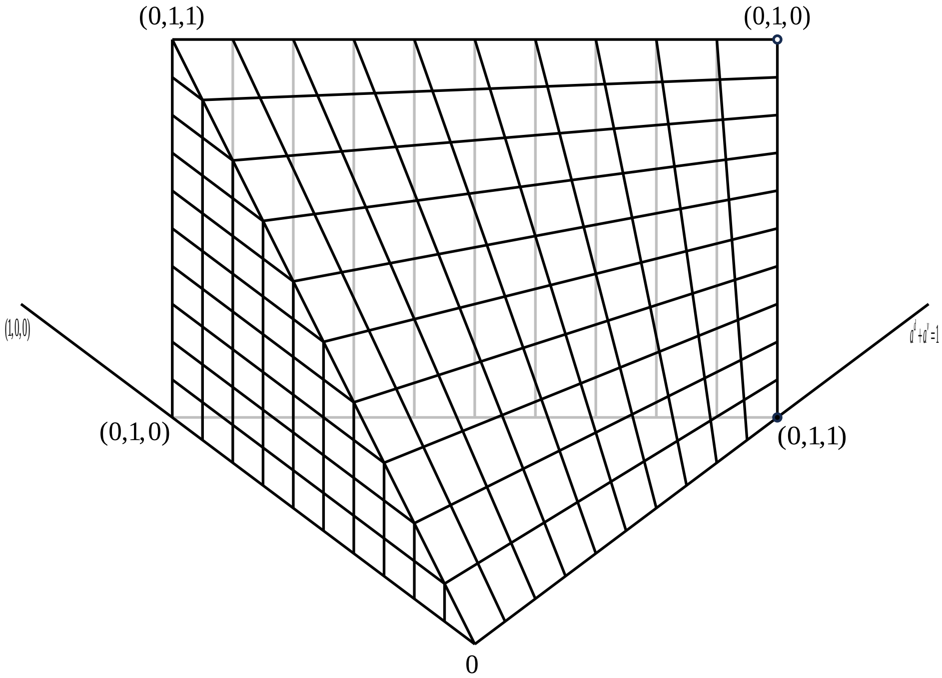


Figure 3. Graph of $f(a^d, a^v) = \dfrac{a^v}{1-a^d}$

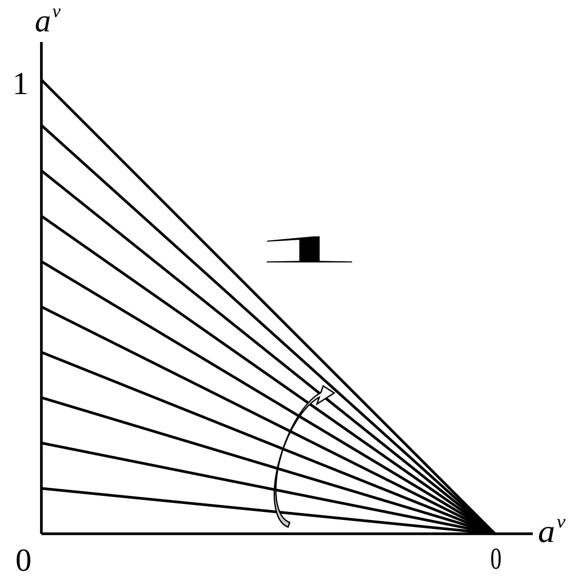
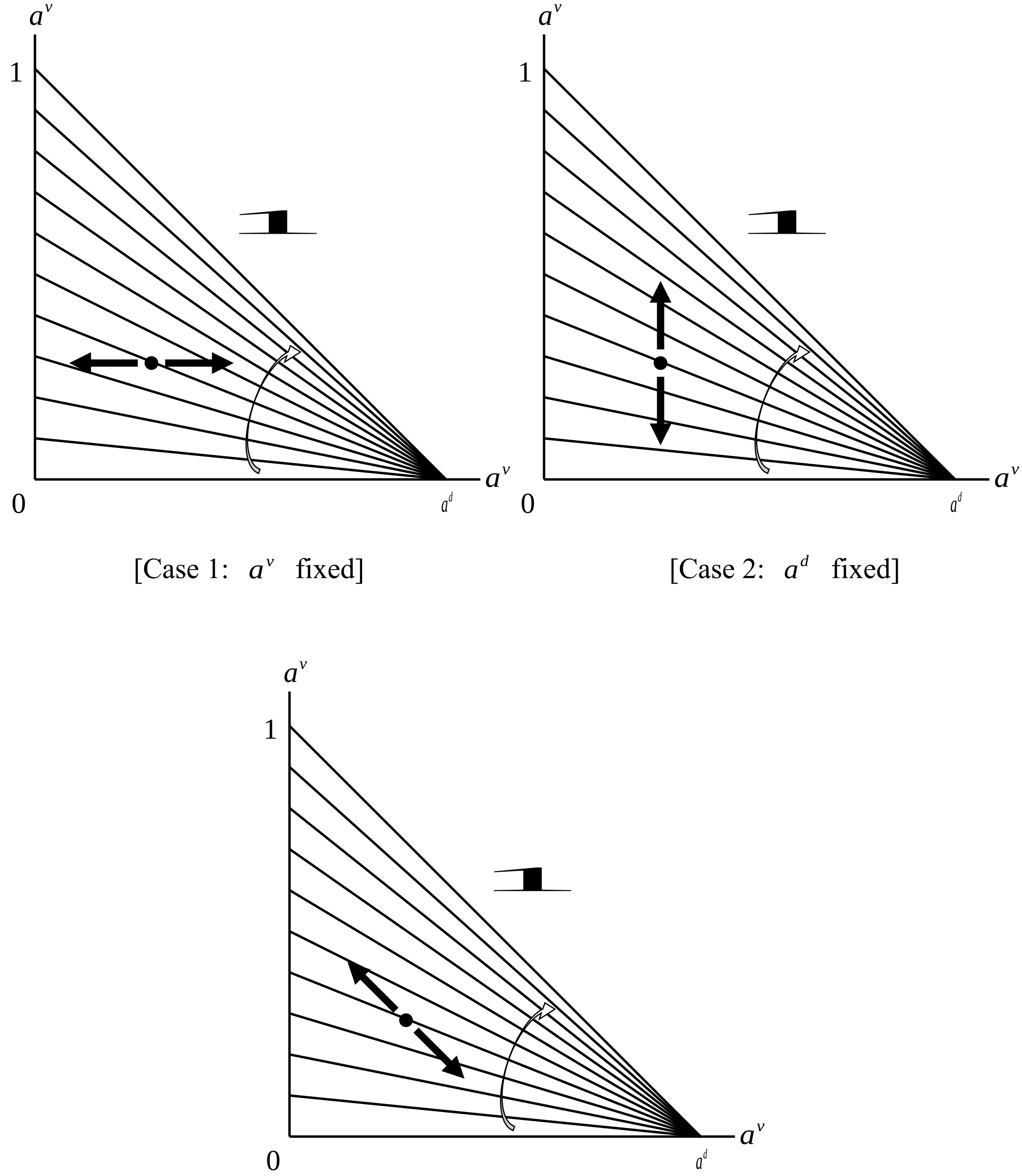
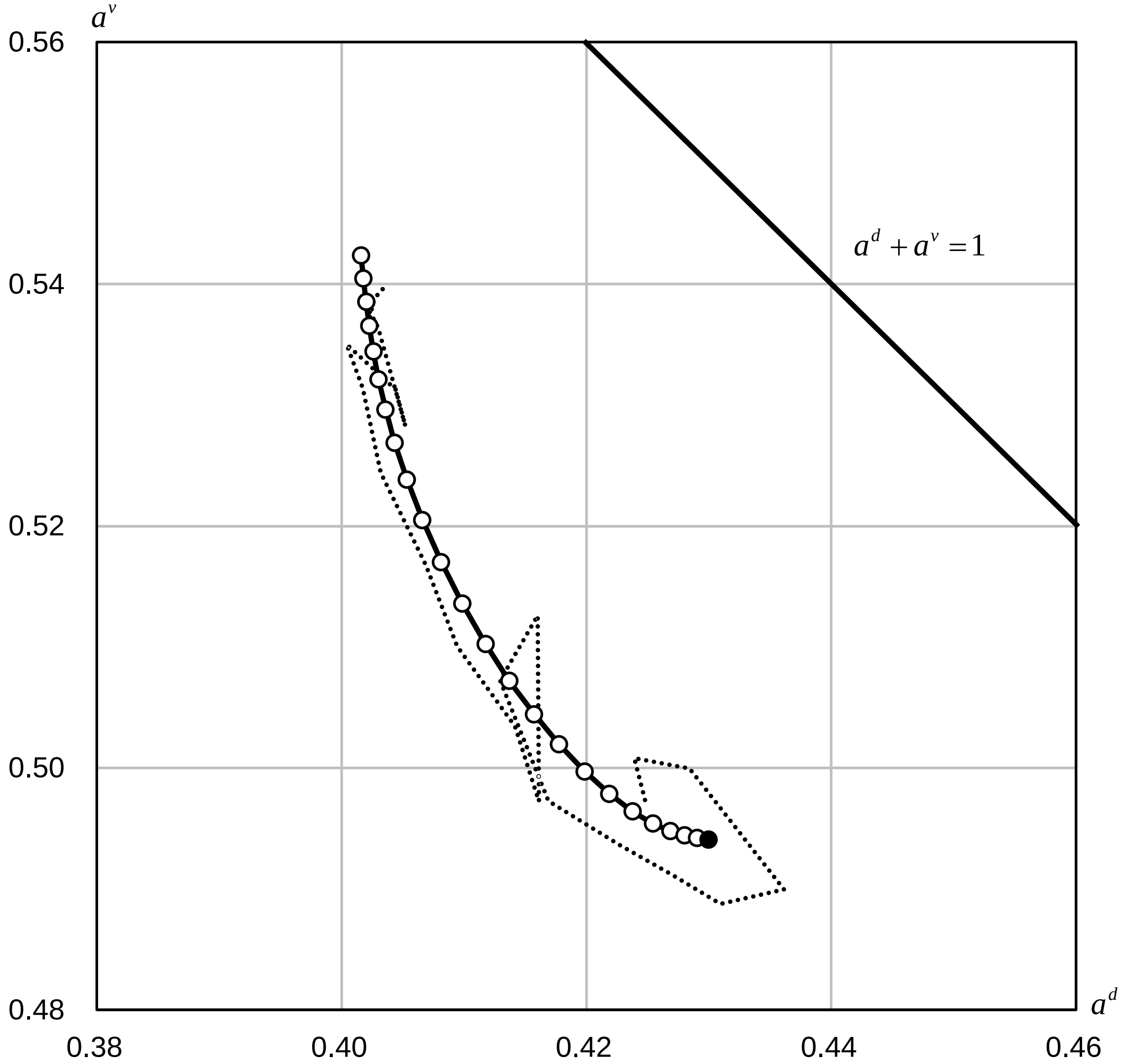


Figure 4. Contour map of $f(a^d, a^v) = \dfrac{a^v}{1-a^d}$



[Case 3: a^m fixed]

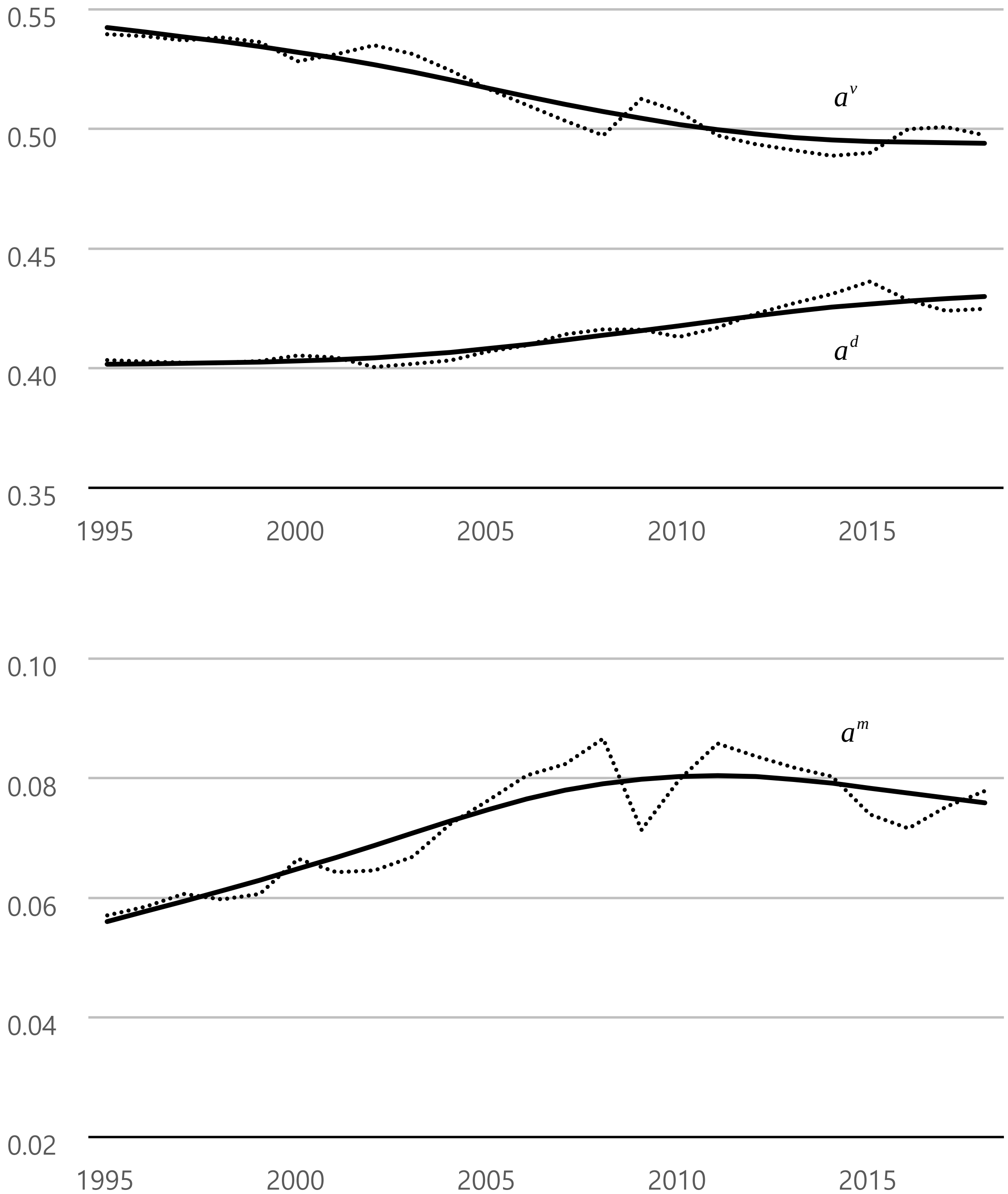
Figure 5. Impact of input structure on VAMF



Note: Broken and solid lines represent the original and HP filtered series, respectively.

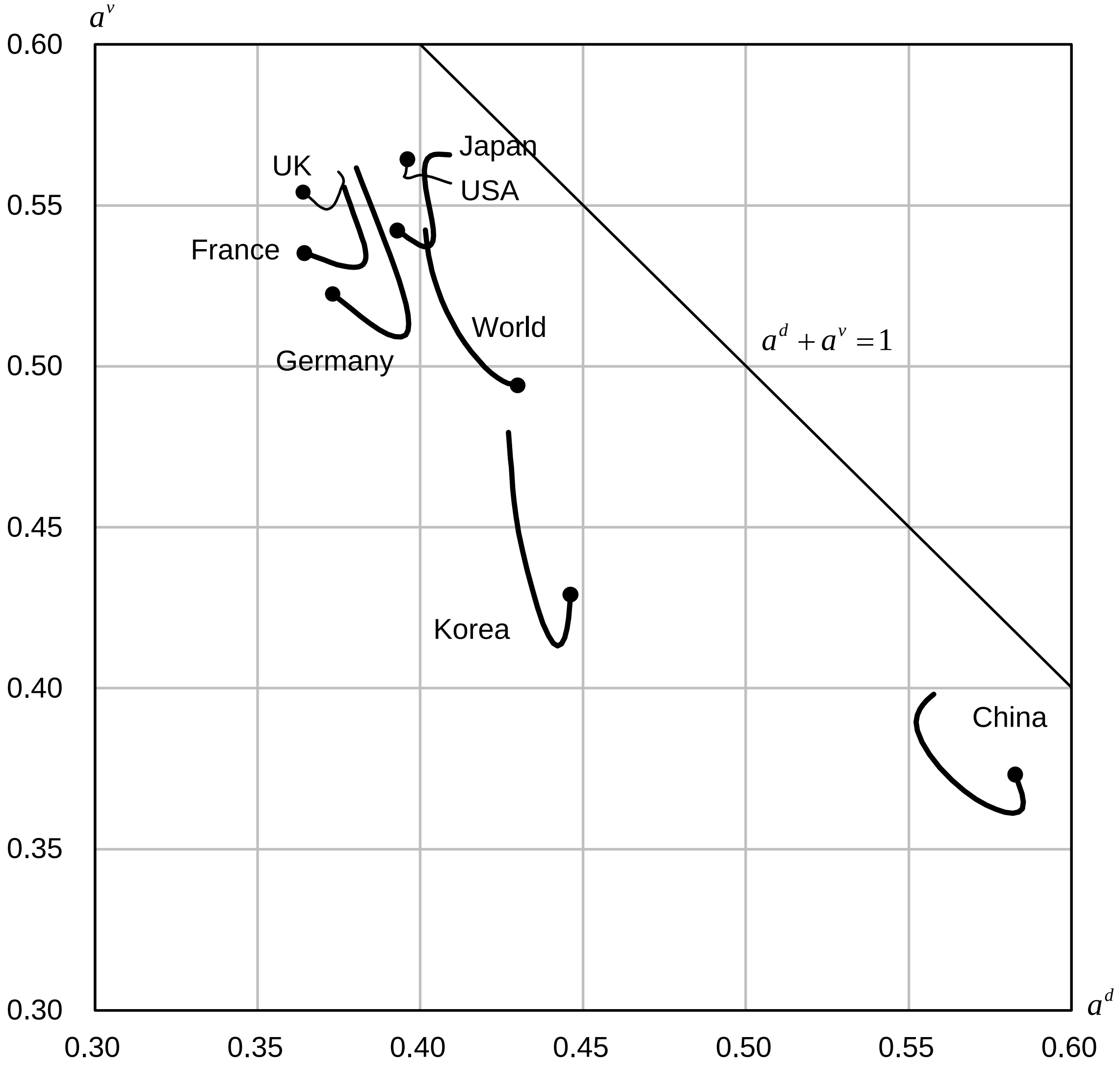
Note: Solid circle represents the year 2018.

Figure 6. Input Structure of the World Economy



Note: Broken and solid lines represent the original and HP filtered series, respectively.

Figure 7. Input Structure of the World Economy

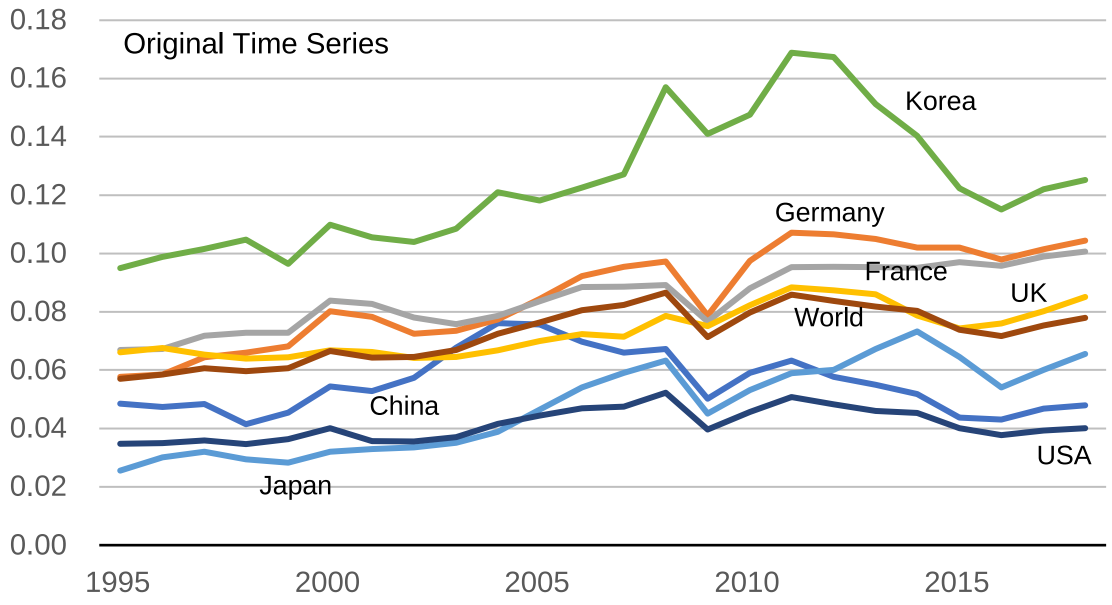


Note: All series are HP filtered.

Note: Solid circle represents the year 2018.

Note: The graphs of UK and USA are drawn in thinner lines in order to avoid confusion.

Figure 8. Input Structure of Seven Countries



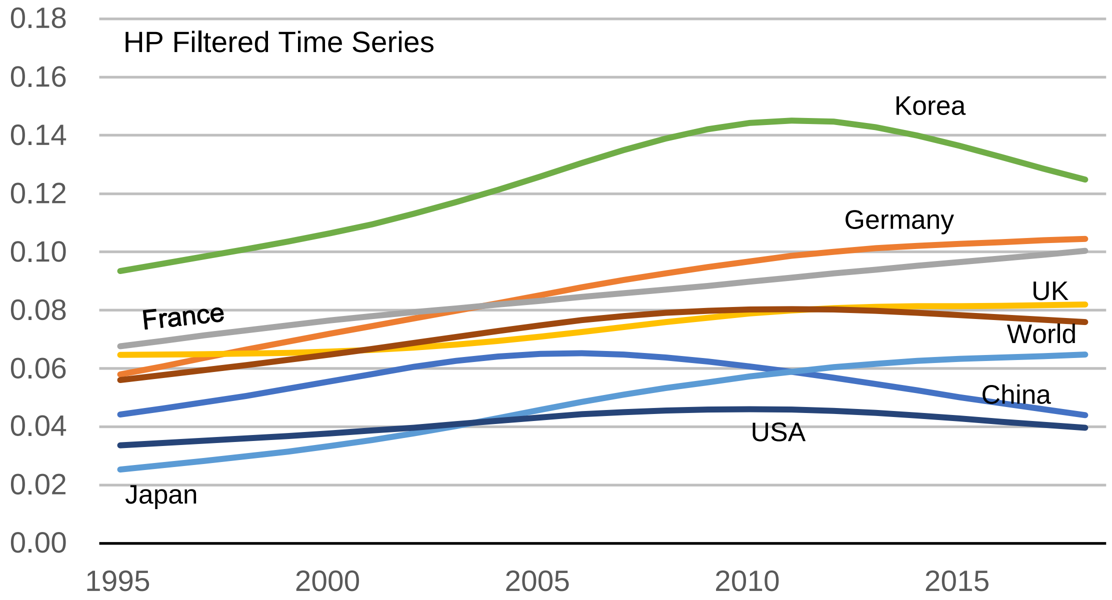
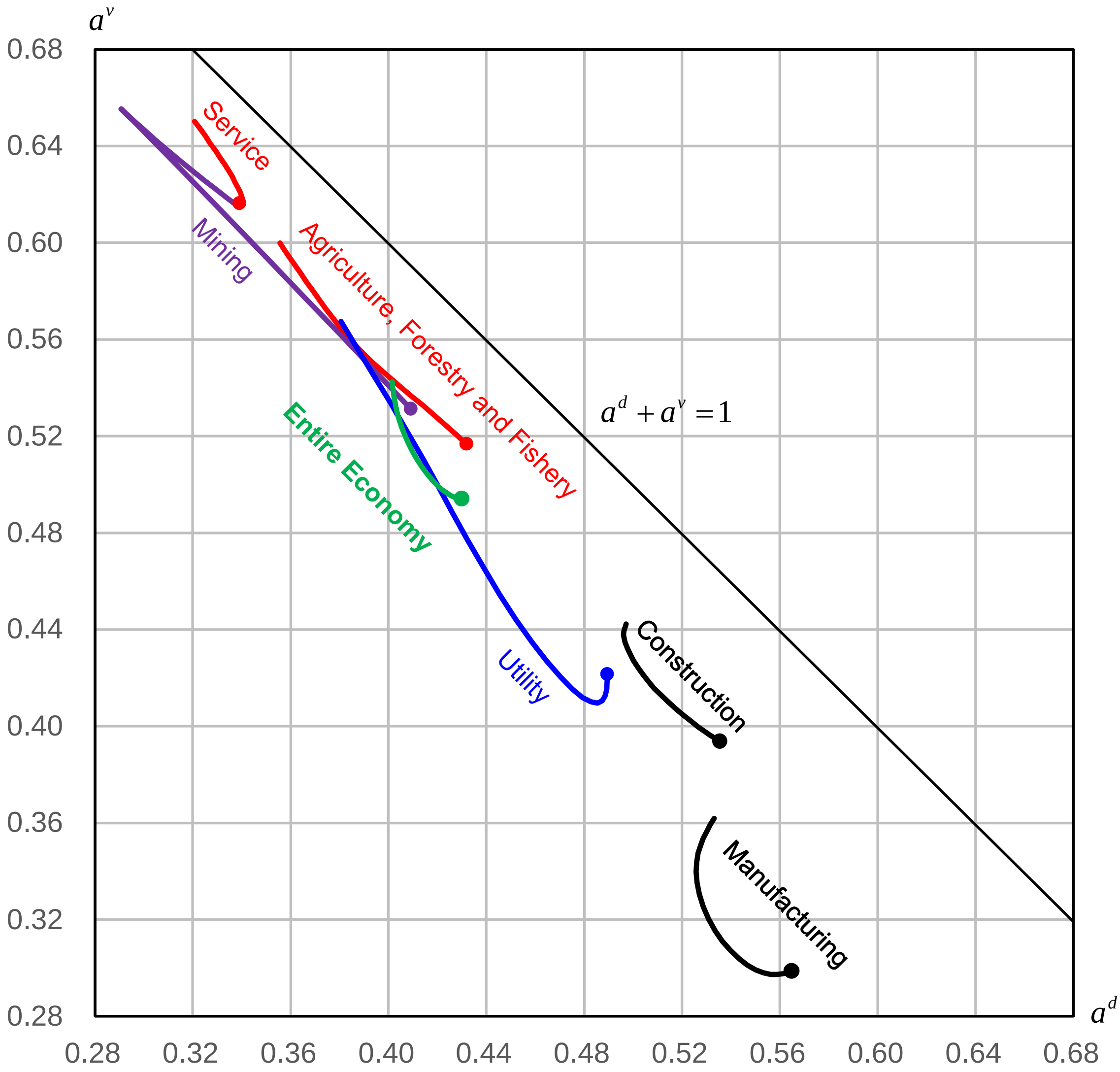


Figure 9. Share of Imported Intermediate Input (a^d) by Country



Note: All series are HP filtered.

Note: Solid circle represents the year 2018.

Figure 10. Input Structure of the World Economy By Sector

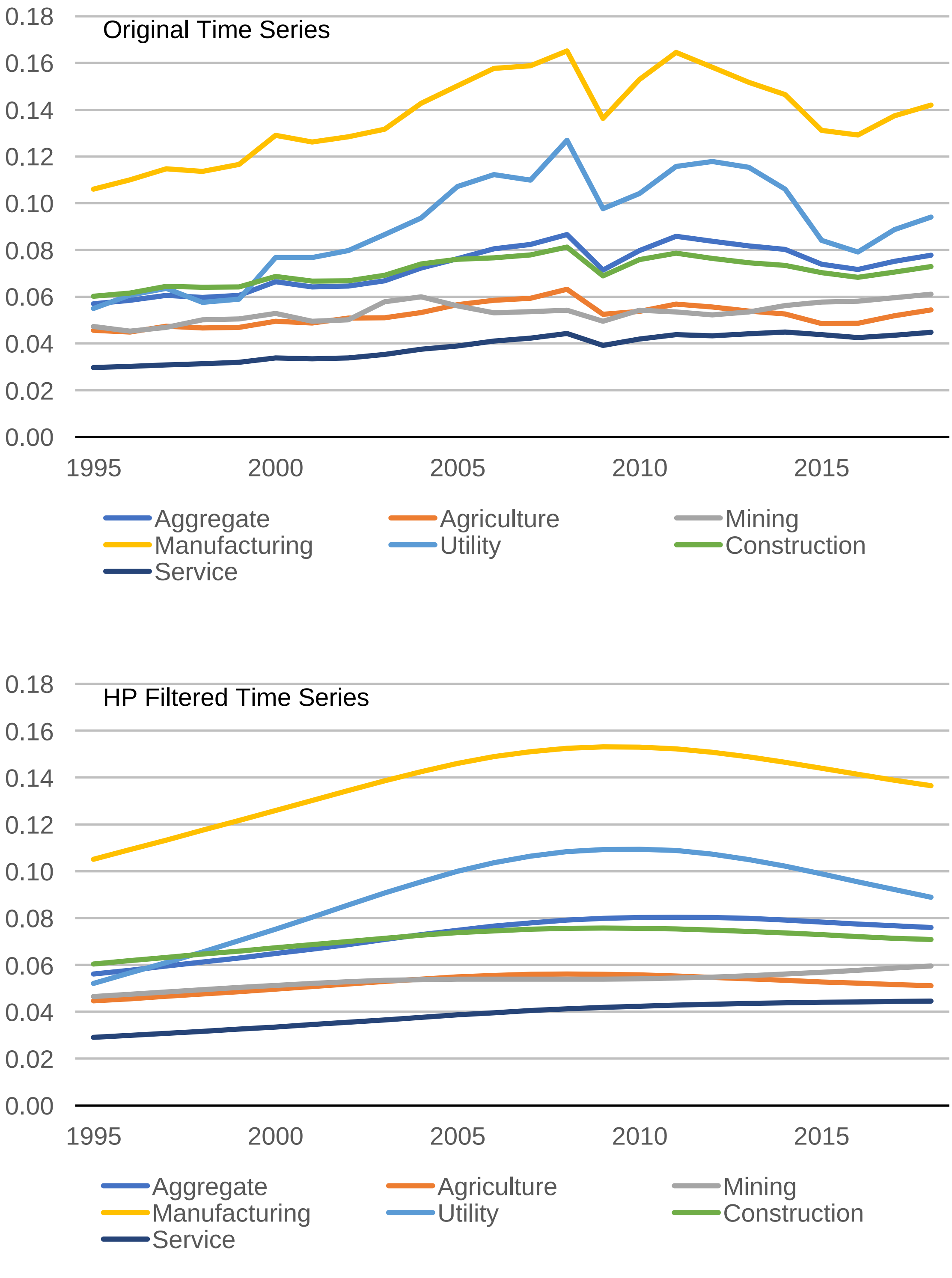
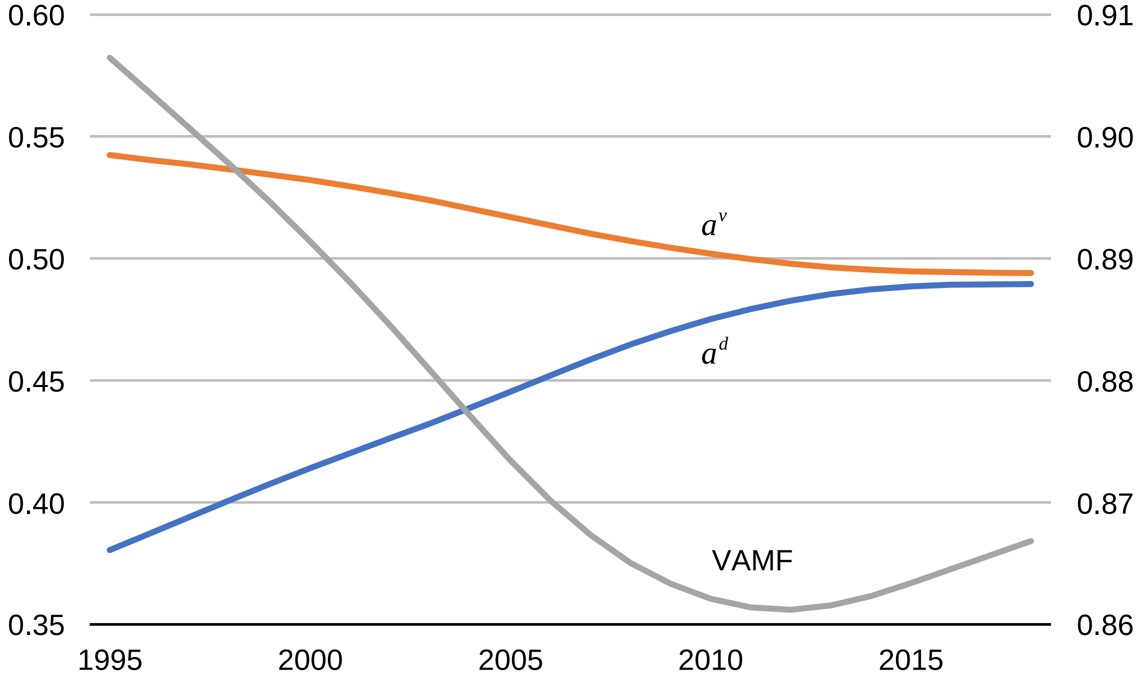


Figure 11. Share of Imported Intermediate Input (a^m) by Industry



Note: Left axis for a^d and a^m, and right axis for VAMF.

Note: All series are HP filtered.

Figure 12. Input structure and VAMF of the World economy

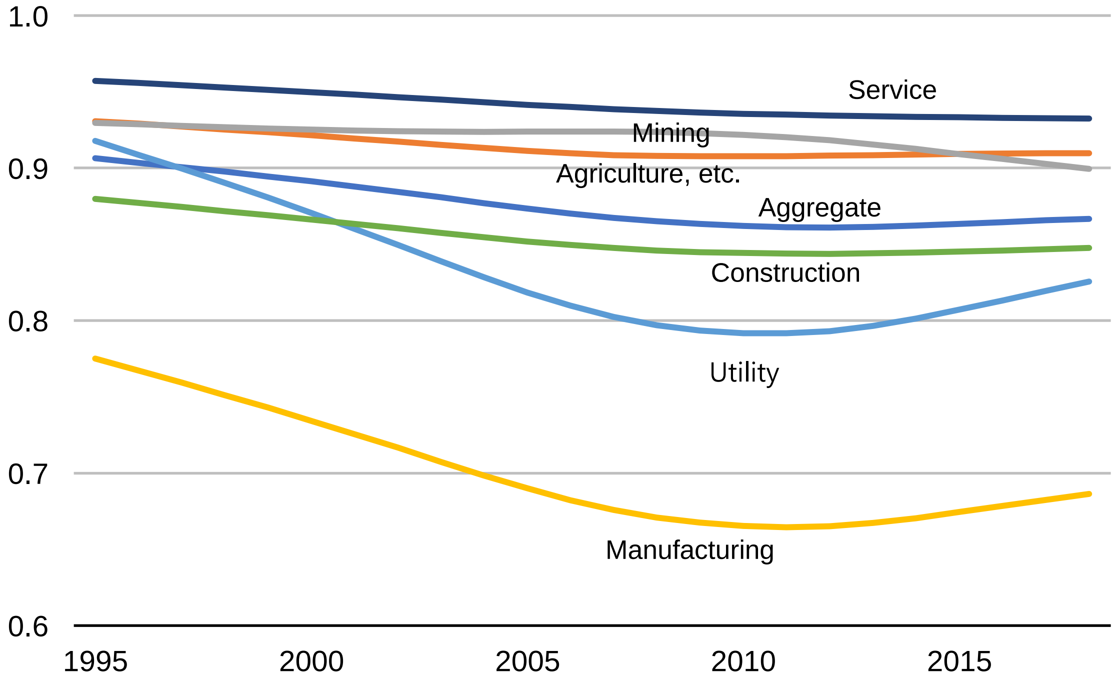


Figure 13. VAMF of the World economy by Sector

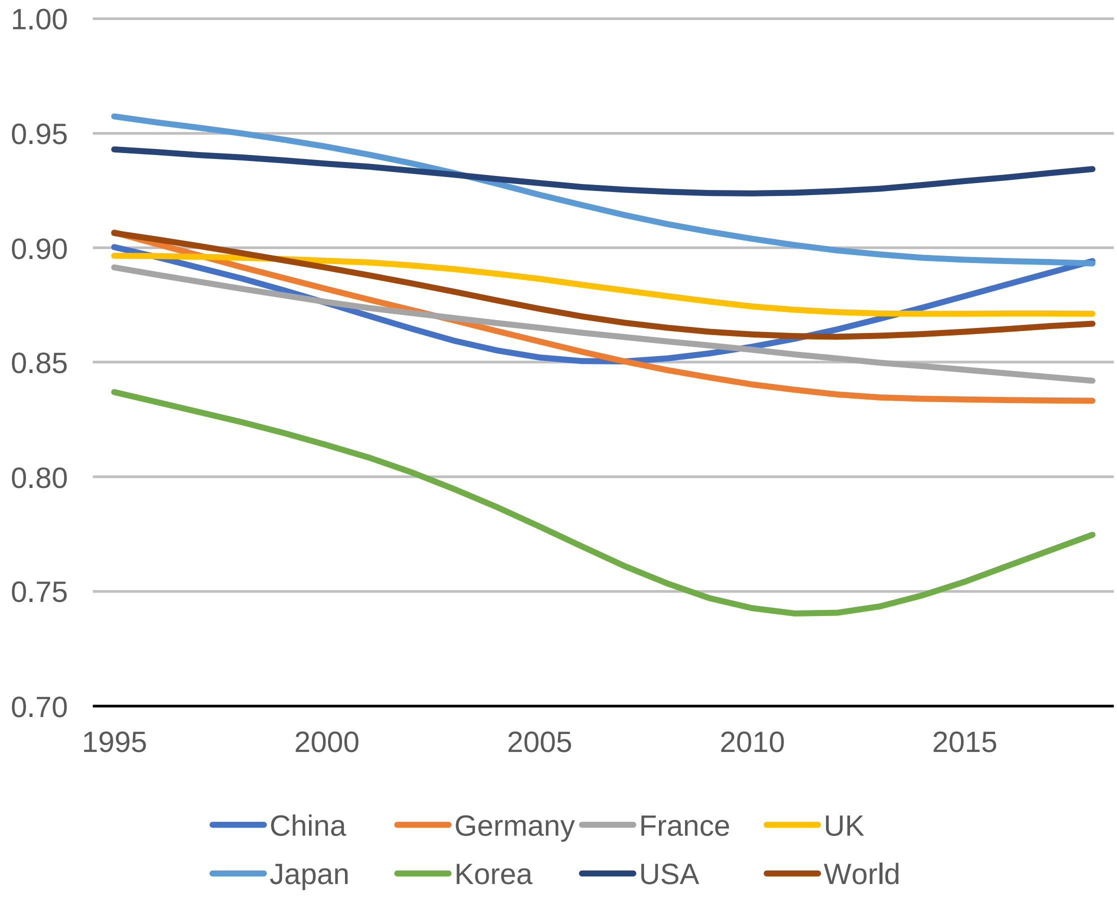


Figure 14. VAMF of the World economy by Country

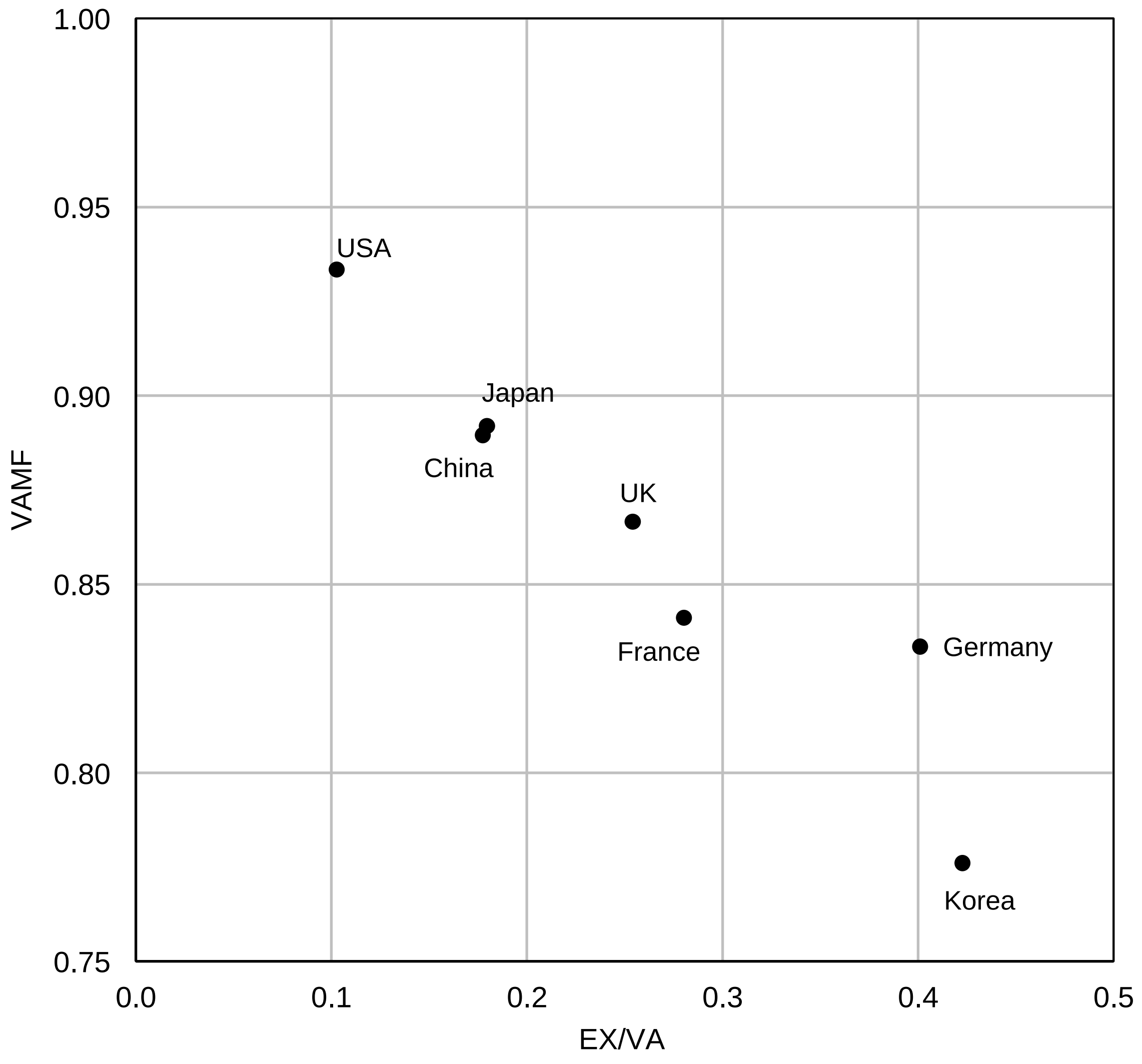
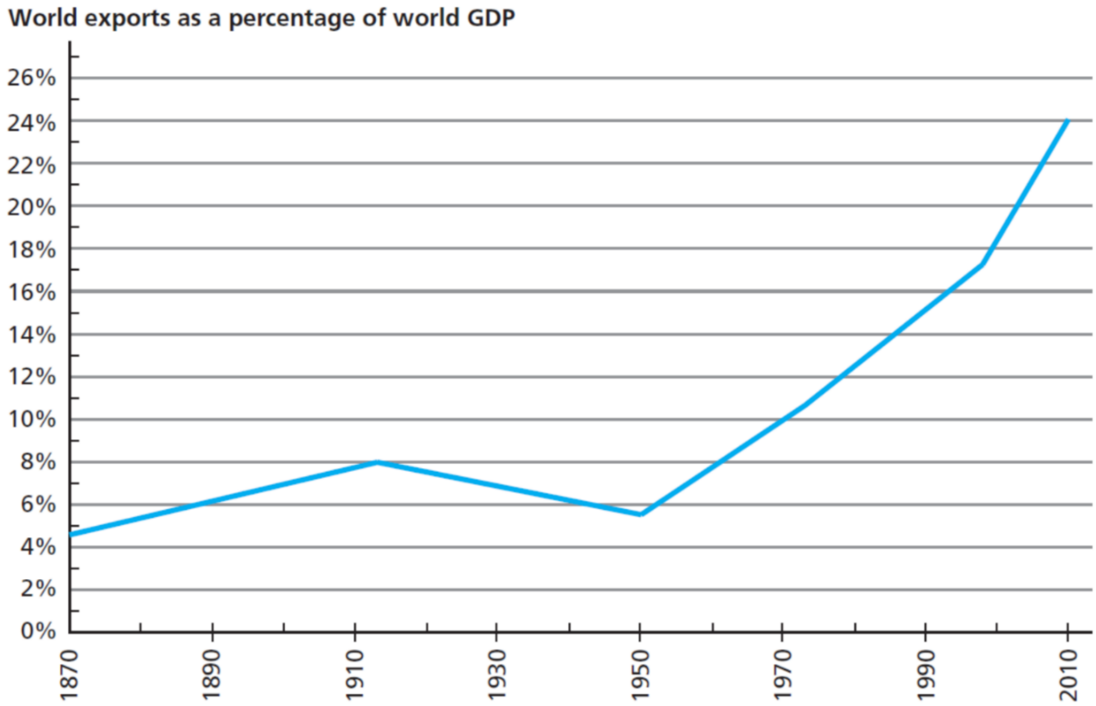


Figure 15. Relationship between VAMF and the share of total exports in GDP



Note: Maddison (2001) recited from Weil (2013)

Figure 16. Ratio of Exports to GDP

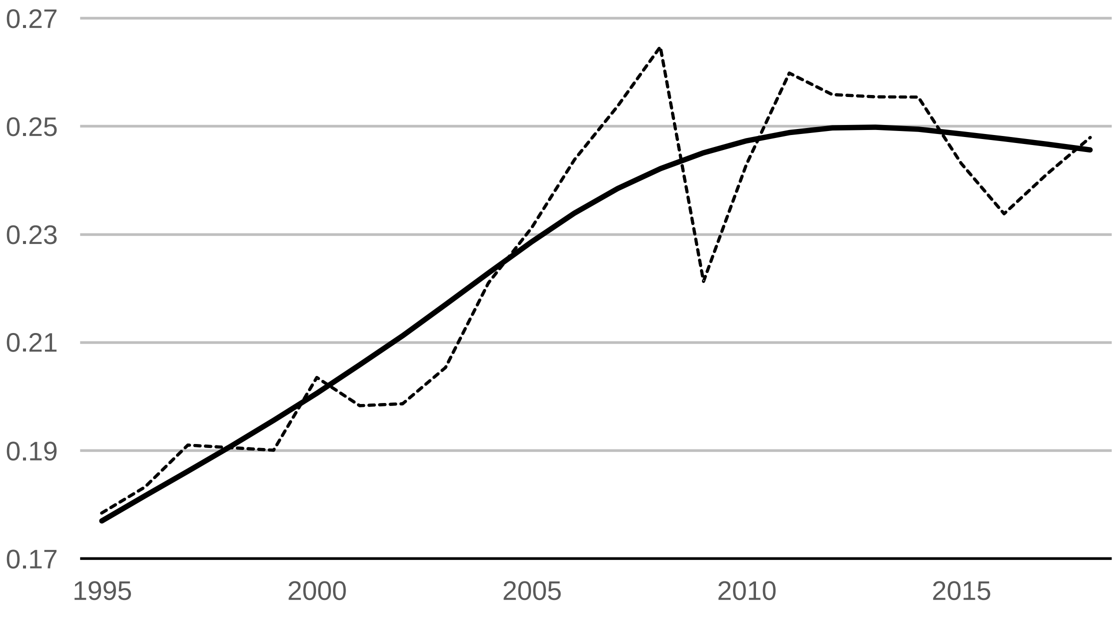


Figure 17. Ratio of Exports to GDP

Figure 18. Share of Imported intermediate Input out of Total Cost (a^m)

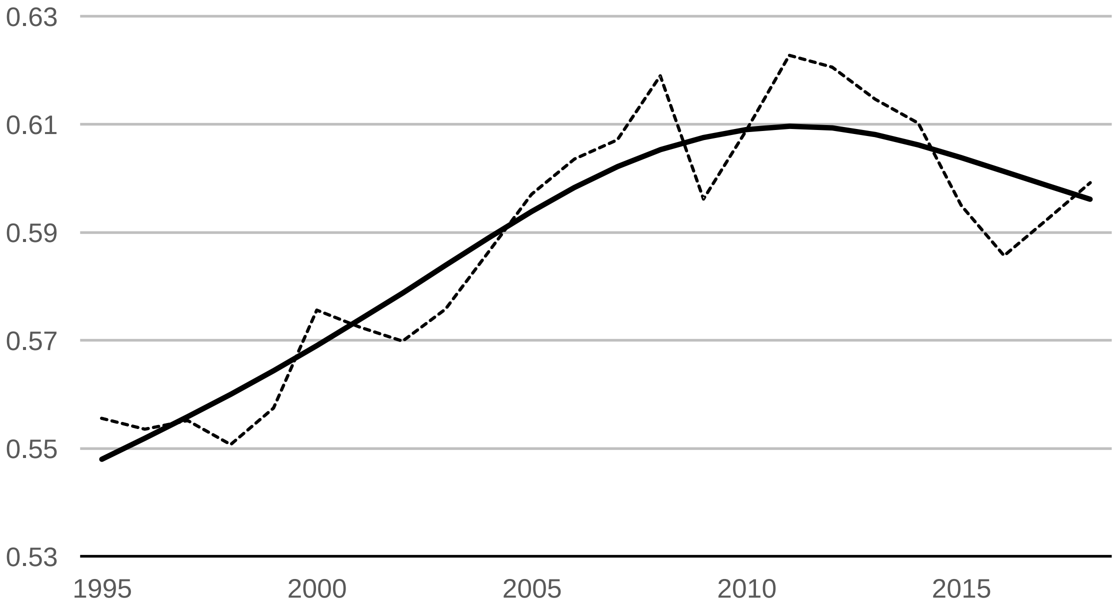


Figure 19. Share of Imported intermediate Input out of Total Imports ($\frac{x^m}{m}$)

Figure 20. Ratio of Total Imports to Gross Output ($\frac{m}{x}$)