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Intra-industry fragmentation: Bilateral value added in electronics exports

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HIGHLIGHTS

- This letter investigates intra-industry fragmentation in electronics exports.
- It provides bilateral value added for measuring intra-industry fragmentation.
- Novel visual representations of intra-industry fragmentation are presented.

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ABSTRACT

This letter provides an indicator of home value added in foreign exports (HVAF) generated from foreign value chains, which is utilized herein with the existing measure of foreign value added in home exports (FVAH), to investigate intra-industry fragmentation in electronics exports. The HVAF/FVAH ratio is used to measure bilateral value added in exports and interdependence on intermediate inputs within the electronics industry. Novel visual representations of intra-industry fragmentation are presented.

1. Introduction

Issues of international fragmentation have attracted considerable attention in the past two decades. New measures of international fragmentation have been developed since the release of the world input–output database (WIOD), which was funded by the European Commission.[1] For instance, Foster-McGregor and Stehrer (2013) in this Letter provided an approach to decomposing the value added content of trade, and suggested various indicators of international fragmentation. The foreign value added in exports is used therein to measure international production fragmentation, i.e., the contribution for foreign countries providing intermediates in a country's production chains; see Koopman et al. (2014) and Stehrer (2012) for more measures on value added in exports. However, the extent to which a country benefits from international fragmentation and, specifically, the value added that a country might capture from foreign production chains, is less well known. This letter, following the Foster-McGregor and Stehrer's framework, provides a modified indicator from their domestic value added in imports, the home value added (embodied) in foreign exports (abbreviated as HVAF), which is used herein with the existing measure of foreign value added in home exports (FVAH, which is denoted as FVA in Foster-McGregor and Stehrer's work), to observe patterns of international fragmentation and their interdependence on intermediates *within* an industry.

Production in any industry in the global network requires inter-industry and intra-industry intermediate inputs—both domestic and foreign. In contrast to the literature, this letter focuses on the extent of intra-industry fragmentation, neglecting all value added, generated from an industry's exports, that accrues to the other industries, either domestic or foreign. The electronics industry is

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[1] Before the release of the WIOD, international fragmentation was frequently measured on the basis of national input–output tables, see Hummels et al. (2001) and Feenstra and Hanson (1999).

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selected as a case study because the volume of global electronics exports in 2011 was US$ 2.49 trillion,[2] making this industry the largest of 14 manufacturing industries.

2. Measuring international fragmentation

Foster-McGregor and Stehrer (2013) provided diverse value added shares of one country's export and import as a means of measuring international fragmentation. Based on a slightly revised version of their notation, a three-country and single-industry aggregate framework is used to illustrate the value added contents of exports as follows.

$$\hat{\mathbf{v}} \times \mathbf{L} \times \hat{\mathbf{x}} = \begin{pmatrix} v^1 & 0 & 0 \\ 0 & v^2 & 0 \\ 0 & 0 & v^3 \end{pmatrix} \times \begin{pmatrix} l^{11} & l^{12} & l^{13} \\ l^{21} & l^{22} & l^{23} \\ l^{31} & l^{32} & l^{33} \end{pmatrix} \times \begin{pmatrix} x^1 & 0 & 0 \\ 0 & x^2 & 0 \\ 0 & 0 & x^3 \end{pmatrix} = \begin{pmatrix} v^1 l^{11} x^1 & v^1 l^{12} x^2 & v^1 l^{13} x^3 \\ v^2 l^{21} x^1 & v^2 l^{22} x^2 & v^2 l^{23} x^3 \\ v^3 l^{31} x^1 & v^3 l^{32} x^2 & v^3 l^{33} x^3 \end{pmatrix} \quad (1)$$

where the diagonal of $\hat{\mathbf{x}}$ comprises the volume of exports of each industry/country. The diagonal of $\hat{\mathbf{v}}$ denotes value added over gross output ratios. $\mathbf{L}$ is the well-known Leontief inverse matrix.

With reference to Eq. (1), to export and produce the amount x^1, industry/country 1 requires direct and indirect intermediate inputs from all industries/countries. Column one in Eq. (1) presents the values added that accrue to all industries/countries that are involved in the production chain of x^1. The total value added that is generated from x^1 equals the sum over column one whose first entry ($v^1 l^{11} x^1$) denotes the domestic value added in home exports (abbreviated as DVAH) and the sum of the remaining entries is called the foreign value added in home exports (FVAH). The ratio of the FVAH of the value chain x^1 over its total value added, or the value of x^1, is the FVAH share (FVAHS); similarly, the ratio of the DVAH of the value chain x^1 is called the DVAH share, denoted as DVAHS.

Furthermore, $v^1 l^{12} x^2$ ($v^1 l^{13} x^3$) in Eq. (1) is the value added that is captured by country 1, which supplies direct and indirect intermediates that are required by country 2 (3) when x^2 (x^3) is produced and exported by country 2 (3) to the *world*. In this letter $v^1 l^{12} x^2$ and $v^1 l^{13} x^3$ denote country 1's home value added (embodied) in foreign exports, HVAF, which is akin to the domestic value added in imports, DVAiM, in Foster-McGregor and Stehrer (2013). Specifically, country 1's home value added (embodied) in country 2's exports x^2, $v^1 l^{12} x^2$ in Eq. (1), equals $v^1 l^{12} x^{21} + v^1 l^{12} x^{23}$, where x^{21} and x^{23} denote country 2's exports to country 1 and 3 by Foster-McGregor and Stehrer who denote country 1's domestic value added in imports from country 2 as $v^1 l^{12} x^{21}$. In this letter the HVAF which is extended from DVAiM is a more appropriate indicator to measure the value added that accrues to a country involved in the global value chain. For instance, in 2011, the total home value added in foreign exports (HVAF) that was captured by the US as a result of the exports of other countries to the world, presented herein, is 49.7 times that received by the US due to exports by other countries only to the US, whose measure was suggested by Foster-McGregor and Stehrer (2013).[3] The importance of a country's home value added that is generated from foreign exports is expressed as a share of total value added (including the domestic counterpart $v^1 l^{11} x^1$) for country 1 captured from all value chains: the share of home value added in foreign exports (HVAFS) for country 1 is the sum of $v^1 l^{12} x^2$ and $v^1 l^{13} x^3$ over the sum of row one as described by Eq. (1).

This letter concerns the intra-industry fragmentation of the electronics industry. Based on the WIOD database, both measures of FVAH and HVAF of electronics exports in a particular country r can be expressed in general form. The world input–output table involves 41 countries, each with 35 industries over the years 1995–2011, see Timmer et al. (2015) and Dietzenbacher et al. (2013). The intra-industry FVAH for the electronic exports of country r is expressed as $\mathbf{v}^{-r}\mathbf{L}\mathbf{x}^r$, where $\mathbf{x}^r$ ($r = 1, 41$) has dimension 1435×1, with only one entry for the volume of the electronic exports of country r to the world and zeros elsewhere, and $\mathbf{v}^{-r}$ has dimension 1×1435, with 40 value added ratios for the remaining electronics industries of non-r countries and zeros elsewhere. Therefore, FVAHS equals $\mathbf{v}^{-r}\mathbf{L}\mathbf{x}^r / \mathbf{v}\mathbf{L}\mathbf{x}^r$, where $\mathbf{v}$ includes 41 electronic value added ratios and zeros elsewhere.

Similarly, the intra-industry HVAF for the electronics industry of country r is $\mathbf{v}^r\mathbf{L}\mathbf{x}^{-r}$, where $\mathbf{x}^{-r}$ is a vector with 40 values of electronic exports of non-r countries, zeros elsewhere; $\mathbf{v}^r$ is the vector with only one value added ratio for electronics of country r, zeros elsewhere. Hence, the intra-industry HVAFS is expressed as $\mathbf{v}^r\mathbf{L}\mathbf{x}^{-r} / \mathbf{v}^r\mathbf{L}\mathbf{x}$, where $\mathbf{x}$ is the vector of electronic exports for all 41 countries. The HVAFS measures not only the share of home value added acquired by a country from foreign production chains over the total value added that is generated from all electronics production chains, but also the benefits that a country might capture from the international fragmentation of foreign production chains. Specifically, in the notation in Eq. (1), country r's HVAFS is

$$\frac{\mathbf{v}^r\mathbf{L}\mathbf{x}^{-r}}{\mathbf{v}^r\mathbf{L}\mathbf{x}} = \left[\sum_{s \neq r} \frac{v^r l^{rs} x^s}{x^s} \times \frac{x^s}{\sum_{\forall j} x^j} \right] \times \frac{\sum_{\forall j} x^j}{\mathbf{v}^r\mathbf{L}\mathbf{x}}, \quad r, s, j = 1, 2, 3$$

where the first term in brackets is the FVAHS that accrues to country r from the electronics exports of country s; the sum of product of two terms in brackets is the weighted average FVAHS that accrues to country r, which measures the importance in terms of value added captured by country r in the production chains of non-r countries.

To study the fragmentation of production for a region of many countries, the measures defined above must be slightly modified. The home value added in foreign exports share of a region with many countries is expressed as HVAFS $= \sum_j \theta_j \text{HVAFS}_j$, where HVAFS_j is country j's home value added in foreign exports share, and θ_j is country j's share of the total value added (the sum of all countries' HVAF and DVAH in the region) that accrues to the region to which the country belongs. Similarly, the foreign value added in home exports share of a region is defined as FVAHS $= \sum_j \theta_j' \text{FVAHS}_j$, where FVAHS_j is country j's foreign value added in home exports share, and θ_j' is country j's share of the total value added (the sum of FVAH and DVAH of all countries in the region) that is generated by the regional electronic exports.

A novel indicator for a region, the intra-industry HVAF/FVAH ratio, is readily obtained by combining simultaneously bilateral value added flows. Since a region consists of many countries, a region's HVAF that is gained from the production of electronic exports outside the region can be obtained directly as the product of the region's HVAFS and the total value added that is captured by the region. The latter, in turn, is the region's DVAH divided by the regional domestic value added share, which equals 1 − HVAFS. Accordingly, a region's HVAF equals HVAFS[DVAH/(1 − HVAFS)].

[2] Author's calculations based on the WIOD data.

[3] Author's calculations using 2011 WIOD data.