Economics Letters 120 (2013) 354–357

Contents lists available at SciVerse ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

Value added content of trade: A comprehensive approach

Neil Foster-McGregor [1], Robert Stehrer *,[1]

The Vienna Institute for International Economic Studies – wiiw, Rahlgasse 3, A-1060 Vienna, Austria

HIGHLIGHTS

- The letter provides an approach to measure value added content of exports and imports.
- It discusses how this relates to other recent literature.
- It provides results over time based on a new database.

ARTICLE INFO

Article history:
Received 12 October 2012
Received in revised form
29 April 2013
Accepted 3 May 2013
Available online 9 May 2013

JEL classification:
F1
F15
F19

Keywords:
Value added trade
Vertical specialization
Factor content of trade

ABSTRACT

This letter provides an approach to decompose the value added content of trade into foreign and domestic components when intermediates are traded. The measure adds to the existing literature by considering both exports and imports simultaneously. In this way this approach generalizes the commonly applied vertical specialization measures based on exports only which are encompassed.

1. Introduction

The flows of value added across countries rather than goods have become an increasingly debated topic due to the rapid international integration of production processes. Empirically the challenge remains to properly measure this ongoing integration of production processes and its consequences for trade flows. The literature includes case studies for products like the iPod, studies of trade patterns in particular products such as 'parts and components' and studies of trade in intermediates based on national and import IO tables or – more recently – global input–output tables focusing on vertical specialization, value added embodied in a country's exports or value added absorbed in final consumption abroad (Hummels et al., 2001; Daudin et al., 2011; Johnson and Noguera, 2012; Koopman et al., forthcoming). Based on recent approaches measuring the factor content of trade when accounting for intermediates trade and in particular the contribution by Trefler and Zhu (2010) we introduce an approach to decompose trade flows into value added which can be related to contributions mentioned above.

2. Measuring value added and factor content of trade

In the literature measuring the vertical integration of production processes the main focus is on exports (e.g. measuring the 'import content of exports'). Literature focusing on the effects of offshoring however often focuses on the import side only. This paper suggests a more comprehensive approach considering both imports and exports simultaneously by adopting a method similar to that in Trefler and Zhu (2010) of calculating the factor content of trade in a Vanek-consistent way with two modifications: Firstly, value added to gross output ratios are used rather than physical input coefficients, meaning that one not only allows for cross-country and cross-industry differences in direct and indirect input coefficients but also for differences in factor rewards. These

* Corresponding author. Tel.: +43 1 5336610 47; fax: +43 1 5336610 50.
E-mail address: Robert.Stehrer@wiiw.ac.at (R. Stehrer).

[1] http://www.wiiw.ac.at.

0165-1765/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.econlet.2013.05.003

two approaches are therefore linked as the physical inputs multiplied by factor prices and summed over all factors are equal to value added. Secondly, rather than calculating net trade only (in value added or of particular factors in physical terms) the approach can be used to derive measures of value added trade in line with measures of vertical integration and the value added content of trade.

The starting point is indicators of the ratio of value added to gross output denoted by a vector $\mathbf{v}$ with dimension $NC \times 1$ where C is the number of countries and N the number of industries. The Leontief inverse of the global input–output matrix is expressed as $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$ with $\mathbf{A}$ denoting the global coefficients matrix. Both matrices have dimension $NC \times NC$. The vector of country r's exports, denoted by $\mathbf{x}^r$, is of dimension $NC \times 1$ and contains positive entries for country r's exports to all other countries and zeros otherwise. Similarly, the vector of country r's imports, $\mathbf{m}^r$, contains positive entries for imports of country r from the respective partner. Following Trefler and Zhu (2010) the trade vector for country r is defined as $\mathbf{t}^r = \mathbf{x}^r - \mathbf{m}^r$. For example, for country 1 this vector looks like $\mathbf{t}^1 = (x^{1*}, -x^{21}, -x^{31})'$ with $x^{1*} = x^{12} + x^{13}$, where x^{rs} denotes country r's exports to s. Note, that the column sum of the trade vector, $\mathbf{1}'\mathbf{t}^r$, is country r's net trade in gross terms with $\mathbf{1}$ denoting a summation vector. The net value added content of country r's trade, $\mathbf{v}'\mathbf{L}\mathbf{t}^r$, equals a country's net trade in gross terms by realizing that $\mathbf{v}' = \mathbf{1}'(\mathbf{I} - \mathbf{A})$ (see Stehrer (2012)).

For the suggested decomposition one requires the individual entries of the matrix capturing exports and imports of country r which is achieved by diagonalizing the value added coefficients and trade vector, i.e. $\mathbf{T}_V^r = \hat{\mathbf{v}}\mathbf{L}\hat{\mathbf{t}}^r$ where a 'hat' indicates the diagonalization of the respective vectors. In the simple case of three countries and only one industry aggregate this would result in the following value added trade matrix (for country 1):

$$\mathbf{T}_V^1 = \begin{pmatrix} v^1 & 0 & 0 \\ 0 & v^2 & 0 \\ 0 & 0 & v^3 \end{pmatrix} \begin{pmatrix} l^{11} & l^{12} & l^{13} \\ l^{21} & l^{22} & l^{23} \\ l^{31} & l^{32} & l^{33} \end{pmatrix} \times \begin{pmatrix} x^{1*} & 0 & 0 \\ 0 & -x^{21} & 0 \\ 0 & 0 & -x^{31} \end{pmatrix} = \begin{pmatrix} v^1 l^{11} x^{1*} & -v^1 l^{12} x^{21} & -v^1 l^{13} x^{31} \\ v^2 l^{21} x^{1*} & -v^2 l^{22} x^{21} & -v^2 l^{23} x^{31} \\ v^3 l^{31} x^{1*} & -v^3 l^{32} x^{21} & -v^3 l^{33} x^{31} \end{pmatrix}.$$

The first matrix contains the value added coefficients of the three countries, the second matrix denotes the elements of the Leontief inverse from the global input–output matrix and the last matrix contains exports and imports as defined above. Summing up this matrix over rows and columns equals country 1's net trade in gross and value added terms as $\mathbf{1}'\mathbf{T}_V^1\mathbf{1} = \mathbf{v}'\mathbf{L}\mathbf{t}^1 = \mathbf{1}'\mathbf{t}^1$.

It is informative to discuss the entries in the matrix separately. The first column in matrix $\mathbf{T}_V^1$ describes value added contained in the exports of country 1. The first entry, $v^1 l^{11} x^{1*}$, denotes the direct and indirect value added content of country 1's exports to all other countries (domestic VA in exports, DVAiX). Koopman et al. (forthcoming) discuss further decompositions of this term. More generally, using the notation above this can be written as $\text{DVAiX}^r = \mathbf{v}^r\mathbf{L}\mathbf{x}^r$ with $\mathbf{v}^r$ denoting a row coefficients vector with non-negative entries for country r and zeros otherwise. The production of these exports also requires inputs from other countries which creates value added (i.e. factor income) in the other countries. This is captured by the remaining terms in the first column by partner country, i.e. $\sum_{p=2,3} v^p l^{p1} x^{1*}$ (foreign VA in exports, FVAiX), or in general terms, $\text{FVAiX}^r = \mathbf{v}^{-r}\mathbf{L}\mathbf{x}^r$ with $\mathbf{v}^{-r} = \mathbf{v}' - \mathbf{v}^r$. This term can be interpreted as a measure of vertical integration on a value added basis (see Hummels et al. (2001)). Using a country's total exports, i.e. including intermediates, might be considered to be not innocent as usually in input–output modelling one post-multiplies the Leontief inverse with a vector of final demand. However, from a single country perspective as is envisaged here, total exports (i.e. including intermediates) are considered as exogenous final demand in line with national accounting and the aim is to measure value added which is created domestically due to its total exports. As a counter-example let us consider a country which would export only intermediates (e.g. an oil-producing country). If one were to post-multiply with final goods exports only this country would neither export domestic nor foreign value added which cannot be the case by definition. Using total exports is also in line with the literature. E.g. Hummels et al. (2001) calculate the import content of (total) exports and the approach in Koopman et al. (forthcoming) decomposes a country's total exports into the domestic content – consisting of three types of value added exports (VAX) as defined in Johnson and Noguera (2012) and the returned value added which are further discussed below – and the foreign content; see also Stehrer (2013) for an in-depth discussion in a bilateral setting.

The next two columns capture the value added content of country 1's imports. The imports of country 1 from 2 and 3 embody value added created in countries 2 and 3, respectively. The elements of the diagonal in the import block therefore contain the partner country's value added content of bilateral imports, $\sum_{p=2,3} v^p l^{pp} x^{p1}$ (bilateral foreign VA in imports, BVAiM), or in general notation $\text{BVAiM}^r = \text{trace}(\mathbf{R}\widehat{\mathbf{v}^{-r}}\mathbf{L}\widehat{\mathbf{m}^r}\mathbf{R}')$, with $\mathbf{R}$ denoting a summation matrix to first sum up over industries. Imports of country 1 from the others also require inputs from country 1 itself (as, e.g., country 2 exports also embody value added from the other countries). Therefore, the elements in the first row of the second and third column capture country 1's value added embodied in imports from country 2 and 3 (re-imports of VA or "domestic VA in imports", DVAiM). This is also referred to as 'returned domestic VA' in either final or intermediate goods (Koopman et al., forthcoming). Total re-imports of value added are therefore $\sum_{p=2,3} v^1 l^{1p} x^{p1}$, or more generally, $\text{DVAiM}^r = \mathbf{v}^r\mathbf{L}\mathbf{m}^r$. This term is akin to the VS1* measure as suggested in Daudin et al. (2011). When subtracting the re-imported VA from the domestic content of exports one arrives at the value added exports as defined in Johnson and Noguera (2012), i.e. $\text{VAX}^r = \text{DVAiX}^r - \text{DVAiM}^r = \mathbf{v}^r\mathbf{L}\mathbf{t}^r$. Finally, country 1's imports from countries 2 and 3 also require inputs from the other countries 3 and 2, respectively. Thus, for example, the entry in row three of the second column captures country 3's value added embodied in country 1's imports from country 2. The total amount of value added imports from other countries is given by $\sum_{p,q=2,3} v^p l^{pq} x^{q1}$ (foreign value added in imports, FVAiM), or $\text{FVAiM}^r = \mathbf{v}^{-r}\mathbf{L}\mathbf{m}^r$. Subtracting BVAiM^r provides a measure of VA from a third country embodied in imports of this country from the direct trading partner (multilateral foreign VA in imports, MVAiM); formally $\text{MVAiM}^r = \text{FVAiM}^r - \text{BVAiM}^r$.

3. The value added content of trade since 1995

The calculation of these indicators requires a global input–output table capturing all bilateral flows of goods and services both for intermediate and final use. We use the recently compiled WIOD database which provides such data for 41 countries and 35 industries over the period 1995–2011 available at www.wiod.org (see Dietzenbacher et al. (2013)).

Figs. 1 and 2 provide these shares according to our decomposition into the five components showing the foreign value added in exports (FVAiX) and the multilateral foreign value added content of imports (MVAiM).

These former shares range from more than 60% in the case of the Netherlands to levels of about 15% in the US, 12% in Brazil and 6%