Trending Trades: Investigating Comparative Advantage through Vertical Specialization in Supply Chains

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Introduction

In 1980, Milton Friedman introduced everyday viewers of a PBS special entitled “Free to Choose” to the power of a free market. While the length of the entire PBS series was around ten hours and covered a broad range of economics, in a brief segment spanning less than three minutes, Friedman distilled the power of free trade into the production of a single, everyday object.

Taking an ordinary pencil, Friedman claimed that not a single person in the world could reproduce such a writing utensil. To prove this, Friedman broke apart each component. First, he noted that the wood likely came from a tree in Washington. To cut down this tree, someone needed a saw, requiring steel. The steel in turn required mining and smelting iron ore. Moving on to the compressed graphite core, Friedman speculated that it most likely was mined in South America. The rubber eraser, he hypothesized, originated in Malaya using rubber trees import from South America. He commented similarly on the metal ferrule, yellow and black paint, and glue. Each of these components required specialized skills, access to raw materials, and particular tools that would be nearly impossible for a single person to posses. Yet, Milton held up one such well-made pencil that cost mere pennies.

The thousands of people who cooperate across time and space to produce this good never know each other. Nor are they under the direction of any manager from some central office. Instead, they are each connected by the “magic of the price system,” a global supply chain that links together inputs form across the planet to create a single item. This “impersonal operation of prices” brings people together such that a consumer can trade a few minutes of their time for a few seconds of time from all those thousands of people who work in conjunction to create a pencil.[1]

The magic that Friedman observed in the creation of a pencil is a common occurrence in today’s globalized market that witnesses goods in constant motion across borders. Raw materials are converted into intermediate goods that in turn are transformed into finished products. While this process once

[1] Milton Friedman’s “The Power of the Market” from the “Free to Choose” special (1980)

existed within the confines of a single country's borders, the changing nature of manufacturing has reshaped the mechanisms by which goods are produced.

For industries that have many inputs, such as high-tech products or the automobile-industry, the list of components and countries that touch the manufacturing process is extensive. It can be difficult to separate out the effects that each country has on a given good. While products used in developed countries might be stamped with "MADE IN CHINA," this label merely reflects the final exporter, the country that lists the completed item on their gross exports.

Yet, China's exports do not always represent the full value that has been added in a good's production. When China only participates in the last step of production, it does not make sense to credit China with the full value encapsulated in that good. Instead, China merely adds value in the final assembly of these products. Cars, computers, and clothing rolling off assembly lines are often not designed within final exporters' countries. China does not hold a comparative advantage in all of these products merely because it is the final exporter. Instead, China holds a comparative advantage in the final stages of production for goods that are imported in intermediate stages from other countries.

Supply chains that operate on a global scale change the scope of comparative advantage. The general theory of comparative advantage as formulated by Ricardo (1817), and extended by others, has largely neglected the use of intermediate inputs in models with many countries and many commodities.[2] In the 1970s, there was revived work on including intermediate trade but this was still restricted to the Heckscher–Ohlin model with limited countries or commodities considered.[3] As Shiozawa notes, even "the standard Heckscher-Ohlin theory is not well fitted to analyze intra-industry trade."[4] More recent work, mainly in the past ten years, has seen the successful integration of the theory with the generalized models of comparative advantage.

[2] Shiozawa 2007
[3] Schweinberger 1975
[4] Shiozawa 2007

On the empirical side, excluding intermediates is akin to only using gross export statistics to measure which countries have comparative advantages in producing given products. Exclusively evaluating countries' productivity based on gross exports misrepresents their economic contributions and relative advantages over other countries.[5] To combat this skewed perception, each section of the supply chain must be broken down to reflect the fragmentation inherent in the globalized production process. The goal of understanding comparative advantage within each stage of production is accomplished by isolating where each country adds value at each step of a good's journey from raw material to finished product.

With incorrect assessments of value-added trade measurements, policymakers may implement protectionist trade policies that can hurt the very industries and economies that the policies aim to protect. Similarly, policymakers may lack an understanding of the movement of intermediates necessary to facilitate the production of goods in their home country. This may similarly lead to poor policies. The goal of this paper is to provide a better lens with which to view trade between countries and comparative advantage. This will in turn help policymakers create well informed trade policies as well as reveal trends within international trade.

The value of deconstructing the supply chain into value-added stages and the danger of evaluating trade based solely on gross exports has been recognized in earlier literature. However, the cautionary messages presented thus far use small windows of data to analyze either single products or economies over the course of a single period. Thus, previous publications are unable to investigate the changing landscape in comparative advantages between countries. This paper investigates these changes and identifies trends within value-added supply chains. This enlightens the discourse over policies and the geo-political debate by describing how comparative advantage has evolved over time.

[5] Ali-Yrkko et al. 2011

Literature Review

Previous literature on comparative advantage and value-added supply chains can be divided into two main camps: papers using individual case studies to give a microeconomic picture and papers using data on country input-output tables to give a macroeconomic picture. Dai (2013) provides a good exposition of these two areas which is followed below. The first area explored is using the micro level approach.

As a simple and straightforward method for understanding global production chains, case studies detail the discrepancy between gross and value-added trade. To accomplish this, authors use detailed micro data for a single product or sector. In 2008, Dedrick et al. examined the supply chain for three major IT companies, Apple, HP, and Lenovo. Using industry analyst estimates and internal company data, they found that Apple's iPod was the product that captured the largest value-added for its parent company yet the value-added that China, its final exported, captured was very small, less than 3%.[6] All companies' products experienced similar discrepancies between gross and value-added trade. In 2011, Ali-Yrkko et al. performed a similar investigation into smartphones by tracking the production of a Nokia model from 2007. The results showed that developed countries capture the vast majority of value-added from production over developing countries.[7]

While case studies provide a picture of global production chains in particular industries, they lack a comprehensive view of the gap between value-added and gross trade within economies' cross-border production chains due to their inherent focus on small scopes. Furthermore, they do not illustrate trends in comparative advantage since they only investigate single periods of time. This paper demonstrates how a value-added approach provides a better picture of comparative advantage in fragmented industries as well as the evolution of these advantages between countries over time.

[6] Dedrick et al. 2008
[7] Ali-Yrkko et al. 2011

A more complete approach to tracking value-added production can be accomplished on a macro level by using input-output tables. Such tables provide a "comprehensive and methodical approach to decomposing a country's gross exports into exports of value-added and double counted terms such as imported foreign intermediates." These double counted terms are known as such since they are already counted in a country's gross exports. For instance, if a country exports a good containing imported components, then the components are considered double counted in the country's gross exports.[8]

Input-output tables quantify the way in which a given industry utilizes inputs from other domestic and foreign industries. This is in contrast to case studies that look at a single good in a given sector. Such a difference allows for this approach to more accurately describe the value-added chains because it considers the value-added of all preceding stages of inputs, not just the first and intermediate ones.

The literature around input-output tables can be divided into two main camps. The first approach uses the tables in order to break apart value-added production while the second breaks apart gross exports into the value-added and double counted terms mentioned above. The first strand has largely been influenced by Timmer et al. who released a paper in 2012 that introduced a new measurement into the literature. This indicator, global value chain (GVC) income, is the value that is added by a country in any activity during the production process of a particular good.[9] When a given good is produced in a global production network, each country adds value in accordance with the activity carried out at a given stage of production.[10] The GVC income for developed counties has been declining over time, with a reverse trend occurring in developing countries.[11] Timmer et al. demonstrated that this metric can then be used to measure a country's comparative advantage against others in its industries. This was accomplished by using a given country's share in the GVC income

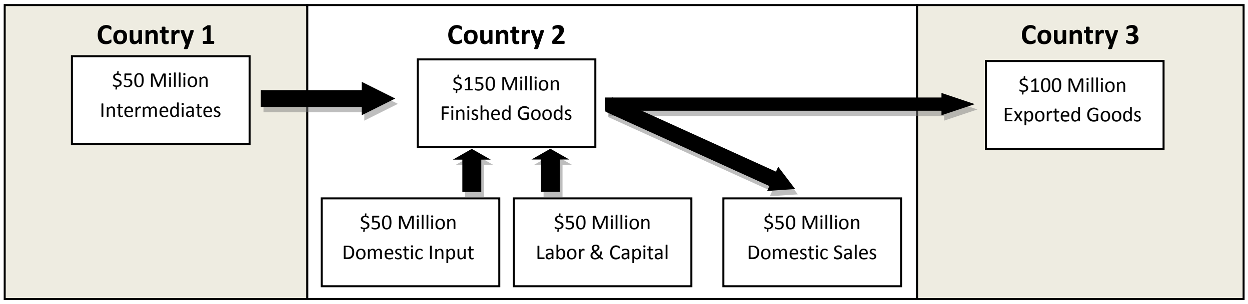
[8] Wei 2012
[9] Timmer et al. 2012b
[10] Timmer et al. 2012a
[11] Timmer et al. 2012c

indicator to demonstrate its competitive strength. However, one of the shortfalls that Timmer et al. recognize in this metric is the effect induced by a country's size.

The second camp of literature uses input-output tables to look at gross exports in terms of its value-added and double counted components in order to track the degree of fragmentation with a supply. Another term for such fragmentation, or cross-border specialization, is vertical specialization. At its basic level, vertical specialization is a country's use of imported inputs in producing exported goods. This term is defined by Hummels et al. 2001 to also include the export of intermediates to be used as inputs by other countries to produce goods for exports.[12] Thus, for a given country, the term can be defined as the fraction of gross production that is imported as an input multiplied by the country's exports multiplied by two. The reason for multiplying by two is the inclusion of the exports of intermediates. Imported inputs are counted twice since they are included as imports and embodied within exports. As the fraction of exported gross production increases, vertical specialization increases as well.

To illustrate this metric with an example from Hummels et al., assume three countries and one good as shown in the Figure below. Country 1 exports $50 million of intermediate goods to Country 2 and then Country 2 uses $50 million of domestic intermediates and $50 worth million of domestic labor and capital. Then Country 2 exports $100 million of finished goods to Country 3. Vertical specialization is thus ($50/$150) x $100 x 2 = $200/3 million, twice the value of imported inputs embodied within exports. Since Country 2 has a total trade of $150 million, vertical specialization-based trade accounts for 44% of its total trade. If the imported intermediates are not used to produce goods that are exported, the imports do not count towards vertical specialization.[13]

[12] Hummels et al. 2001
[13] Hummels et al. 1998



Hummels et al. find that vertical specialization has grown by up to 40% in the twenty-five years before the turn of the century and furthermore, they find that it accounts for up to 30% of world exports.[14] They attribute the large role played by vertical specialization to trade barriers so even small improvements in transportation technologies or changes in protectionist policies can lead to greatly increased cross-border specializing.[15]

Koopman et al. point out that Hummels et al. use a methodology that assumes imported intermediates contain no domestic inputs and thus underestimate the domestic value-added (DV) in exports.[16] This paper's framework more accurately estimates domestic value-added in exports by allowing for domestic content to be contained within imported intermediates.

Looking to improve on other shortcomings in the work of Hummels et al., Johnson and Noguera use a new metric to measure vertical specialization. This attribute, the VAX ratio, is the ratio of value-added to gross exports.[17] Using this new tool, Johnson and Noguera reveal that the VAX ratio has declined over the past forty years.[18] Specifically, they find that in the 1970's and 1990's there are two

[14] Hummels et al. 2001
[15] Ibid
[16] Koopman et al. 2012.
[17] Johnson and Noguera 2012a
[18] Johnson and Noguera 2012b

periods of major decline with the VAX ratio. They note that these periods correspond to periods of striking increases in vertical specialization.[19]

While Johnson and Noguen demonstrate the change in vertical specialization over a long period, they only focus on this VAX ratio. This means their model ignores double counted terms in gross exports. By doing so, the authors neither provide an estimate for the positioning of countries within global supply chains nor shows the evolution of vertical specialization, beyond the end result that it has gone up over the period. By instead investigating the structure of both double counted terms and a given country's value-added exports, this paper shows the relative positioning of companies along the supply chain and shows how trends have been changing over time.

The reason that previous literature has neglected the issues of trends in comparative advantage is due to a dearth of data. The recent release of the World Input-Output Database (WIOD) now allows for the fragmented process of production in a globalized economy to be teased apart and investigated as a series of value-added stages across a worldwide network of countries. The database provides a 17 year window of annual time series input-output tables that break apart the globalized supply chain in over 30 industries.

Data

The World Input-Output Database is a recently released trove of data created by the European Commission that can be used to analyze the fragmentation of production across borders. It brings together three forms of data: national accounts, supply and use I/O tables, and socio-economic accounts. The world input-output tables use this information to show detailed flows of intermediate and

[19] Ibid

final goods around the globe. The database covers 40 countries, as well as a measure for the rest of the world, from 1995 to 2011. A list of countries can be found in Appendix A.

The WIOD provides an improved dataset compared to others used in previous literate by providing data over an extended period collected using a consistent method. Earlier databases either had limited windows of data or used incompatible metrics that prevented them from being easily combined. The WIOD also does not rely on standard assumptions for import proportionality to calculate imported intermediates that are used to produce one unit of output.[20] The WOID relaxes the assumption that “an industry uses an import of a particular product in proportion to its total use of that product”[21]. For instance, if an industry uses a given raw material and X per cent of all of that raw material is imported, it is assumed that X per cent of the raw material is used in production is imported.

The goal of an input-output table is to measure the flows of goods into and out of industries and economies. This begins on a national scale as can been seen in the “Schematic Outline of National Input-Output Table” in Appendix A. It assumes that each industry only produces one product and the table is of the industry by industry type. As Timmer explains, “The rows in the upper parts indicate the use of products, being for intermediate or final use. Each product can be an intermediate in the production of other products (intermediate use). Final use includes domestic use (private or government consumption and investment) and exports.”[22] For a further discussion of the construction of the tables and the intuition behind their inner workings, see Timmer 2012c. Additionally, an illustration is provided in the examples section.

The WIOD uses 35 high level industries to break apart exports. A list of these industries is in the Appendix. Additionally, a simplified table is provided in Appendix A that shows a single industry shared across three countries. It demonstrates the large space of the data. With only one industry and three

[20] Timmer 2012c.
[21] Koopman et al. 2012
[22] Timmer 2012c.

countries, the space is already growing large. With the eventual 40 countries, plus a proxy, and 35 industries, the space blows up to 1435 rows and columns each. This paper uses the all seventeen annual WIOTs, one for each year, to examine the seventeen periods in the data. This allows for a consistent time series analysis that measures the evolution of each country's position within global supply chains.

Goals

The availability of the WIOD provides the opportunity for an examination into the evolution of countries role within global supply chains. This paper specifically investigates the role that the United States, China, South Korea, and Taiwan have played over the seventeen year period from 1995 to 2011. These countries were chosen to give a picture of well developed countries and developing countries that are making the transition to developing countries.

This paper provides an updated description of the evolution of roles that the United States, China, South Korea, and Taiwan have had over the past seventeen years. A shift to more upstream production will be shown for the emerging economies while the data for the United States will reveal long term trends that diverge from traditional gross exports numbers when understood in terms of a value-added supply chain. This paper provides a statistical analysis of the results through a regression on these trends.

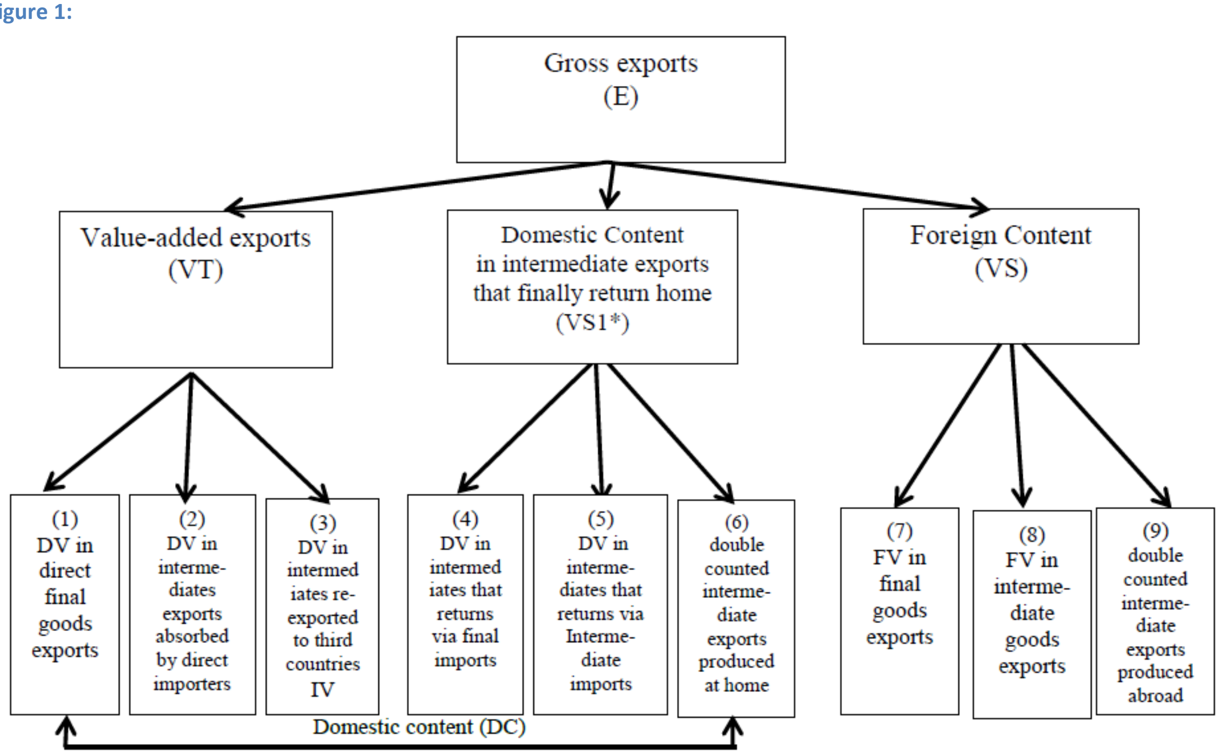
While trade is typically understood as a transfer of finished products between countries, this investigation uses Koopman et al.'s decomposition framework to measure how countries interact under global production chains. For instance, an automobile might be designed in the Unites States, manufactured in Mexico or China, and then finally assembled back in the US. This paper improves upon Koopman et al.'s work by reporting the numbers found using their framework and exploring the trends found in their work.

Equations and Methodology

In order to best understand and interpret the WIOD, this paper utilizes the framework developed by Koopman et al. 2008 and later improved upon by Koopman et al. 2014. Their model requires decomposing gross exports into their sources and destinations of value-added in order to break apart the global supply chain. While they created the model and method for decomposing gross exports, they have not published an analysis of the results as this paper does.

Figure 1 below is used by Koopman et al. to demonstrate the subdivision of exports into nine components, each grouped together into value-added exports, domestic value-added content that returns home, and foreign content incorporated in domestic exports. Value-added exports denote value that has been created domestically that is absorbed by a foreign country. Domestic content that returns home describes something that is at first exported as an intermediate good but returns home through imports. Finally, foreign content describes foreign produced intermediates that are imported into a country and later incorporated in that country's gross exports.

Figure 1:



As evidenced in Figure 1, a country's gross exports can be thought of as the result of numerous components operating under the surface. These separate mechanisms can be used to calculate different metrics used within the literature to understand a country's relative trade position. To apply this framework, Koopman et al. 2014 utilize various equations. For a full listing of the equations, the proofs of these methods, the intuition behind each equation, and a summarization of the history of these terms in the literature, refer to Koopman et al. 2014. The major equation utilized by this paper represents each of the nine terms from Figure 1 in mathematical form (Equation 36 in Koopman et al. 2014).

In addition to this equation, Koopman et al. 2014 draw attention to the two main metrics that this paper uses to evaluate comparative advantage and trade. These calculations measure vertical specialization in international trade. Hummels et al. 2001 initially introduce the terminology of vertical specialization into the literature: "a country can participate in vertical specialization in two ways: (a) uses imported intermediate inputs to produce exports; (b) exports intermediate goods that are used as inputs by other countries to produce goods for export."[23] Koopman et al. 2014 identify these two measurements as VS and VS1 respectively which are computed using Equations 38 and Equations 42 from their paper. These two equations simplify the computation needed compared with Equation 36.

Instead of calculating each term for VS, it is defined as the sum of foreign content in final goods and foreign content in intermediate goods. The second term in the last expression of VS captures the double counted portion that is accounted for in Figure 1.

Using the definition of Equation 42, VS1 is composed of four terms. The first term is domestic value-added in intermediates that is re-exported to other countries. The second term "measures how much domestic content in exported goods from the source country is used as imported inputs to

[23] Koopman et al. 2014

produce other countries' intermediate goods exports."[24] It uses Hummel at al.'s measure of VS1 in intermediates. The third term and forth terms are equal to VS1*, the middle column in Figure 1.

Other countries' exports of finished products, domestic goods used as inputs to produce foreign exports of intermediates, DV that is imported as a final good, and domestic content that returns as intermediate imports (including the double counted portion).

Methodology Examples

The following examples provide an illustration of the methodology used. The first demonstrates a simple case of two countries with a single exporter of a single intermediate good. It serves as a basic foundation with which to understand the more generalized version of multinational trade. It is used by Koopman et al. 2012 to illustrate their method. The second example breaks down the method for decomposing gross exports for a single sector in the US from 2006. Finally, the third example shows the entire US economy for the year 2006. A breakdown of VS and VS1 for the US from 1995 can also be found in Appendix B. It shows sector level data for where the US has a comparative advantage.

Example 1

In this first example, assume that there is only a single industry, transportation, and two countries, the US and China. Furthermore, assume that the two countries involved in trade have identical gross exports, identical value-added exports, and gross outputs of 200.

For the US, assume gross output is comprised of 150 unites of intermediate goods and 50 units of final goods. Of the intermediate goods, assume 100 are used domestically while 50 are exported. Of the final goods, 30 are consumed domestically and 20 are exported. The DV for the US is equal to: 100 = (value of gross exports of 200) – (value of domestic intermediate good of 100) – (value of imported intermediates of 0).

[24] Koopman et al. 2014

For China, assume gross output is comprised of 50 units of intermediate goods and 150 unties of final goods. Of the intermediate goods, assume all of the 50 units are used domestically. Of the final goods, 80 are consumed domestically and 70 are exported. The DV for China is equal to 100 = (value of gross exports of 200) - (value of domestic intermediate good of 50) – (value of imported intermediates of 50).

The information above is summarized in the figure and equations below. It can be used to construct the accompanying inter-country input output model, Leontief inverse matrix, and VB matrix:

Output / Input		Intermediate Use		Final Use	
		US	**China**	**US**	**China**
Intermediate Input	**US**	100	50	30	20
	China	0	50	70	80
Value-Added		100	100		
Total Input		200	200		

$$Total\ outputs\ for\ each\ country: Y = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 200 \\ 200 \end{bmatrix}$$

$$Block\ input-output\ coefficinet\ mattrix: A = \begin{bmatrix} 0.5 & 0.25 \\ 0 & 0.25 \end{bmatrix}$$

$$Direct\ value-added\ coefficient\ matrix:\ V = \begin{bmatrix} 0.5 & \\ 0 & 0.5 \end{bmatrix}$$

$$ICIO\ model: \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0.5 & 0.25 \\ 0 & 0.25 \end{bmatrix} \begin{bmatrix} 200 \\ 200 \end{bmatrix} + \begin{bmatrix} 30 & 20 \\ 70 & 80 \end{bmatrix}$$

$$Leontief\ inverse\ matrix: B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} 2 & 0.67 \\ 0 & 1.33 \end{bmatrix}$$

$$VB\ matrix: VB = \begin{bmatrix} 1 & 0.33 \\ 0 & 0.67 \end{bmatrix}$$

The above equations can be rearranged to create a gross exports decomposition matrix. This shows how gross output is decomposed based on where the output is ultimately absorbed:

$$\begin{bmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \end{bmatrix} = \begin{bmatrix} 2 & 0.67 \\ 0 & 1.33 \end{bmatrix} \begin{bmatrix} 30 & 20 \\ 70 & 80 \end{bmatrix} = \begin{bmatrix} 60 + 46.69 & 40 + 53.3 \\ 0 + 93.33 & 0 + 106.67 \end{bmatrix} = \begin{bmatrix} 106.67 & 93.33 \\ 93.33 & 106.67 \end{bmatrix}$$

As a quick check, the horizontal sum of the decomposed matrix is equal to the total gross export for each country ($x_{11} + x_{12} = x_1$). Below, the gross exports decomposition matrix is used to compute the value-added production matrix:

$$VBY = \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix} \begin{bmatrix} 106.7 & 93.3 \\ 93.3 & 106.7 \end{bmatrix} = \begin{bmatrix} 53.3 & 46.7 \\ 46.7 & 53.3 \end{bmatrix}$$

From this, the value-added export for the US can be seen to be 46.7 (v_1x_{12}=0.5*93.3). To further decompose this, the value-added in exported final goods absorbed by China is 20 ($v_1b_{11}y_{12}$ = 0.5*2*20) and the value-added exported as intermediate goods to China is 26.7 ($v_1b_{12}y_{22}$ = 0.5*0.667*80). Finally, the US value-added embedded in export of intermediates that eventually are consumed domestically is 23.3 ($v_1b_{12}y_{21}$=0.5*0.667*70). This is the measurement for VS1*. Yet, since there is no foreign value-added in its exports (because it does not import anything), VS is equal to 0.

This method can be replicated for China and produces the chart below. Since both countries were assumed to have identical gross exports and exports of value-added, their VAX ratios are the same. To compute these, the sum of VS and VS1* (23.3 for both countries) is subtracted from gross exports (70 for both countries) and then divided by gross exports, producing 0.67 for both countries. This strange occurrence, where VS in the US and VS1* in China are zero and VS1* in the US and VS in China both equal 23.3 happens since there is trade of intermediates to the US from China.

	US	**China**
Value-added exports	46.7	46.7
Value-added that returned home	23.3	0
Foreign value	0	23.3
Gross exports	70	70
VAX ratio	0.67	0.67

(Example from Koopman et al. 2010).

Example 2

The second example demonstrates the methodology used when there are multiple countries and sectors at work. This case only looks at the results from the transportation sector as composed of "inland transport," "water transport," "air transport," and a miscellaneous category (codes 23-26 from the table in Appendix A). Data from 2006 for the US is used.

In 2006, transportation exports from the US accounted for just less than 7% of gross exports at $92.8 Billion. This amount can be decomposed into smaller measurements which can in turn be used in part to compute both VS and VS1. Though in the aggregate, the decomposed portions of gross exports for each country totals the country's gross exports, the movement of goods between sectors results in the decomposition of each sector not totaling the gross exports for that sector. Thus, when the $92.8 Billion of gross exports is decomposed, the subsections do not account for the full total. This effect goes away in example three when we investigate the US economy as a whole. Note that for the remainder of this second example, gross exports refer to gross exports within the transportation industry.

The first step to calculating the metrics is using the methodology of Koopman et al. 2014 to compute the necessary components. We begin with the gross trade for transportation. This can be thought of as the summation of three parts, as broken down in Figure 1. They measured as percentages of gross exports in order to compare their significance across multiple countries.

The first section of Figure 1, value-added exports, comprises the majority of exports for nearly all countries. It epitomizes the basic definition of an export as a good that is manufactured in one country and then consumed in another country. As can be seen in Figure 1, it is made up of domestic value-added in final exported goods (1), domestic value-added in intermediate exported goods (2), and domestic value-added in exported intermediates that are re-exported to other countries (3). Their values are calculated as $17.22 Billion, $30.16 Billion, and $11.05 Billion respectively. This makes up 62.98% of gross exports. Thus, we can say that this country's VAX ratio is 62.98.

The next calculation is for the domestic value-added in intermediate exports that return home. This represents goods that were originally produced in the US, then exported to other countries, and then finally imported back to the US yet are counted in the gross trade exports of both countries. This metric is found by combining the following three terms: domestic value-added in exported intermediate goods that are re-imported as final goods, domestic value-added in exported intermediate goods that are re-imported as intermediate goods, and double counted intermediate exports produced at home. Together, these three values represent VS1*. We do not break apart the double counted exported intermediates and domestic value-added in exported intermediates since it is unnecessary to do so if only calculating VS1*. Using the data from the WIOD, we calculate that re-imported DV in final goods is $0.39 Billion and in intermediate goods it is $1.31 Billion. Summing these two, we find that VS1* is equal to $1.70 Billion or 1.8 as a share of gross exports. Combined with VAX, these two metrics measure domestic content.

Finally, we calculate remaining third, VS. This is the share of gross exports that contains foreign value-added. VS can be broken apart into the following three subparts: foreign value in final goods that are exported, foreign value in intermediate goods that are exported, and double counted intermediate exports produced abroad. To calculate this value, we do not need to further decompose the double counted portion and only need to calculate two values. From this paper's calculations, foreign VA in final goods is $2.13 Billion and Foreign VA in intermediate goods is $7.6 Billion. Together, these two terms represent $9.65 Billion or 10.4% of gross exports. While on the country wide level, VS = VAX – VS1*, on an industry level this relationship does not hold. This is true for the same reasons that gross trade statistic for the sector does not equal the sum of three decomposed subsections. The data captures the movement of goods between sectors within a single country such that everything only works out on a country level.

The calculations above are summarized in the table below where each column represents a row from Figure 1.

<table>
<tr><td rowspan="9">Gross exports for transportation industry
($92.8)</td><td rowspan="3">Value-added exports
= VT
($58.43)</td><td>DV in direct final goods exports
($17.22)</td><td></td></tr>
<tr><td>DV in intermediates exports absorbed by direct importers
($30.16)</td><td></td></tr>
<tr><td>DV in intermediates re-exported to third countries
($11.05)</td><td></td></tr>
<tr><td rowspan="3">Domestic content in intermediate exports that finally returns home
= VS1*
($1.70)</td><td>DV in intermediates that returns via final imports
($0.39)</td><td></td></tr>
<tr><td>DV in inter intermediates returns via intermediate imports</td><td rowspan="2">DV in intermediate goods returned via intermediates and double counted term
($1.31)</td></tr>
<tr><td>Double Counted intermediate exports produces at home</td></tr>
<tr><td rowspan="3">Foreign Content
= VS
($9.65)</td><td>FV in final goods exports
($2.13)</td><td></td></tr>
<tr><td>FV in intermediate goods exports</td><td rowspan="2">FV in intermediate goods exports and double counted term
($7.52)</td></tr>
<tr><td>Double counted intermediate exports produced abroad</td></tr>
</table>

Once we have these metrics, VS1 can be computed (since VS was already calculated above). For VS1, we add the four terms that compose this metric. This provides the measurement for the total domestic value-added that is embodied in foreign export figures. The last two terms of VS1 represent VS1* and we use the value we calculated above and add to it the portion of value-added exports that never return home. This makes sense since domestic value-added in intermediates that are re-exported to other countries will not return home (and any portion that does return will be counted in VS1*). Therefore the entire value of $11.05 Billion is added to VS1*. From the remaining $30 Billion, this paper uses Hummel at al.'s measure of VS1 in intermediates (as explained in previous section) to compute the share of VS1 in intermediate exports which is $14.64 Billion. This is taken from domestic value-added in intermediate exported goods and included in VS1. This gives 14.64 + 11.05 + 1.70 = $27.39 Billion or 29.5% of gross exports.

These results are summarized in the tables below:

Decomposed VS		
Terms	FV in final goods exports	FV in intermediate goods exports and double counted intermediate exports produced abroad
Values	$2.31 Billion	$7.60 Billion

Decomposed VS1			
Terms	DV in intermediates re-exported to third countries	VS1 from Hummel et al.	Domestic content in intermediates exports that finally return home (VS1*)
Values	$11.05 Billion	$14.64 Billion	$1.70 Billion

It is interesting to note that VS1 = 29.5 and VS = 10.4, as shares of gross exports. From these values and their ratio, it becomes clear that the US is a relatively upstream producer in the transportation industry. To find how this small segment plays into the larger picture of US exports, the next example will investigate the exports for the entire US economy from 2006.

Example 3

This third example provides a good picture for what is used in later sections of this paper. The same methodology as above is applied to break apart gross exports into more precise components of trade. Before, each term was measures by gross value, however in this example, each metric is reported as a percentage of gross exports. This makes it easier to compare values between countries.

The tables below are used to represent each value from Figure 1 and better show where it comes from. Since the methodology does not break apart double counted values, these are not reported. Therefore, there is not a direct one-to-one correspondence. Nonetheless, this example demonstrates the general methodology used.

Value-added exports (VT)			
Terms	DV in direct final goods exports	DV in intermediates exports absorbed by direct importers	DV in intermediates re-exported to other countries
Computed Values	28.3%	43.7%	6.0%

Domestic Content in intermediate exports that return home (VS1*)			
Terms	DV in intermediates that is returned via final imports	DV in intermediates that returns via intermediate imports	Double counted intermediate exports produced at home
Computed Values	4.3%	4.6%	

Foreign Content (VS)		
Terms	FV in final goods exports	FV in intermediate goods exports and double counted intermediate exports produced abroad
Computed Values	3.6%	9.4%

From the results reported above, VS can easily be calculated. From Figure 1, it can be seen that VS is the summation of FV in final goods exports, FV in intermediate goods exports, and double counted intermediate exports produced abroad. These last two values are combined during computation leading to the two values of 3.6 and 9.4. This total gives us 13.0 for VS.

To calculate VS1, we first compute VS1* and then combine that with indirect exports sent to other countries as final goods and as intermediate inputs. VS1* can be found by summing DV in intermediates that are returns via final imports, DV in intermediates that returns via intermediate imports, and double counted intermediate exports produced at home. These two components are in the second table as 4.3 and 4.6 and represent the middle column of Figure 1. Therefore VS1* equals 8.9, the summation of these two terms.

The remaining amount of VS1 is equal to the domestic value-added in exports less exports consumed by direct importers. VT, which is the domestic value-added in exports, is equal to the summation of its three parts calculated in the first table above, which is 78.1. Yet, a large portion of this is exports consumed by direct importers and is thus never contained within foreign exports (which is the portion that we are interested in). Therefore, the portion that was counted as foreign exports needs to be removed. This amount is composed of DV in intermediates re-exported to third countries and Hummel at al.'s measure of VS1 in intermediates. These are calculated to be 6.0 and 15.2, respectively. Summing these two values together, we get 21.2 which represents the share of US value-added exports which are encapsulated within foreign exports that are not re-imported back into the States. When combined with VS1*, it yields a final value of 30.1 for VS1. Each section can be seen in the table below.

Decomposed VS1 (As a share of gross exports)			
Terms	DV in intermediates re-exported to third countries	VS1 from Hummel et al.	Domestic content in intermediates exports that finally return home (VS1*)
Values	6.0	15.2	8.9

These two values show that the US is relatively upstream in its production since more domestic value-added is embodied in foreign exports than foreign value-added is embodied in its exports. The ratio or these two numbers (VS1/VS) gives a good measurement of that relative upstream or downstream position. In this case, the US has a ratio of 2.4. By comparing this metric to other countries, it can be seen that this is a high value and represents the US's strong contribution to foreign exports that is not intuitively available when looking at gross exports.

Data Analysis

This paper computes the values of VS1 and VS as well as their ratio for United States, China, South Korea, and Taiwan from 1995 to 2011. This reveals the countries' relative production roles in the global supply chain as either upstream or downstream in the value-added production of goods.

The ratio of VS1 to VS brings to light the differences between relatively upstream and downstream countries. For example, a downstream country would have most its value-added exports embodied in final goods exports whereas an upstream country would have most of its intermediate exports go through other countries. China is the typical example for a downstream economy since its value-added assembly of goods is embodied in the final exportation to the US. The US, on the other hand, might export intermediate components to China that are later imported back as finished products. From this, we would expect that the US has a high VS1/VS ratio (well above 1) while China should have one a low ratio (below 1).

Besides recognizing countries' relative positions in global supply chains, this paper captures the changing landscape of production. The results demonstrate a consistent trend for the United States to remain upstream while China's younger economy remains downstream. However, China also appears to be experiencing an evolution in its economy as its production of intermediates increases and assembly work shrinks. South Korea and Taiwan, meanwhile, are somewhere between these two trade powerhouses. Each of these two nations import and export intermediates. Yet, they also demonstrate a keen enthusiasm and vigor that are driving their economies to produce more intermediates as opposed to final goods. This represents an improvement as the countries continue to move upstream.

Focusing on the Untied States, the data demonstrates that the US specializes in upstream production of goods. As in previous literature, the technique of measuring VS and VS1 helps to define this characteristic.[25] This is demonstrated through the US's high share of exported goods that are in turn used as inputs by other countries to further produce exports (VS1). Similarly, the US imports a small amount of foreign intermediates to be used as inputs for future exports (VS). Since the country exports more early stage goods than it imports and similarly imports fewer intermediates than it exports, the US resides upstream in the global value-added supply chain.

[25] Hummels et al. 2001

This result can be seen in Figure 4 below and in Appendix C. It is further reinforced by the results of the regressions shown in Appendix D. These regressions are used to validate the findings and interpretations about countries. The statistically significant positive coefficients of the variable for "year" that is present for all countries for both VS and VS1 show that over time, countries have both larger portions of their domestic gross exports comprised of value-added content produced elsewhere and larger portions of other countries' gross exports comprised of domestic value-added content. This effect demonstrates the growth of vertical specialization in the global supply chain.

Since the US has a higher ratio of exported intermediates than imported intermediates, its ratio of VS1 to VS is much larger than other countries. Similarly, since China, South Korea, and Taiwan are all further downstream, they are all below the average ratio of one. In the aggregate, the ratio is equal to one since everything that is counted as VS is in turn later counted as VS1. In other words, for each good that one country counts as foreign value-added content in its domestic exports (VS), another country must account for as domestic value-added in its foreign exports (VS1). We can indeed see that this is the case for the world average.

Looking at just the figures for VS1, South Korea and Taiwan appear more upstream compared to China, thus driving the conclusion that both enonomies are further upstream than China (Figure 2). While China uses imported foreign intermidiates to export foreign goods, South Korea and Taiwan use their imports of foreign goods to in turn export intermediates. This can be seen in Figure 3. Similarly, they both have a relativly high VS and VS1 compared with other countries.

The data also bring to light China's changing position within the supply chain. A surge to more upstream production is visible in Figure 4 from 1995 to 2001 and in more recent years while a significant movement to more downstream production is evidenced in the sharp decline of VS1/VS in Figure 4 from 2001 to 2008. The overall trend to a more upstream producer is drawn out in the ratio of the coefficients for the regression of VS1 and VS. In other words, the slope of the regression line representing the change in VS1 over the past seventeen years (0.204) is flatter than the slope of VS (1.245) which means that this ratio is decreasing. This suggests that China's developing economy is beginning the move upstream as their trade focuses more and more on the exporting of intermediates.

Figure 2: Measure of VS1

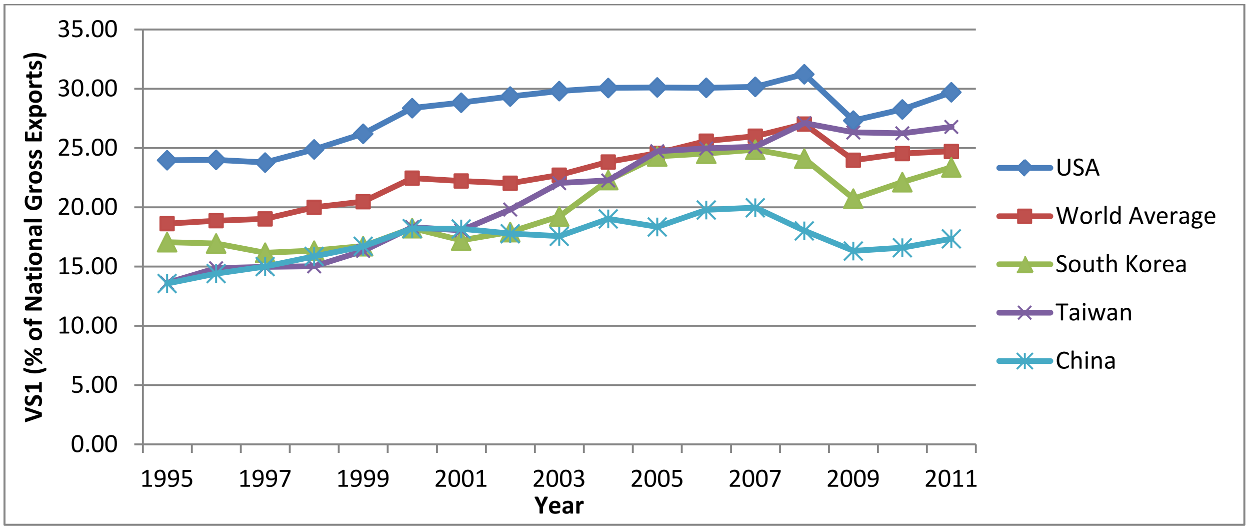


Figure3: Measure of VS

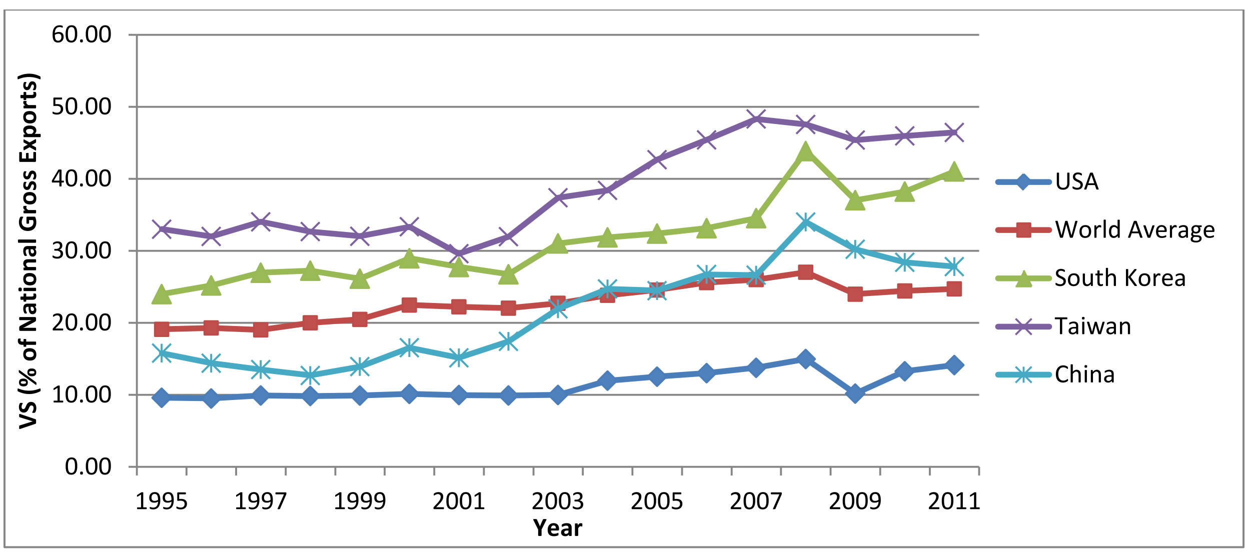
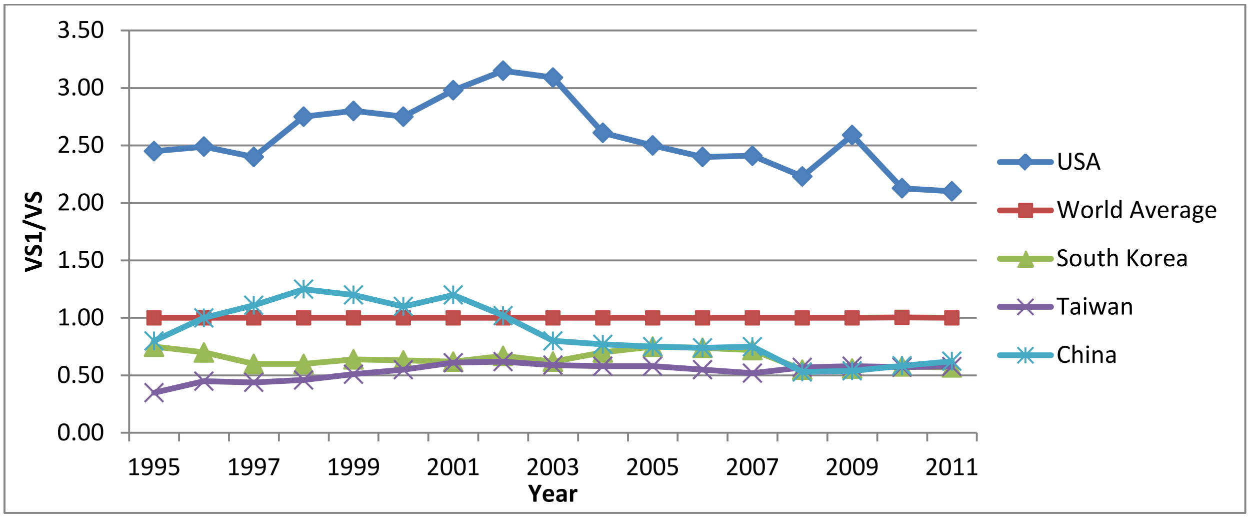


Figure 4: Ratio of Vertical Specialization (VS1/VS)



To further investigate how a given country has changed over this period of time, an intra-sector analysis can be conducted. This process can reveal new information about the evolution of sectors within a given country as well as shed light on the structure of a given country's comparative advantage. To accomplish this, a country's exports must be broken apart into sector level details. This allows for an examination into the changing composition of VS and VS1 within those sub-segments. A snapshot of this was done for the US for the year 2006 in Example 2 above. This paper will now present an overview of the US economy from the year 1995 to 2011 by examining the changes within specific sectors. The data and results for these two years can be found in Appendix B. This data shows the gross exports and well as measurements of VS and VS1.

It should be noted that the technique used to accomplish this investigation into sector level details was derived from Koopman et al.'s same method used above to calculate country level information. Since it was not initially designed to attain a granular perspective, there may exist unknown issues with the results. Future work can validate these methods or improve upon their execution. Nonetheless, below is a brief analysis from a section of analyzed data.

From the data, a few key insights can be made. First, gross exports for sectors within the US economy have all grown with the exception of "Leather, Leather and Footwear" and "Wood and

Products of Wood and Cork." These declined 5% and 12% respectively. Yet, these sectors also witnessed declines in VS and large increased in VS1, indicating that the US might have been losing downstream production to other countries while strengthening upstream production. Specifically, the VS1/VS ratios increased by 118% and 102% respectively.

The majority of sectors saw similar, though mostly lesser increases in this ratio, representing a continued upstream position for the US within the global supply chain. Exceptions to this include the "Coke, Refined Petroleum and Nuclear Fuel" sector. Though exports increased by over 400%, the VS1/VS ratio declined by 50%, moving from above 1 to below 1. This change indicates that the US has moved from being an upstream producer to a downstream producer. However, since these industries behave differently than manufacturing, this result should be taken with some caution. The final stages of production for these goods might require more refined techniques than creating the intermediates. For instance, refined petroleum might be recovered from another country and then refined in the US. An increase in US refining would be reflected as a move further downstream.

"Electrical and Optical Equipment" and "'Post and Telecommunications" also saw large increase in VS1 relative to VS, both increasing around 100%. As international technology companies like Apple, Microsoft, Google, and the like continue to play increasing large roles in global trade, we are likely to see these ratios continue to stay high. Further investigations in this area can be made in future literature however this brief overview serves as an introduction to such techniques.

Conclusion

We have come a long way since Milton's PBS special. Today, the US produces 3 billion of the world's 14 billion pencils produced annually. The goods are sourced from every corner of the globe and pass through more hands than can be measured. They fly across the global supply chain, picking up value at each stop. The fragmented production line that stretches from European rubber to US clay and wood to South American graphite represents but one of the innumerable strings tying countries together through the magic of trade. Nearly every industry and every product is touched in some way by the hands of globalization. Yet even though it has been nearly 35 years since Milton broadcast his message (and many more since the study of free trade began), there has been a slow response in the literature to include the studies of the trends in the value-added field.

Part of the historical issue with research into this field has been the dearth of information freely available. The recently released data from the WIOD makes the analysis accomplished in this paper possible. The database provides a consistent set of input output tables that can be used to examine the trade between countries over the past seventeen years. This paper uses this data to investigate these trends and present a new view of the evolution of global value-added supply chains.

This paper demonstrates the role that developing countries have been playing in upstream production as their economies move away from downstream activities. While the US utilizes more foreign produced intermediate goods, China, South Korea, and Taiwan have moved to producing those intermediate goods. As such, we have seen the surfacing of new trade patterns as multinational companies take advantage of emerging economies to supply intermediate inputs. All the while, advanced economies remain dominant in their upstream position. All of this is found when analyzing the situation through the lens of value-added supply chains.

These trends, as shown in this paper, diverge from previously identified trends found using gross exports. For the reasons stated early in this paper, gross exports provide a misleading portrayal of the true state of trade. When viewed from the perspective of gross exports, the US appears to be in decline from its peak of production. Yet, using a value-added approach, the country's comparative advantage looks as strong as ever, something that the executives in Silicon Valley dearly hope is true.

The significance of these results emanates from the policy implications inherent in the divergence of views between the flawed perspective of gross exports and the enlightening picture of trade found through decomposing value-added supply chains. While protectionist policies remain an often reached for tool in the tool belt, the evidence found within this paper coupled with prior research should dissuade policymakers from blinding enacting such policies at the first site of trade deficits and misguided views of competitiveness.

When the labels stamped on goods that declare which country had the final hand in producing a given good, no longer hold any value beyond the little added in the last stage of production, consumers will better appreciate the thousands of hands that need to come together in order to make something as extraordinarily ordinary as a pencil.

Appendix A

WIOD Table Information ***(All information from WIOD)***

List of Countries in Database

European Union			North America	Asia and Pacific
Austria	Germany	Netherlands	Canada	China
Belgium	Greece	Poland	United States	India
Bulgaria	Hungary	Portugal		Japan
Cyprus	Ireland	Romania		South Korea
Czech Republic	Italy	Slovak Republic	**Latin America**	Australia
Denmark	Latvia	Slovenia	Brazil	Taiwan
Estonia	Lithuania	Spain	Mexico	Turkey
Finland	Luxembourg	Sweden		Indonesia
France	Malta	United Kingdom		Russia

Schematic Outline of National Input-Output Table

	Industry	Final use		Total
Industry	Intermediate use	Domestic Final use	Exports	Total Output
	Imports			
	Value added			
	Total Output			

Schematic Outline of World Input-Output Table

		Country A Intermediate *Industry*	Country B Intermediate *Industry*	Rest of World Intermediate *Industry*	Country A Final domestic	Country B Final domestic	Rest of World Final domestic	Total
Country A	*Industry*	Intermediate use of domestic output	Intermediate use by B of exports from A	Intermediate use by RoW of exports from A	Final use of domestic output	Final use by B of exports from A	Final use by RoW of exports from A	Output in A
Country B	*Industry*	Intermediate use by A of exports from B	Intermediate use of domestic output	Intermediate use by RoW of exports from B	Final use by A of exports from B	Final use of domestic output	Final use by RoW of exports from B	Output in B
Rest of World (RoW)	*Industry*	Intermediate use by A of exports from RoW	Intermediate use by B of exports from RoW	Intermediate use of domestic output	Final use by A of exports from RoW	Final use by B of exports from RoW	Final use of domestic output	Output in RoW
		Value added	Value added	Value added				
		Output in A	Output in B	Output in RoW				

List of Industries in WIOD

Columns in USE Table		
Code	NACE	Description
1	AtB	Agriculture, Hunting, Forestry and Fishing
2	C	Mining and Quarrying
3	15t16	Food, Beverages and Tobacco
4	17t18	Textiles and Textile Products
5	19	Leather, Leather and Footwear
6	20	Wood and Products of Wood and Cork
7	21t22	Pulp, Paper, Paper , Printing and Publishing
8	23	Coke, Refined Petroleum and Nuclear Fuel
9	24	Chemicals and Chemical Products
10	25	Rubber and Plastics
11	26	Other Non-Metallic Mineral
12	27t28	Basic Metals and Fabricated Metal
13	29	Machinery, Nec
14	30t33	Electrical and Optical Equipment
15	34t35	Transport Equipment
16	36t37	Manufacturing, Nec; Recycling
17	E	Electricity, Gas and Water Supply
18	F	Construction
19	50	Sale, Maintenance and Repair of Motor Vehicles Retail Sale of Fuel
20	51	Wholesale Trade and Commission Trade, Except of Motor Vehicles
21	52	Retail Trade, Except of Motor Vehicles ; Repair of Household Goods
22	H	Hotels and Restaurants
23	60	Inland Transport
24	61	Water Transport
25	62	Air Transport
26	63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	64	Post and Telecommunications
28	J	Financial Intermediation
29	70	Real Estate Activities
30	71t74	Renting of M&Eq and Other Business Activities
31	L	Public Admin and Defence; Compulsory Social Security
32	M	Education
33	N	Health and Social Work
34	O	Other Community, Social and Personal Services
35	P	Private Households with Employed Persons

Appendix B

Breakdown of VS and VS1 for the US Economy (1995)

Sector		VS[1]	VS[2]	VS[3]	VS[4]		VS1[1]	VS1[2]	VS1[3]	VS1[5]
Agriculture, Hunting, Forestry and Fishing		1871.541	6.866	0.002	0.026		3626.393	13.305	0.005	0.021
Mining and Quarrying		585.235	5.834	0.001	0.008		6907.142	68.852	0.009	0.039
Food, Beverages and Tobacco		2962.111	9.159	0.004	0.040		2996.802	9.266	0.004	0.017
Textiles and Textile Products		1349.949	10.329	0.002	0.018		5426.184	41.516	0.007	0.031
Leather, Leather and Footwear		145.049	14.994	0.000	0.002		5989.141	619.114	0.008	0.034
Wood and Products of Wood and Cork		489.794	10.191	0.001	0.007		14415.706	299.955	0.019	0.082
Pulp, Paper, Paper , Printing and Publishing		2518.672	8.940	0.003	0.034		11948.792	42.410	0.016	0.068
Coke, Refined Petroleum and Nuclear Fuel		2613.595	27.336	0.003	0.036		3926.049	41.064	0.005	0.022
Chemicals and Chemical Products		5868.614	11.086	0.008	0.080		12343.809	23.319	0.016	0.071
Rubber and Plastics		1268.938	11.625	0.002	0.017		3614.759	33.115	0.005	0.021
Other Non-Metallic Mineral		400.626	7.653	0.001	0.005		1063.344	20.311	0.001	0.006
Basic Metals and Fabricated Metal		3543.657	12.062	0.005	0.048		12637.602	43.017	0.017	0.072
Machinery, Nec		7288.834	12.022	0.010	0.100		5115.452	8.437	0.007	0.029
Electrical and Optical Equipment		18606.791	14.546	0.024	0.254		32610.401	25.493	0.043	0.186
Transport Equipment		14555.747	16.042	0.019	0.199		21923.553	24.162	0.029	0.125
Manufacturing, Nec; Recycling		1227.848	9.794	0.002	0.017		3061.918	24.423	0.004	0.018
Electricity, Gas and Water Supply		21.615	5.811	0.000	0.000		856.397	230.214	0.001	0.005
Construction		5.592	7.817	0.000	0.000		526.557	736.049	0.001	0.003
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel		2.249	6.815	0.000	0.000		204.603	619.900	0.000	0.001
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles		1762.020	2.209	0.002	0.024		1219.192	1.528	0.002	0.007
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods		0.856	2.441	0.000	0.000		505.075	1440.034	0.001	0.003
Hotels and Restaurants		23.029	4.793	0.000	0.000		479.454	99.793	0.001	0.003
Inland Transport		905.047	5.711	0.001	0.012		7153.948	45.146	0.009	0.041
Water Transport		864.058	8.109	0.001	0.012		1864.325	17.496	0.002	0.011
Air Transport		1076.737	5.731	0.001	0.015		1554.136	8.272	0.002	0.009
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies		217.170	2.681	0.000	0.003		894.522	11.044	0.001	0.005
Post and Telecommunications		339.888	3.024	0.000	0.005		281.908	2.508	0.000	0.002
Financial Intermediation		1012.248	2.241	0.001	0.014		1360.875	3.012	0.002	0.008
Real Estate Activities		8.681	1.504	0.000	0.000		84.474	14.639	0.000	0.000
Renting of M&Eq and Other Business Activities		1138.746	2.671	0.001	0.016		6873.919	16.125	0.009	0.039
Public Admin and Defence; Compulsory Social Security		216.194	3.988	0.000	0.003		1045.203	19.280	0.001	0.006
Education		7.113	2.942	0.000	0.000		105.918	43.802	0.000	0.001
Health and Social Work		3.033	3.379	0.000	0.000		963.596	1073.544	0.001	0.006
Other Community, Social and Personal Services		257.049	2.794	0.000	0.004		1334.663	14.510	0.002	0.008

[1] *In Billion $*

[2] *As a Percent of Sector Exports*

[3] *As a Percent of US Gross Exports*

[4] *As a Percent of Total US VS*

[5] *As a Percent of Total US VS1*

Breakdown of VS and VS1 for the US Economy (2011)

Sector		VS[1]	VS[2]	VS[3]	VS[4]		VS1[1]	VS1[2]	VS1[3]	VS1[5]
Agriculture, Hunting, Forestry and Fishing		4099.615	9.973	0.003	0.026		6614.716	16.091	0.005	0.016
Mining and Quarrying		1346.127	6.615	0.001	0.008		17408.485	85.551	0.012	0.042
Food, Beverages and Tobacco		5478.064	10.839	0.004	0.034		7004.428	13.859	0.005	0.017
Textiles and Textile Products		1805.797	13.186	0.001	0.011		7619.974	55.641	0.005	0.019
Leather, Leather and Footwear		136.701	14.937	0.000	0.001		12317.078	1345.860	0.009	0.030
Wood and Products of Wood and Cork		483.826	11.396	0.000	0.003		28743.180	677.007	0.020	0.070
Pulp, Paper, Paper , Printing and Publishing		3448.798	9.006	0.002	0.022		22783.919	59.494	0.016	0.055
Coke, Refined Petroleum and Nuclear Fuel		18179.744	37.844	0.013	0.114		13594.241	28.299	0.009	0.033
Chemicals and Chemical Products		18764.426	15.771	0.013	0.117		34411.306	28.921	0.024	0.084
Rubber and Plastics		3500.242	16.372	0.002	0.022		7812.924	36.544	0.005	0.019
Other Non-Metallic Mineral		716.706	9.372	0.000	0.004		2316.199	30.287	0.002	0.006
Basic Metals and Fabricated Metal		8459.532	14.238	0.006	0.053		27709.606	46.636	0.019	0.067
Machinery, Nec		14003.814	13.956	0.010	0.087		14461.219	14.412	0.010	0.035
Electrical and Optical Equipment		20977.722	11.260	0.015	0.131		73284.259	39.336	0.051	0.178
Transport Equipment		30571.093	19.227	0.021	0.191		27966.072	17.589	0.019	0.068
Manufacturing, Nec; Recycling		3770.612	11.812	0.003	0.024		8180.108	25.626	0.006	0.020
Electricity, Gas and Water Supply		66.115	9.888	0.000	0.000		3078.500	460.434	0.002	0.007
Construction		7.292	9.471	0.000	0.000		2020.697	2624.271	0.001	0.005
Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel		4.390	7.135	0.000	0.000		446.534	725.757	0.000	0.001
Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles		2636.825	2.197	0.002	0.016		4919.486	4.099	0.003	0.012
Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods		1.785	2.795	0.000	0.000		1952.174	3056.601	0.001	0.005
Hotels and Restaurants		43.341	5.203	0.000	0.000		1576.074	189.217	0.001	0.004
Inland Transport		2748.506	8.437	0.002	0.017		15396.327	47.263	0.011	0.037
Water Transport		2079.227	12.643	0.001	0.013		9352.711	56.870	0.006	0.023
Air Transport		3227.308	10.742	0.002	0.020		4371.589	14.551	0.003	0.011
Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies		967.474	4.865	0.001	0.006		2105.655	10.588	0.001	0.005
Post and Telecommunications		799.364	4.750	0.001	0.005		1457.622	8.661	0.001	0.004
Financial Intermediation		5248.609	3.858	0.004	0.033		9746.277	7.164	0.007	0.024
Real Estate Activities		13.012	1.550	0.000	0.000		386.430	46.042	0.000	0.001
Renting of M&Eq and Other Business Activities		4634.342	3.589	0.003	0.029		22783.803	17.643	0.016	0.055
Public Admin and Defence; Compulsory Social Security		965.177	5.754	0.001	0.006		1935.188	11.538	0.001	0.005
Education		30.501	2.900	0.000	0.000		227.122	21.596	0.000	0.001
Health and Social Work		8.911	3.906	0.000	0.000		1818.866	797.265	0.001	0.004
Other Community, Social and Personal Services		866.140	4.123	0.001	0.005		4356.687	20.741	0.003	0.011

[1] *In Billion $*
[2] *As a Percent of Sector Exports*
[3] *As a Percent of US Gross Exports*
[4] *As a Percent of Total US VS*
[5] *As a Percent of Total US VS1*

Appendix C

Calculated Results

The following tables are calculated values for VS1, VS, and the ratio between the two for the following countries gross exports from 1995-2011: USA, World Average, South Korea, Taiwan, and China.

Measurement of VS1 (As a Share of National Gross Exports):

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
USA	23.98	24.01	23.78	24.89	26.21	28.37	28.83	29.35	29.81	30.07	30.12	30.09	30.17	31.23	27.32	28.26	29.71
World Avg.	18.63	18.88	19.03	20.01	20.48	22.47	22.23	22.04	22.72	23.83	24.56	25.59	26.01	27.03	23.98	24.54	24.72
S. Korea	17.07	16.96	16.18	16.35	16.73	18.25	17.21	17.92	19.24	22.31	24.30	24.53	24.87	24.12	20.74	22.13	23.38
Taiwan	13.63	14.87	14.97	15.03	16.33	18.34	18.06	19.82	22.05	22.27	24.74	24.97	25.12	27.10	26.32	26.25	26.79
China	13.58	14.42	15.01	15.87	16.72	18.21	18.18	17.78	17.56	19.03	18.35	19.78	19.97	18.02	16.32	16.60	17.35

Measurement of VS (As a Share of National Gross Exports):

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
USA	9.60	9.50	9.92	9.85	9.91	10.14	9.98	9.92	9.99	11.98	12.53	13.02	13.76	14.98	10.18	13.28	14.14
World Avg.	19.10	19.30	19.03	20.01	20.48	22.47	22.23	22.04	22.72	23.83	24.56	25.59	26.01	27.03	23.98	24.43	24.72
S. Korea	24.00	25.20	26.97	27.25	26.14	28.97	27.76	26.75	31.03	31.87	32.40	33.15	34.54	43.85	37.04	38.23	41.03
Taiwan	33.00	32.00	34.02	32.67	32.02	33.35	29.61	31.97	37.37	38.40	42.66	45.40	48.31	47.54	45.38	45.96	46.43
China	15.80	14.40	13.52	12.70	13.93	16.55	15.15	17.43	21.95	24.71	24.47	26.73	26.63	34.00	30.22	28.41	27.81

Ratio VS1/VS:

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
USA	2.45	2.49	2.40	2.75	2.80	2.75	2.98	3.15	3.09	2.61	2.50	2.40	2.41	2.23	2.59	2.13	2.10
World Avg.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
S. Korea	0.75	0.70	0.60	0.60	0.64	0.63	0.62	0.67	0.62	0.70	0.75	0.74	0.72	0.55	0.56	0.58	0.57
Taiwan	0.35	0.45	0.44	0.46	0.51	0.55	0.61	0.62	0.59	0.58	0.58	0.55	0.52	0.57	0.58	0.57	0.58
China	0.80	1.00	1.11	1.25	1.20	1.10	1.20	1.02	0.80	0.77	0.75	0.74	0.75	0.53	0.54	0.58	0.62

Appendix D

Calculated Regression

The following tables are the results from regressing VS1 and VS (as ratios of gross exports) for each country on the year from which it was calculated over the range 1995-2011. The tables list the county, intercept, coefficient for year, P-value for the intercept, P-value for the coefficient for year, and the R^2 value.

VS1 = α + β (Year)				
Country	**α**	**β**	**β P-value**	**R^2**
USA	-722.279	0.375	0.00045	0.57
World Average	-915.272	0.468	0.00000	0.82
South Korea	-1073.905	0.546	0.00002	0.70
Taiwan	-1865.423	0.941	0.00000	0.95
China	-391.872	0.204	0.01503	0.29

VS = α + β (Year)				
Country	**α**	**β**	**β P-value**	**R^2**
USA	-583.625	0.297	0.00012	0.63
World Average	-878.554	0.450	0.00000	0.81
South Korea	-2086.541	1.057	0.00000	0.85
Taiwan	-2325.198	1.180	0.00000	0.78
China	-2472.904	1.245	0.00000	0.84

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