TRADE IN INTERMEDIATE GOODS: TRENDS, EFFECTS, AND DETERMINANTS

by

NINO SITCHINAVA

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Confirmation of Approval and Acceptance of Dissertation prepared by:

Nino Sitchinava

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This dissertation has been accepted and approved in partial fulfillment of the requirements for the degree in the Department of Economics by:

Bruce Blonigen, Co-Chairperson, Economics
Ronald Davies, Co-Chairperson, Economics
Glen Waddell, Member, Economics
Michael Pangburn, Outside Member, Decision Sciences

and Richard Linton, Vice President for Research and Graduate Studies/Dean of the Graduate School for the University of Oregon.

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Original approval signatures are on file with the Graduate School and the University of Oregon Libraries.

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Title: TRADE IN INTERMEDIATE GOODS: TRENDS, EFFECTS, AND DETERMINANTS

Approved: ______________________________
Bruce A. Blonigen, Co-Chair

Approved: ______________________________
Ronald B. Davies, Co-Chair

A large number of studies search for stylized facts on the rapid growth, impact, and determinants of international outsourcing of production. The analyses of these studies are considerably constrained by limitations in the international trade data, which do not differentiate between trade in intermediate and finished goods. I improve on these data and develop a trade dataset that draws a clear distinction between trade in intermediate and finished goods. I use new data to provide an integrated view of the importance of U.S. global production sharing. I assess the magnitude and nature of global production sharing, explore its impact on growing U.S. manufacturing wage inequality, and examine the forces driving the location and volume of this trade. My findings indicate that the composition of trade has not changed as previously speculated and that trade in intermediate inputs is just as prevalent as trade in consumer goods. Additionally, my results indicate that the impact of foreign offshoring of intermediate inputs on the growing wage gap in U.S. manufacturing industries is larger than previously estimated. Lastly, I show that quality of contracting environment and thickness of input supplier markets are important factors for the location and extent of trade in specialized inputs.

CURRICULUM VITAE

NAME OF AUTHOR: Nino Sitchinava

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon, Eugene, OR

Whitworth University, Spokane, WA

DEGREES AWARDED:

Doctor of Philosophy in Economics, Spring 2008, University of Oregon

Master of Science in Economics, May 2005, University of Oregon

Bachelor of Arts in Economics and International Business, May 2002, Whitworth University

AREAS OF SPECIAL INTEREST:

Microeconomics, Econometrics, Industrial Organization, International Economics

PROFESSIONAL EXPERIENCE

Graduate Teaching Fellowship, Department of Economics, University of Oregon, 2003-2008

Independent Course Instructor

- Introduction to Econometrics, Spring, Fall 2007, Spring 2008
- Issues in Industrial Organization, Spring, Fall 2006
- Principles of Microeconomics, Summer 2005, Winter 2006

Teaching Assistant

- Principles of Economics, Principles of Microeconomics, Money and Banking, Intermediate Macroeconomics, Issues in Developing Economies, Introduction to Econometrics

Research Assistant, Department of Economics, University of Oregon and Institute for Water Resources U.S. Army Corps of Engineers, 2005

Research assistantship under direction of Wesley W. Wilson

Foundation for Russian American Economic Cooperation, Seattle, WA, 2002-2003

GRANTS, AWARDS AND HONORS:

Graduate Teaching Fellowship, University of Oregon, 2003-present

Graduate School Research Award, University of Oregon, 2006-2007

Kleinsorge Research Fellowship, University of Oregon, 2006

PUBLICATIONS:

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Моим родителям, Гуле и Шалику.

To my parents, Gulya and Shalik.

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CHAPTER I

INTRODUCTION

U.S. trade has increased dramatically over the last four decades, with the export share of GDP doubling and the import share nearly tripling since the 1970s. Various evidence suggests that much of this increase stems from the explosive growth in international outsourcing of intermediate inputs production and finished goods assembly. The rapid widening of the wage gap that happened concurrently with these developments drew the attention of politicians and popular press to the potentially adverse affects of global production sharing. In response, many trade economists have been concerned with various aspects of such overseas production arrangements, mainly: 1) their relative importance, 2) their impact on home economies, and 3) their determinants. Unfortunately, data constraints have hampered progress and it is well understood that the available measures of offshoring do not accurately reflect the true nature and/or impact of global production sharing. Furthermore, the mixed evidence suggested by these measures neither justifies nor dismisses the fear of outsourcing projected by the popular press.

In my dissertation I offer a fresh perspective on international outsourcing and the three issues troubling trade economists. I accomplish this goal by first addressing the primary shortcoming of the literature – the unavailability of data on global production sharing. With this in mind, I construct data on trade in intermediate goods, which is integral for gauging the value of international outsourcing. The technical documentation of this dataset is provided in Appendix A. Beginning with Chapter II of the dissertation, I employ the new data on intermediate inputs to provide unique insights into the magnitude and the nature of global production sharing. Next, I utilize this knowledge to examine the impact of international outsourcing on U.S. manufacturing wage inequality during 1989-2004, which I describe in Chapter III. Finally, in Chapter IV, I explore the determinants of global production sharing, with a particular focus on institutions, input supplier markets, and specific investment. Throughout my analyses, I use trade in final goods as a benchmark for assessing the relative importance of trade in intermediate goods. This comparison offers a novel perspective on the relevance of trends, effects, and determinants of outsourcing and highlights one of the contributions of my research.

The new data and my analyses uncover a wealth of unique findings on the nature and effects of international outsourcing. In Chapter II, I find that contrary to the common perception, the composition of U.S. imports remained relatively constant, with imports of intermediate and consumer goods each comprising roughly a third of U.S. imports during the 1990s and 2000s. Trade in inputs is largely vertically differentiated, with superior varieties produced in high-income countries. In Chapter III, I find that international outsourcing is a one of the main drivers of the growing wage gap during the 1990s and that these findings are largely obscured if one uses the old proxies of outsourcing. In Chapter IV, I reveal that input supplying countries with good quality of legal systems and thick supplier markets specialize in the production of inputs that are more specialized.

The key finding of my work is that there is not sufficient evidence to conclude that the patterns of trade in intermediate goods are qualitatively different from trade in finished goods. However, the impact of the two forces on the U.S. economy is very different.

CHAPTER II

STRUCTURE OF U.S. TRADE

II.I. Introduction

Various evidence indicates that the rapid growth in trade over the last several decades is driven, to a large extent, by a dramatic increase in the offshoring of intermediate inputs production and finished goods assembly. A number of studies search for stylized facts on the magnitude and nature of such overseas production arrangements. However, the results of these studies are considerably constrained by the fact that international trade data do not make a clear distinction between trade in intermediate and finished goods. In light of the ongoing political debate on the potentially adverse effects of offshoring on the already shrinking workforce of U.S. manufacturing, the need for such distinction continues to be relevant. This chapter provides an analysis of the patterns of global production sharing, made possible by newly constructed dataset that isolates intermediate goods and a portion of finished goods assembly from total U.S. trade flows.

Previous literature circumvented the absence of data on international outsourcing, by relying on two key measures of trade in intermediate goods. The first measure isolates trade in intermediate goods by focusing on goods described as "parts of" or "components of". Another measure relies on a crude assumption that economy-wide trade can proxy for trade in intermediate goods. It is commonly believed, however, that these measures provide an incomplete or inaccurate view of international outsourcing. Thus, the first measure neglects a vast array of other intermediate inputs, e.g., engines, semiconductors, etc, which do not contain "parts" or "components" in their descriptions. In this chapter, I show that it underestimates trade in intermediates by more than three-fold. The second measure allows noise in the estimates of imported inputs, which may impute a potentially large bias when used in a regression analysis. Finally, since the data on trade in finished goods do not exist either, previous studies are not able to estimate the importance of global production sharing relative to other trade. Using the three measures, previous studies' findings are limited to observing a dramatic growth in trade in intermediate goods and reorientation to include a larger number of non-traditional trading partners.

In this chapter I use a unique dataset of trade in intermediate goods that offers considerable improvements over the previous measures of such trade. First, this dataset is meticulously derived from detailed U.S. trade data, which span over 200 countries and sixteen years. Second, the derivation is based on clearly defined physical and stage-of-processing characteristics of the goods, which include both "parts", "components", and a vast range of other intermediate goods. Third, goods are further decomposed into their estimated end-use demand, so as to not confuse intermediate goods used in manufacturing with repair components purchased by consumers. Finally, unlike the other measures, the new data allow for the direct comparison of the intermediate goods trade with trade in finished goods.

I utilize the new data on intermediate goods to provide a unique view on the structure of the U.S. global production sharing. My contributions dramatically expand the findings of the prior literature. First, I explore the overall trends in the U.S. trade in intermediate goods with respect to overall magnitudes, commodity composition, and cyclical behavior. My findings indicate that contrary to the common speculation, the composition of trade, when measured by import volume shares, has changed little over the period of 1989-2004. However, the content of intermediate inputs in U.S. imports is higher than previously thought and is similar in magnitude to that of consumer goods. Thus, manufacturing materials comprise roughly a third of total U.S. import volumes, while over 70% of products imported in the U.S. are purchased to some extent by U.S. manufacturing for use as intermediates. Next I find that while the commodity composition of materials imports remained relatively constant over time, material imports are rapidly gaining importance relative to U.S. output in a number of key industries. For example, the imports of computer and electronics, primary metals, and electrical equipment materials imports more than doubled relative to U.S. output, constituting 23%, 30%, and 15% of output of respective industries in 2004. Finally, my findings provide reasonable evidence to suggest that imports of manufacturing intermediates are more prone to fluctuations in business cycles, than imports of consumer goods.

Next, I use data on materials imports to put to test two alternative predictions of the Heckscher-Ohlin theory of trade. The theory implies that countries with different relative endowments specialize in either distinct sets of products or distinct varieties of vertically differentiated products. To examine whether countries specialize in distinct sets of materials products, I group countries in regions and income categories that may better reflect endowments distributions across U.S. trading partners. I then check whether some U.S. materials imports and products are sourced predominantly from specific region/income groups. Similar to previous studies of total trade patterns, I find little evidence of across-product specialization for trade in intermediates. Next I use data on detailed unit values of materials imports to proxy for differences in vertical characteristics of differentiated products. Using standard panel estimation techniques, I find a positive relationship between unit values and countries' per capita GDP. This result implies that countries use their skill/capital endowment advantage, proxied by higher per capita GDP, to produce vertically superior varieties.

The approach taken to identify within-product specialization of trade is complementary to that of Schott (2004). Schott (2004) sets out to test the two predictions of the Heckscher-Ohlin theory of trade using detailed U.S. imports unit values for 1972-1994. He finds a positive relationship between countries' endowments and U.S. import unit values. My analysis is different from that of Schott in that I examine the extent of international specialization for U.S. imports of intermediate inputs and for a more recent period of 1989 to 2004. Additionally, I examine specialization patterns across selected industries, durable and non-durable manufacturing, and total manufacturing imports. Compared to Schott's results for 1980s, my estimates indicate that the importance of within-product specialization increased substantially in the 1990s.

The remainder of this chapter is structured as follows. Section II.II documents the relevant existing empirical research. Section II.III provides a detailed description of my dataset. Section II.IV establishes some stylized facts on trade in intermediate goods. Section II.V explores international specialization of production. Section II.VI concludes.

II.II. Existing Measures of Global Production Sharing

A number of studies attempt to establish stylized facts on the extent of global production sharing in the form of international outsourcing of manufacturing or processing of intermediate inputs and assembly of finished goods. Until recently, however, data constraints have prevented researchers from gauging the full scope of international outsourcing, as the existing trade data do not differentiate between trade in intermediate and finished goods. Consequently, previous research resorts to crude estimates of such trade of which three measures stand out the most: 1) trade in parts and components, 2) proxies based on input-output relationships; and 3) other, i.e. processing trade. It is commonly believed, however, that these estimates either capture only a subset of trade in intermediate inputs, are limited to only a number of countries, and/or fail to capture the true magnitude of trade altogether. Nevertheless, the explosive growth of outsourcing during the recent decades suggested by these estimates convey the growing importance of global production sharing. In the survey below I investigate the current approaches to decomposing international trade into relevant components, the results of these efforts, and their limitations.

II.II.1 Trade in Parts and Components

The most common approach to assess the trade in intermediate inputs or global production sharing is to look at trade in parts and components. This approach was pioneered by Yeats (2001), who brought attention to the changes in the SITC system of trade classification, which greatly expanded the number of product groups identified as "parts" and "components". One limitation of this approach is that the coverage of these items is mostly limited to the machinery and transport equipment sector of trade (SITC 7). Another shortcoming is that this approach limits intermediate trade only to that containing "parts of" or "components of" in the product description. Thus, stylized facts derived from this approach largely discount global production sharing of other vital manufacturing sectors, e.g. computers and electronics, and omit a large array of other processed inputs in machinery and transport equipment sector, e.g. internal combustion engines (Kaminski and Ng 2005).

Despite these shortcomings, previous investigation of trade in parts and components provide some indication of the patterns and explosive growth of global production sharing. Thus, studies suggest that, while cross-border fragmentation of production initially began as North-North trade, it is rapidly transitioning into trade between the developed and developing countries. For example, in the 1980s and the early 1990s, the U.S. and Japan were the largest exporters of transport and machinery components and parts in the world, both in total dollar value and as a share of their total exports, where a large portion of this trade took place between these countries (Yeats 2001). However, the U.S. and Japanese shares of total world exports of parts and components declined from 22% and 16% in 1987 to 16% and 11% in 2003, respectively, while East Asia's share grew from 8% in 1987 to 25% in 2003 (Kimura et al. 2007). A similar upward trend has been documented for the transition economies of Central

Europe (Kaminski and Ng 2005). The recipients of parts and components exports of East Asia and Central Europe are not only North America, Japan, and Western Europe, but also an increasing number of low and middle-income countries (Yeats 2001; Kimura et al. 2007).

II.II.2 Input-Output Tables and Trade

An alternative approach to estimating trade in intermediate goods combines data on total imports with data from input-output tables to determine the extent of an industry's purchases of intermediate inputs from overseas suppliers. This measure was originally proposed by Feenstra & Hanson (1996) and, for each industry *i*, is constructed as follows:[1]

$$\sum_j [\,purchases\,of\;interm.\,inputs_{ij}] \cdot [\frac{imports_j}{dom.\,output_j + imports_j - exports_j}], \qquad \text{(II.1)}$$

where subscript j refers to an industry supplying input j to industry i, where $i,j = 1,\ldots N$. Each product term in equation (II.1) is interpreted as industry i's estimate of imported material inputs from industry j. The measure in equation (II.1) is generally represented as a share of industry i's total expenditure on non-energy intermediates to arrive at industry imported input share.

Equation (II.1) uses the jth supplier's total import share in total domestic supply to estimate how much of the ith sector's input purchases are due to imports. The underlying assumption that total import share is a reasonable proxy for estimating the import share of intermediate inputs may be flawed. At high levels of supplier industry aggregation at

1 This formula first appears in Feenstra and Hanson (1996), but has been originally used by the BEA in construction of imported input purchases for the Import Matrices.

which these measures are commonly constructed, total imports and total domestic supply encompass imports and output of both intermediate and non-intermediate goods. Then the the import share in domestic supply of all goods used in the numerator of equation (II.1) may in fact over or underestimate the import share in domestic supply of only intermediate goods. As a result, the measurement error introduced in equation (II.1) may be potentially very large. I discuss the extent of the measurement error in the next section.

A number of studies use the Feenstra and Hanson (1996) measure of imported intermediates to determine the extent and characteristics of vertical fragmentation of production (e.g. Campa and Goldberg 1997; Feenstra and Hanson 1999, 2001). Their findings indicate that the use of imported intermediates has increased in many industrial countries since the 1970s. For example, U.S. imported intermediate inputs, expressed as a share of total non-energy intermediates purchases, nearly doubled from 6.5% in 1972 to 11.6% in 1990. On the other hand, Canada and Japan are shown to outsource over 20% of their total materials purchases to overseas suppliers in the 1980s and early 1990s (Campa and Goldberg 1997; Feenstra and Hanson 1999, 2001). Additionally, the value of imported intermediates embodied in exported goods are shown to have accounted for 30% of the growth in the overall export GDP share between 1970 and 1990 and that it grew by about 40% between 1970 and 1995 for ten OECD countries when measured relative to exports (Hummels et al. 2001, 2003).

II.II.3 Other Measures

The two measures described above are the primary measures of trade in intermediate goods used in the literature. There are a number of studies, which focus on a subset of trade in intermediates, which involves intermediate goods that are imported (exported) for processing and later are exported (imported) back to the country of origin. To measure "processing trade", studies either examine trade under special tariff provisions, which exempt inputs imported for processing from custom duties, or proxy for such trade by looking at the imported intermediate input content of exports.[2] These measures are heavily limited in the scope of their country, commodity, and year coverages (Feenstra et al. 1998, Chen et al 2005). Additionally, with the wide-spread adoption of free trade agreements, some special tariff provision are becoming obsolete (Yeats 2001). For example, U.S. processing reimports declined from 12.2% in 1990 to 8.5% in 1995, where much of the decline is likely to be attributable to the producers' failure to claim the tariff provisions after the introduction of NAFTA (USITC 1996; Feenstra et al. 1998).

II.II.4 Key Implications

The country, sector, and commodity-level restrictions and short time-spans that characterize the current data used to estimate the extent of global production sharing considerably limit the information that is available to us about the current state of global production sharing. The studies that use these data are able to identify only two primary

2 For studies of "processing trade" under special tariff provision see USITC (1996); Feenstra et al. (1998), Egger & Egger (2005), Swenson (2005). For studies of proxies of "processing trade" see Hummels et al (2001), Yi (2003), Chen et al. (2005)

trends of trade in intermediate goods. These trends characterize, for the most part, only trade in the machinery and transportation equipment sectors. First, they show that trade in intermediate goods increased dramatically over the past several decades, specifically, during the 1980s and 1990s. Second, there is an increasing reorientation of the developed countries' trade in intermediate goods away from their traditional Western suppliers.

In this chapter I expand our understanding of the extent and characteristics of U.S. trade in intermediate goods by relying on new data on trade in intermediate goods. These data significantly improve on the measures of trade discussed above in that they span sixteen years, a comprehensive set of imported manufacturing commodities, and over 200 U.S. trading partners. Using these data, I uncover new dimensions of global production sharing in regards to the magnitude and composition of trade, the characteristics of source countries and commodities.

II.III. Data Description

This chapter exploits a new dataset, which links a recently constructed Market Structure Index of HTS Imports (Imports Index) with data on detailed U.S. import transactions. I discuss the dataset construction and sources and compare the new data to existing measure of trade in intermediate goods below.

II.III.1 Dataset Construction and Sources

The Imports Index classifies detailed U.S. manufacturing imports into manufacturing materials, non-manufacturing supplies, capital goods, and consumer goods. The Imports Index is constructed from a number of official government sources. The first is a dataset of all U.S. manufacturing import products classified according to the ten-digit coding of the Harmonized Tariff System of the United States (HTS), and maintained by the U.S. International Trade Commission. These data cover all manufacturing products that crossed into the U.S. between 1989 and 2004 inclusive.

The detailed descriptions of HTS products identify the physical characteristic of products and their stages of processing, or the related industry that has use for the good. These descriptions allowed me to classify imported products by their final destination markets, e.g. manufacturing materials. Nevertheless, a large share of products are implied to serve multiple final destination markets, i.e. manufacturing materials and consumer goods. I verify the accuracy of the implied final destination markets against three existing indexes of U.S. domestic and imported production. The first index is the Federal Research Board (FRB) Market Structure of Industrial Production Index, which classifies detailed domestic industrial production into manufacturing input, non-manufacturing input, capital, and consumer end-use markets. The second source is the BLS Stage of Processing Index, which classifies the detailed manufacturing commodities into various stages of processing, i.e. crudes, intermediates, consumer goods, and capital goods. The final data sources are the BEA Import Matrix and Input-Output table for 1997, which provide data on imported and domestic input purchases by industry. I use the input purchases data from the BEA Import Matrix to assign relative importance weights to the HTS imports that serve multiple markets. (See Appendix A for full description of the imports index and its methods of construction.)

As the result of these efforts, the Imports Index classifies import products by four final destination markets: manufacturing materials, non-manufacturing supplies, capital goods, and consumer goods. *Manufacturing materials* consist of (1) goods that are incorporated into final goods produced by a manufacturing industry and (2) those that are used during the production of final goods[3]. The first category of materials incorporates intermediate inputs into non-durable manufacturing, e.g., flour, vegetable oils, wood pulp, wood logs, industrial chemicals, plastics, and textiles, and materials for durable manufacturing, e.g., metal mill products and parts and components of machinery and equipments. The second category of materials are intermediate inputs that complement the production of final goods, e.g., processed fuel and lubricants, packaging materials, some administrative supplies, and others.

Non-manufacturing supplies are defined as inputs into the non-manufacturing sector; i.e., construction, agriculture, utilities, and other industries. For example, construction supplies include building lumber, plywood, millwork, glass, plumbing fixtures, etc, while agricultural supplies consist of feeds, processed fuels, machinery repair parts, etc.

Capital investment goods consist of products that are used to manufacture or transport other goods in the manufacturing sector and include goods, such as machine tools for cutting and stamping metals, other specialized machinery (such as farm machinery and textile machinery), heavy trucks, ships, and boats. In addition, this grouping includes non-manufacturing industry and non-defense related government

3 Intermediate goods are also commonly referred to as industrial materials or just materials (FRB).

products, such as computers, office furniture, and heating equipment, that are used in the operation of businesses. Defense-related government investment such as military weapons and transportation equipment are also included in this category.

Finally, *consumer goods* are defined as nondurable goods and durable goods purchased by consumers and defense- and non-defense related government supplies[4]. Examples of these goods include such nondurable items as foods, children's apparel, prescription drugs, gasoline, home heating oil, and residential electric power and durable items as passenger cars, light trucks, household appliances, and home electronic equipment, to name a few. On the other hand, examples of defense and non-defense related government supplies include ammunition, repair parts for military equipment and machinery, education-related products, office supplies, and repair parts for non-military equipment and machinery owned by the government.

As noted above, a large portion of the 10-digit HTS products are classified as serving multiple final destination markets. Table B.1 illustrates the shares of imported manufacturing materials and consumer goods according to their assigned utilization weights. Thus, Columns I, II, and III, refer to those imported materials, which have final destination market weights of at least 25%, 50%, 75%, and 100%. As can be seen, only 16% of manufacturing materials products, which comprise roughly 23% of total materials import volumes, are used by U.S. manufacturing alone. However, over 60% of materials products, which comprise roughly 84% of total materials import volumes, are utilized

4 Consumer nondurables consist of items with a shelf life of less than three years and that are ready for final demand. Consumer durable goods include products that have a much longer shelf life than nondurables (SOP).

predominantly as manufacturing materials (rate of utilization is larger than 50%). On the other hand, less than 0.5% of consumer goods serve the consumer markets alone. The figures for consumer goods imports show, that consumer goods are generally also classified as non-manufacturing suppliers (e.g., paper), capital investment goods (e.g., computers), and/or manufacturing materials (e.g. tires).

In this chapter, I place my focus on trends in U.S. trade in manufacturing materials, but contrast them with the trends of trade in consumer goods. As I reveal in the following section, the two types of trade components represent the largest share of the U.S. imports. I link the Imports Index to detailed U.S. trade transactions from Feenstra (2002) and U.S. Census (2005) to derive data on import volumes of intermediate and non-intermediate goods for the period of 1989-2004. I then use these data to derive stylized facts of the trade in intermediate goods, with a particular focus on differences across region and industries. For industry-level statistics, I aggregate data up to 3-digit industry classification according to the North American Industrial Classification System (NAICS). While NAICS was not introduced until 1997, the U.S. Census provides a NAICS-HTS concordance for HTS codes going as far back as 1989.

Next, I compare the new data on inputs trade with the previously used measures of such trade and reveal potentially severe measurement errors in the old measures.

II.III.2. New Data Versus Old Measures

In my comparison of new and old data on offshoring of intermediate inputs, I focus on the measure of trade in intermediates defined by "parts" and "components" descriptions, and the measure of imported inputs originally proposed by Feenstra and Hanson (1996). These measures are described in Sections II.II.1 and II.II.2, respectively.

Figure B.1 illustrates the differences between the new data on imports of intermediate goods and the old data on imports of goods labeled as "parts" and "components". The classification of "parts" and "components" was kindly provided by Schott (2004), and includes a selection of 1989-2001 ten-digit HS codes, which contain these words in their description. As can be seen, the differences between the two measures are very distinct and large. The volume of U.S. trade in "parts" and "components" underestimates by more than three times the total volume of trade in intermediate goods.

Next, I turn my attention to the second measure of import of intermediate inputs originally proposed by Feenstra and Hanson (1996) and shown in equation (II.1). This measure is useful for assessing the extent to which each domestic industry imports intermediate inputs, which is not identified in raw imports data. As discussed in section II.II.2, equation (II.1) employs an industry's total import share in total domestic supply to proxy for the industry's share of imports of inputs in the domestic supply of inputs. If for some industries, the total import share includes data on both intermediate and non-intermediate goods, the measure of imported inputs in equation (II.1) may be driven by variation in the import share of non-intermediates. Using the new data on imports of intermediate goods, I am able to refine the original measure and derive imported inputs of each industry i as:

$$\sum_j [\, purchases\ of\ interm.\ inputs_{ij}] \cdot [\frac{interm.\ imports_j}{interm.\ dom.\ output_j + interm.\ imports_j - interm.\ exports_j}] \quad (II.2)$$

where as before subscript j refers to an industry from which industry i purchases its intermediate inputs, where $i,j = 1,...N$. The measure in equation (II.2) differs from the original measure of imported inputs by the right term of the numerator, where the total import share is replaced by import share of intermediate inputs.

To arrive at the two measures of imported inputs, I combine data on imports with data on inputs purchases. The inputs purchases are obtained from U.S. input-output tables provided by the BEA. The industries in input-output tables are classified on the three-digit Standard Industrial Classification (SIC) basis during 1989-1996 and four-digit North American Industrial Classification System (NAICS) basis during 1997-2004. I aggregate the imports data up to three-digit SIC and four-digit NAICS industries, using the HS-SIC and HS-NAICS concordances provided by U.S. Census. I then calculate the original and the refined measures of imported inputs in equations (II.1) and(II.2), respectively, and express them as shares in total non-energy materials purchases. Figure B.2 illustrates the movements in manufacturing weighted averages of imported input shares during 1989-2004, where the discontinuity in the graphs identifies the switch from SIC to NAICS. The differences between the two measures are distinct, although not as large as those shown for the first measure of trade in "parts" and "component". The differences are most pronounced when examining on a detailed industry level, not reported here.

In summary, the comparison of the new data on trade in intermediate goods with the previously used measures of such trade supports the literature's suspicions on the accuracy of the old measures.

II.IV. Magnitudes, Composition, and Cyclicality

In this section, I characterize U.S. imports of manufacturing materials along several dimensions. First, I examine the overall magnitudes of such trade over the period of 1989-2004, with a focus on import volumes, number of traded products, and their respective growth rates. Next, I examine the composition of materials trade by industry and highlight recent trends of primary traded commodities. Finally, I identify a distinct pro-cyclical behavior of U.S. materials imports, which is distinguished from that of other components of U.S. trade.

II.IV.1 Overall Magnitudes

The relative composition of trade is speculated to have changed over time in favor of intermediate goods. Figure B.2 utilizes the new data to reveal the relative composition of U.S. imports during 1989-2004. The imports of materials and consumer goods appear to maintain a roughly similar volume and growth during 1989-2000. The early 2000s saw the trends in the two types of trade diverge, wherein materials imports declined, while consumer goods imports continued to grow roughly at the same rate. Table B.2 shows that materials imports nearly tripled in size, from 131.7 in 1989 to 351.9 billion U.S. dollars in 2004, which corresponds to roughly a third and 29% of total imports in 1989 and 2004, respectively. Additionally, the economic significance of materials trade continued to grow, as the share of materials imports relative to total manufacturing output increased from 4.8% to 8.4%.

The composition of imported products also changed little over time. Table B.2 shows that the number of products used as manufacturing materials increased from 8497 in 1989 to 10615 in 2004. However, their share in total import products increased only from 71.2% to 73.9%, respectively. The number of import products used as manufacturing materials grew roughly at an average rate of 1.5% per year, slightly ahead of the 1.2% growth of consumer products.

These findings indicate that, contrary to the common speculation, the composition of trade, when measured by import volume shares, has changed little over the period of 1989 to 2004. However, the content of intermediate inputs in U.S. imports is higher than previously thought and is similar in magnitude to that of consumer goods.

II.IV.2 Commodity Composition

In this section I examine which commodities are of primary importance for trade in manufacturing materials and whether their relative standing has changed over time, both with respect to other commodity imports and U.S. domestic output. First, I illustrate the relative importance of materials imports in U.S. imports by three-digit NAICS commodities. Figure B.3 shows that materials imports comprise a significant share of most major imported commodities. Exceptions to these are Food/Beverage/Tobacco (311 & 312), Apparel & Leather, & Allied (315 & 316), Printing (323), Furniture (337), and

Miscellaneous (339) industries, which tend to to be non-manufacturing supplies- or consumer goods-heavy.

In Table B.3 I report statistics of market shares of top commodities of materials and consumer goods imports in their respective total imports. The commodity composition of materials imports remained relatively constant during 1989-2004, with computers and electronics and transportation equipment commodities topping the list. Additionally, computer and electronics materials imports are the only category of imports that show a significant growth in market share, from 19% of total materials import in 1989 to 24% in 2004. In the consumer goods markets, the composition of imports has also remained relatively stable over time. The apparel, leather and related products and transportation equipment imports remain the most heavily demanded consumer goods from overseas, although their market shares declined by 4% and 3% during 1989-2004. On the other hand, the market share of consumer chemicals more than tripled in magnitude, from 4% of total consumer goods import in 1989 to 13% by 2004.

Furthermore, it appears that the relative importance of materials and consumer goods with respect to U.S. output has increased significantly for many 3-digit NAICS commodities. For example, materials imports of computer and electronics, primary metals, electrical equipment, machinery, and fabricated metal products have roughly doubled their share in U.S. output of the respective industries during 1989-2004. These trends are even more pronounced for consumer goods imports. For example, apparel, leather and related consumer goods import share grew from 50% of U.S. output in 1989 to a striking 258% of the output in 2004.

The key point to take away from these initial findings is that the commodity composition of materials imports remained relatively constant over time, with the exception of the computer and electronics industry which gained further dominance as a leading source of materials imports. Despite relatively little change in their composition, however, material imports in most commodity groupings have increased significantly relative to U.S. output, with some industries more than doubling their relative share.

II.IV.3 Cyclicality

The period of 1989 to 2004 covered in my sample contains the longest U.S. business cycles ever recorded. According to the NBER's Business Cycles Dating Committee, the 1991-2001 business cycles lasted for 128 months, when measured from trough to trough (NBER). Figures B.2 and B.3 illustrate the volatility of imports over time. It seems that U.S. material imports are perhaps more volatile with respect to fluctuations in the U.S. economy than imports of consumer goods. For example, during the troughs of 1991 and 2001, materials imports grew at negative rate of 1.49% and 12.51%, respectively. During the same years, however, imports of consumer goods experiences a positive a positive rate of 1.41% and a negative rate of 0.54%, respectively.

The correlations and simple regression analyses shown in Table B.4 shed some light on the sources of imports volatility. In these tables, I use real U.S. sectoral output and real GDP as measures of manufacturing-wide and economy-wide business cycles. Output data is obtained from the BEA and covers 18 three-digit NAICS industries. The correlations shown in Table B.4 reveal that U.S. imports of intermediates are more correlated with fluctuations in the manufacturing output, rather than economy-wide fluctuations. The opposite is true, however, for imports of consumer goods.

To explore this issue more rigorously, I proceed to estimate the elasticity of the response of imports to business cycle fluctuations, as

$$\Delta \ln(Imports_{g.it}) = \beta_0 + \beta_1 \Delta \ln(Output_{it}) + \beta_2 Mat_g * \Delta \ln(Output_{it}) + \epsilon_{g.it}, \qquad \text{(II.2)}$$

where $Imports_{g.it}$ are imports of materials or consumer goods, deflated by the CPI deflator, sourced from industry i at time t, $Output_{it}$ is real output of U.S. industry i, and Mat_g is a variable that takes a value of 1 if imports are manufacturing materials and 0 otherwise. Column I of Table B.4 reports the estimated elasticity of response of imports to output fluctuations. The coefficient on the materials dummy interaction is positive and statistically significant, indicating that changes in materials imports are more elastic with respect to changes in business cycle fluctuations, relative to changes in consumer goods. In Column II, I include changes in national GDP instead of the sectoral output. The coefficient on the materials dummy interaction is statistically insignificant in this specification.

The findings described above provide evidence to suggest that imports of manufacturing intermediates are more prone to fluctuations in U.S. manufacturing rather than economy-wide business cycles, and more so than imports of consumer goods. This is consistent with what is known about the firms' response to business cycles, where industries forecast changes in demand by slashing of their inventories in times of recessions and increasing them during recovery.

II.V. International Specialization of Production

In this section of the chapter, I use data on materials import to put to test two alternative predictions of the Heckscher-Ohlin theory of trade. The theory implies that countries with different relative endowments specialize in either distinct sets of products or distinct varieties of vertically differentiated products. Thus, the first prediction of the Heckscher-Ohlin theory would imply, for example, that the labor-abundant Philippines export labor-intensive apparel, labor and capital abundant Ireland exports labor- and capital-intensive chemicals, while capital abundant Japan focuses on capital-intensive machinery. On the other hand, given the same set of countries and a hypothetical product, such as a television set, the second prediction would imply that Philippines exports televisions made with color tubes, Ireland exports television sets made with rear-projection, and Japan exports television set made with plasma displays, given their relative endowments and relative sophistication of the television production technologies.

To examine whether countries specialize in distinct sets of materials products, I group countries in regions and income categories, that may better reflect endowments distributions across U.S. trading partners. I then check whether some U.S. material imports and products are sourced predominantly from particular region/income groups. Similar to previous studies of total trade patterns, I find little evidence of across product specialization for trade in intermediates. Next I use data on detailed unit values of materials imports to proxy for differences in vertical characteristics of differentiated products. Using standard panel estimation techniques, I find a positive relationship between unit values and countries' per capita GDP. This result implies that countries use their skill/capital endowment advantage, proxied by higher per capita GDP, to produce vertically superior varieties.

Other studies testing the predictions of the Heckscher-Ohlin theory find scant evidence in favor of endowment-driven trade at either the industry level (e.g., Bowen et al. 1987, and Trefler 1995) or detailed product level (Schott 2004). On the other hand, Schott (2004) performs an empirical test of the second prediction on detailed U.S. imports unit values during 1972-1994 and finds a positive relationship between countries' endowments and U.S. import unit values. The approach taken in this section is complementary to that of Schott (2004). My analysis is different from that of Schott, in that I examine the extent of international specialization for U.S. imports of intermediate inputs and for a more recent period of 1989 to 2004. Additionally, I contrast the extent of international specialization of trade in intermediate goods to that of trade in consumer goods. Finally, I examine specialization patterns across selected commodities, i.e., computer and electronics, transportation equipment, chemicals, machinery, and electrical equipment, durable and non-durable products, and as a whole.

II.V.1 Across-Product Specialization by Import Share

In an attempt to reveal trends in specialization across materials products, I first explore the import shares of U.S. trading partners across products. Large asymmetries in import shares across products should serve as a sign for across-product specialization. I find these asymmetries to be prevalent in some materials producing industries more than others, pointing to some across-product specialization in materials trade. At the same time, however, I find little support of specialization across consumer goods products.

To facilitate the comparison of trading partners, I make use of the country-region assignments provided in Table B.5. Three aspects of how countries are assigned to regions deserve mention. First, Latin America includes all of the countries of Central and South America, excluding Mexico. Second, I define ASEAN as its current 10 member countries and includes South Korea & Bhutan. Third, OECD comprises of its 18 founding members, excluding Canada and the U.S., and includes the more recent members Finland, Australia, and New Zealand. I exclude Mexico, Canada, and Japan from OECD, as I intend to keep them as independent categories. Additionally, I define China as China (mainland), Hong Kong, Taiwan, and Macao. Finally, the OTHER category consists of the remaining countries. The resulting set of countries is intended to capture regions, according to a more uniform mix of wages/income levels and common cultural characteristics. The Other category serves as an exception, since it groups high-income Israel with low income India.

Table B.6 reports the U.S. market share of U.S. major trading partners in terms of import value by industry, for the first and last years of the sample. A partner's market share by industry is calculated as the sum of U.S. imports from that industry and region as a share of U.S. total imports within the industry. At first glance, it appears that more than half of U.S. imports of intermediate goods is supplied by the world's most developed economies, Canada, Japan, and OECD, although this share decreased from 70% in 1989 to 51% of total manufacturing imports in 2004. The less developed Mexico and China are the primary source countries gaining from the loss of the market share of the traditional partners. The market shares of Mexico and China are roughly equal and, when combined, increased from 12% in 1989 to 26% of total U.S. manufacturing imports in 2004. These trends come in contrast to those of consumer goods. First of all, Canada, Japan and OECD demand a much smaller share of U.S. imports of consumer goods that is only 50% in 1989 and 42% in 2004. All of the loss in the combined market share, in fact, stems only from Japan. Furthermore, Mexico barely competes with China for a share in U.S. imports, sourcing 8% and 25% of total U.S. materials imports in 2004, respectively. In the end, nearly 50% of consumer goods are sourced from China and OECD, and these countries appear stable in their positions as equal leaders.

At second glance, Table B.6 reveals some heterogeneity in market shares of trading partners of materials across industries. For example, it appears that imports of nondurable intermediates are heavily concentrated in the hands of Canada and OECD. Both of these countries are U.S. leading sources of chemicals materials during 1989-2004. In durable manufacturing, Japan and OECD continue to supply the U.S. with the majority of machinery intermediates, while neighboring China and ASEAN are taking the leading positions in sourcing computer and electronics parts and components. By 2004, Mexico takes the lead in the U.S. imports market of electrical equipment materials. At the same time, however, transportation equipment intermediates are sourced roughly equally from Canada, Japan, Mexico, and OECD. In summary, these findings suggest that across-product specialization is more prevalent in some materials producing industries than others.

The patterns of specialization of materials imports are quite different from those of consumer goods. With the exception of the transportation equipment, China and OECD appear to dominate the market of both durable and nondurable consumer goods imports. Furthermore, OECD's leadership continues to grow at the expense of ASEAN countries and China's leadership at the expense of Japan in the nondurable and durable consumer goods markets, respectively.

To shed more light on the U.S.'s most dynamic trading partners, Table B.7 reports the countries with top ten absolute changes in imports market share between 1989-2004. China and Mexico top the lists in both materials and consumer goods imports.

II.V.2 Across-Product Specialization by Product Share

I examine international specialization across materials products further by exploring differences in import product penetration of U.S. trading partners. Each cell in Table B.8 reports the percentage of products in each industry imported in the U.S. from a region. Regional penetration is 100% if every product in the industry is sourced from at least one country in the region and 0% if no country in the region sources any of the industry's products to the U.S. One would expect that product penetration should not be high by each region, since each region should specialize in a set of goods.

As indicated in Table B.8 intermediate imports product penetration by OECD is over 90% and by other countries/regions is between 40% and 80% during 1989 and 2004. The same pattern emerges for product penetration of consumer goods imports. However, both Japan and OECD have experienced slight declines in the product penetration between 1989 and 2004, while the less developed U.S. trading partners are seeing an increase in their product penetration. Table B.9 ranks countries with the biggest absolute gains in penetration between 1989 and 2004. The same countries that had the highest absolute change in market share top the list for highest absolute change in product penetration. The high product penetration of countries/regions reported in Table B.8 poses further evidence against the implications of the Heckscher-Ohlin theory that countries specialize in a distinct mix of products (Schott 2004).

Increases in import market share occur through increasing imports of incumbent products and an increase in the number of products imported. I decompose growth in imports of intermediate goods into those parts that are attributable to growth of imports of the continuously produced goods (intensive margin) and growth of imports from the entry and exist of new products (extensive margin). Table B.10 shows the results of the decomposition growth of U.S. imports from each source country/region for overall manufacturing and by industry. In contrast to previous tables in this section, I use eight-digit HS codes rather than ten-digit HS codes in the decomposition. This is due to the fact that the HS code classification has undergone many revisions over the period of 1989-2004 due to both methodological and tariff schedules changes, which may assign the same commodities different HS codes. In my experience of dealing with the HS codes, these changes are reflected primarily in the last two digits of the ten-digit HS codes. Thus, restricting attention to eight-digit HS product codes may circumvent the discrepancies in the HS classification over time at least partially.

As indicated in Table B.10, the relative contribution of the extensive versus intensive margins varies across industries and import types. The extensive margin is significantly more important for computer and electronics industry across both intermediate and consumer goods import growth. On the other hand the extensive margin is more important for intermediate goods imports and intensive margin is more important for consumer goods imports of electrical equipment industry. The reverse is true in the machinery sector. All in all, however, it is the intensive margin that is relatively more important in the growth of imports of intermediate and consumer goods.

The message of the discussion above is relatively clear: when trade is divided into thousands of products, there is little evidence over time of endowment-related specialization across products for both intermediate and consumer goods when looking at largest trading countries/regions with the U.S. As a final test against across product specialization, I follow Schott (2004) and break countries into relative income cohorts to examine the share of products sourced from low-, middle-, high-income countries at the same time. Income levels are commonly used as an indicator of level of endowments, i.e. skill and capital, with low and high income levels representing less skill/capital and more skill/capital endowments, respectively. A large share of products sourced from low and high income countries levels at the same time should serve as the final test against across product-driven specialization.

I use per capita GNI (pcGNI) data from World Bank classification to group countries in relative income cohorts. I also show whether results are sensitive to the use of alternative relative classifications of income levels, e.g. low income countries are defined if country income is below 40% income percentile relative to world income distribution. Next, I classify imported products according to the source country income classification. Low (L), Middle (M), and High (H) products originate solely in low-, solely in middle-, or solely in high-income countries, respectively. Products are Low and Middle (LM) or Middle and High (MH) if they are sourced simultaneously from at least one country of each type. Finally, a product is Low, Middle, and High (LMH) if it is sourced from at least one low and at least one high-income country. I exclude China from the analysis, as its inclusion significantly inflates the contribution of low income countries.

Table B.11 reports product share by source country income groupings according to various income breakdowns. The share of import products sourced from only high-income countries and the share of import products sourced from both middle and high income countries is diminishing during 1989-2004. At the same time, however, the share of import products sourced simultaneously from at least one low and one high-income country is increasing rapidly during 1989-2004. As a further robustness check, I exclude LMH products sourced from just one low-wage country, which are indicated by a star in Table B.11. The fact that the share of products sourced from the LMH countries increases regardless of the income breakdowns is remarkable, as mentioned in Schott (2004) for total U.S. imports.

The results presented in this section offer compelling evidence against international specialization across products during 1989 and 2004.

II.V. 3. Within-Product Specialization by Unit Values

I now turn my attention to the alternative prediction of the Heckscher-Ohlin theory of the importance of within-production specialization. To test the prediction, I examine whether there is a positive relationship between unit values of U.S. imports of intermediates and source country per capital GDP. Unit values are measured as import volumes divided by import quantity. I use real per capita GDP from the World Development Indicators (2007). Following Schott (2004), I regress log unit values of U.S. imports of manufacturing materials on source country log per capita GDP across ten-digit HS products, source country, and year for all manufacturing imports during 1989-2004.

$$\log(uv_{g.ct}) = \alpha_g + \alpha_t + \alpha_r + \beta * \log(GDPpc_{ct}) + \epsilon_{g.ct} \qquad \text{(II.4)}$$

where $uv_{g.ct}$ is unit value of materials or consumer goods, sourced from country c in year t, $GDPpc_{ct}$ is country c's real per capital GDP in year t, and α_g, α_t, and α_r are product, year, and region fixed effects. In an alternative specification, I pool the unit values for materials and consumer goods, and regress equation (II.4) with an interaction term of the consumer goods dummy with per capita GDP. The latter allows me to gauge whether the extent of international specialization within materials products is different from the extent of specialization within consumer goods products. I estimate these differences for selected industries, as well as non-durable and durable manufacturing imports.

The results in Table B.12 Column I show that unit values of U.S. imports materials are positively and significantly related to countries' per capita GDP. The coefficient in Column I implies that 10% increase in per capita GDP is associated with 1.3% increase in unit values of imported materials. Columns II-IV restrict the sample to only those products, that are used more than 25%, 50%, 75% as manufacturing materials. The estimates in these subsamples are of the expected signs and significant, and are larger than the ones in the full sample. This evidence is indicative of the fact that as materials become more specialized, international specialization along vertical dimensions in fact increase. Finally, Column V reduces that sample to only those products that are sourced simultaneously from at least one low income and one high income country. The coefficients remain unchanged from that of full sample.

Next I break up the sample into non-durable and durable manufacturing materials as shown in Table B.12. Additionally, I include unit values of consumer goods and use a dummy variable to gauge whether there is a statistically significant difference between the effect of per capita GDP on unit values of materials and that of consumer goods. The coefficients in the regressions on each sample are still positive and statistically significant, however the effect diminishes as the sample gets smaller. This comes in contrast to the increasing effect found in the full sample. Furthermore, there is a statistically significant difference of the effect of per capital GDP on unit values of consumer goods, which in fact increases as products' utilization by final destination markets is more concentrated.

Finally, I break the sample up further into selected industries, and estimate (II.4) on each industry products samples, as reported in Table B.13. Chemicals manufacturing exhibits the largest coefficient of any of the selected industries and industry groupings, implying that international specialization across vertical dimensions is greatest for chemicals, compared to other industry groups. The changes in the coefficients with the extent of utilization of chemical materials are also intuitive. When chemicals imports are predominantly used by U.S. manufacturing (measured by more than 75% utilization rate in Column IV), these imports include primarily crudely processed chemicals, which tend to exhibit a lower degree of vertical differentiation. This implies a lower international specialization across the vertical dimension and is reflected by a smaller estimate of the effect of GDP on unit values in Column IV, relative to other columns. On the other hand, chemicals imports used heavily by consumer markets (measured by more than 75% utilization rate in Column IV), refer to consumer pharmaceuticals, which generally exhibit a large degree of vertical differentiation. Thus, as the rate of utilization increases, differences in the effects of GDP on unit values of chemical materials and unit values of consumer goods also increase, as shown by the estimate on the consumer dummy. The patterns of the effects of GDP on selected durable industries are also intuitive and opposite of those for chemicals. Thus, international specialization in varieties of machinery, computers, and electrical equipment materials becomes more pronounced as inputs become more specialized and customized in nature, reflected by higher rates of utilization in Column III.

The evidence linking unit values and income presented in this section supports an old trade theory interpretation of U.S. trade. The results are consistent with endowment-abundant countries using their relative endowments to manufacture vertically distinct varieties that use those endowments more intensively.

II.VI. Conclusion

Previous attempts to shed light on the nature of trade in intermediate inputs have been largely constrained by the fact that trade data do not differentiate between trade in intermediate and finished goods. In this chapter, I introduce a newly constructed dataset that clearly distinguishes between U.S. imports of manufacturing materials, consumer goods, and others, during 1989-2004. With these data in hand, previous findings on the nature of trade in intermediate inputs can be confirmed, revised, and added to.

Using the new data, I reveal that the magnitude of U.S. trade in intermediate goods is larger than previously thought, averaging roughly a third of total U.S. import during 1989-2004. Furthermore, imports of intermediates exhibit sharp pro-cyclical tendencies, which are distinguished from those of other imports components. Finally, I find that while inputs are largely vertically differentiated, with superior varieties produced in high-income countries, the within-production specialization is in fact more pronounced for trade in consumer goods.

CHAPTER III

OUTSOURCING, TECHNOLOGY, AND U.S. WAGE INEQUALITY

I. Introduction

It has been well documented that U.S. wage inequality rose dramatically during the 1980s, when the wages of both the most skilled and moderately skilled workers increased and the wages of least skilled workers dropped. A large literature spans the debate on the determinants of this rise in the wage inequality. A common consensus points to the on-going growth of the demand for high-skilled workers, of which skill-biased technical change (SBTC) and international trade are the often cited sources. While much empirical evidence supports the hypothesis of the effect of SBTC on wages, the evidence for the impact of trade on wages is mixed. Only one U.S. study finds robust estimates of the effect of international trade, specifically, trade in intermediate inputs, on the 1980s wage inequality, and many others arrive at inconclusive evidence of the effects of trade.[5]

Surprisingly, the literature has focused almost exclusively on data from the late 1970s and the 1980s. The few studies that have examined this issue using data from the 1990s find mixed evidence on the overall patterns of wage inequality during this period

5 See Feenstra and Hanson (2003) for the survey of trade's impact on wages.

and merely speculate on its determinants.[6] At the same time, there is growing evidence to suggest that both technology and trade gained further prevalence during the 1990s and early 2000s, as firms finally learned to reap the full benefits of the computer revolution and established extended networks with the low-wage countries.

Prior literature examining the effect of trade on wage inequality has two shortcomings that this chapter will focus on. First, virtually all previous papers have focused on the period of the late 1970s and 1980s, with no work examining the 1990s and 2000s. This seems primarily due to the fact that the National Bureau of Economic Research (NBER) Productivity Database used for these studies ends in 1996. Nevertheless, there is a general perception in the literature that the growth in wage inequality has subsided. This calls into question how strongly trade forces may be affecting the U.S. skilled-unskilled wage gap, since evidence suggests that the 1990s and 2000s saw a dynamic growth of trade. I find that this perception regarding the fall in the wage gap within U.S. manufacturing to be false. I document a significant rise in wage inequality in 1990s and a decline in the 2000s, which closely corresponds to the movements of trade in intermediate inputs over the same period.

A second significant shortcoming of the previous literature is its measurement of imported intermediate inputs, i.e. materials offshoring. Given available data, previous literature has used input-output relationships to determine the extent of a sector's intermediate inputs purchases from an input supplier. Then the suppliers' total imports share in the U.S. supply is used to estimate how much of the sector's input purchases are

6 See the survey in Autor et al. (forthcoming 2008) and Lemiuex (2007).

due to imports. Thus, it is assumed that total import share is a good proxy for estimating inputs import share. As shown in Appendix A of this chapter, this assumption introduces significant measurement error.

I address these shortcomings in the following fashion. First, I update the NBER Productivity Database through the year 2005. Using these data, I first document that while the gap between skilled and unskilled workers continued to rise during the 1990s, it fell significantly after 2000. Next, I use standard data construction techniques and empirical specifications utilized in product-price literature to estimate the effect of trade on the skilled-unskilled wage gap for this later period (1989-2005) and find a significant effect of materials offshoring on the wage gap. However, this effect is not robust to the inclusion of alternative measures of trade and computerization, which calls into question the validity of previous findings; e.g., Feenstra and Hanson (1999) who find that materials offshoring explains up to 25% of the rise in the skilled-unskilled wage gap for their earlier sample covering the years, 1979-1990.

I then turn to recently constructed trade data on U.S. imports of intermediate goods to develop a refined measure of materials offshoring. Using the refined measure, I find a very large and robust effect of offshoring on the skilled-unskilled wage gap of 1989-1996 and a large, albeit insignificant, effect on wages of 1997-2004. Furthermore, offshoring of business services appears to play a large role in the widening of the wage gap during 1989-1996, although services offshoring contributes to the closing of the gap during 1997-2004.

Other findings indicate that one must take caution in interpreting all technological change as skill-biased. I find that computer adoption contributed significantly to the rise in the skilled-unskilled wage gap during 1989-1996, by increasing the non-production wages and decreasing, albeit statistically insignificantly, the production wages. On the other hand, the estimates show that office equipment diffusion has a overall neutral effect on relative wages, while other high-tech technological change is biased towards the unskilled during 1997-2004. Additionally, the failure to identify the effect of computers on the wage gap of 1997-2004 may be indicative of the diminishing role of computer technologies in U.S. manufacturing.

This work is part of the growing theoretical and empirical debate on the effects of technology and international trade on the increase in the relative demand for skill. A plethora of studies document a striking correlation between the adoption of computer-based technologies and the increased use of college-educated labor within detailed industries and firms and across plants within industries.[7] In contrast, the evidence of the impact of trade on the demand for skill is much more conflicting.[8] A number of studies argue that a constant trade to GDP ratio, increasing product prices of least-skilled industries, and within-industry changes in labor composition of developed countries are indicative of a relatively minor role of trade in the prediction of relative wages.[9] Proponents of trade effects, on the other hand, retaliate by pointing to a rising trade to

7 Katz and Autor (1999) summarize this literature.

8 See Feenstra and Hanson (2003) survey of the literature on trade and wages.

9 See Krugman (1995) for a discussion of relative magnitudes of trade; Slaughter (2000) for a discussion of literature on relative-price changes; and Berman et al. (1994) on within vs. between industry labor shift.

value-added ratio, growing relative domestic prices, and aggregation issues of industry-level data on labor composition. Furthermore, recent studies argue that the growing share of trade in intermediate inputs may shift the relative demand for skill in the same manner as SBTC does (Feenstra and Hanson 1999, 2003). Recently, however, these findings have been called into question, as the alleged decline in relative wages during 1990s does not appear to coincide with the dynamic growth of technology and trade of the1990s (e.g., Card and DiNardo 2002). One of the contributions of this work is to attempt to shed more light on the roles of technology and trade in the changing nature of wage inequality of the 1990s and 2000s.

In addition to the contribution discussed above, this work also contributes to the methodology of the product-price literature (see Slaughter 1999). There are only a handful of other studies on underlying factors causing changes in prices and productivity, which then are linked to wage changes. These studies find mixed contributions of trade-related forces, i.e. materials offshoring, trade barriers, and transportation costs, on U.S. wage changes of the 1970s and 1980s (Feenstra and Hanson 1999, Haskel and Slaughter 2003). I contribute to their methods by using more recent data for 1989-2004 and exploring a broader set of causal factors, which include more refined measures of trade.

The chapter is organized as follows. Section III.II documents relative wages during 1989-2005. Section III.III presents empirical methodology. Section III.IV describes data. Section III.V presents empirical results. Section III.VI discusses sensitivity analysis and section III.VII concludes.

III.II. Old and New Evidence of Wage Inequality

The rapid growth of U.S. wage inequality of 1980s has been well documented within both U.S. manufacturing and for the U.S. as a whole. While no papers have analyzed trends in wage inequality within U.S. manufacturing during 1990s and 2000s due to data limitations, a few studies have examined the growth in relative wages using U.S.-wide micro data. These studies find conflicting evidence, suggesting a changing nature of the 1990s U.S. wage inequality, which may not correspond to the dynamic growth of trade and SBTC that occurred during the same period. In this section, I use new industry-level data to document movements of wage inequality within U.S. manufacturing over the period of 1989-2005. The new data show a significant rise in wage inequality in the 1990s and a decline in the 2000s, which correspond to the patterns of trade and SBTC referenced in the literature (e.g., Autor et al. 2003; Feenstra and Hanson 2003).

Prior studies of wage inequality rely on two primary datasets, the earnings data of workers from all U.S. industries compiled in Current Population Surveys (CPS) and the wages of workers in U.S. manufacturing available through the NBER Productivity Database (NBER PD). During the 1980s, these data show a significant rise in wage inequality. According to the CPS data, between 1979 and 1989, the real wages of workers with sixteen or more years of education rose by 3.4%, of full-time workers with twelve years of education fell by 13.4%, and of workers with less than twelve years of education fell by 20.2%.[10] Within U.S. manufacturing alone, the total wages of nonproduction

10 A detailed discussion of basic facts concerning wage movements in the U.S. during 1980s is provided in Katz and Autor (1999).

workers relative to production workers rose by an average of 0.72% per year over the period of 1979-1990 (Feenstra and Hanson 1999).[11]

The early 2000s saw a rise in the studies of wage inequality of 1990s, which paint a mixed picture of the changing nature of U.S. wage inequality and the sources of these changes. For example, Card and DiNardo (2002) explore CPS data and find no noticeable change in wage inequality between 1988 and 2000. This finding leads them to question the validity of the previously estimated effects that SBTC and trade forces have on wage inequality during 1980s. On the other hand, Autor et al. (forthcoming 2008) use similar data for 1989-2005 to show polarization in wages, where the wages in very low and very high skill occupations increased, while those in moderately skilled occupations contracted.[12] No papers document the wage inequality of 1990s and 2000s for the U.S. manufacturing, as NBER PD data ends in 1996.

In order to illustrate the trends in U.S. manufacturing wage inequality over the period of 1989-2005, I expand the NBER PD from 1997 to 2005 (see Appendix A for data and methods description). I use the wages of nonproduction and production workers, which are often used as proxies of skilled and unskilled labor wages, to construct a measure of wage inequality.[13] I follow the literature to define this measure as log of the ratio of nonproduction wages per worker to production wages, where real wages denote

11 In the wage literature, nonproduction and production workers are commonly used to proxy for skilled and unskilled workers in manufacturing.

12 According to Autor et al. (Forthcoming) the rising wage inequality in the lower half of wage distribution was an event confined to the 1980s.

13 Nonproduction wages are constructed as total nonproduction wages divided by total nonproduction worker employment, whereas production wages are constructed as total production wages divided by total production hours worked. Data on total nonproduction hours worked is not available.

wages per worker.[14] Figure D.1 plots 1963-2005 wage inequality for the entire U.S. manufacturing and as industries' average, where weights for the latter are constructed as shares of the industry wage bill in total manufacturing shipments. As can be seen, wage inequality slowly declined from the late 1960s through the 1970s, and began to increase during the 1980s. Perhaps the most rapid widening of the wage gap can be observed during the 1990s, when it was also the most steady. Wage inequality decreased dramatically during the 2001-2002 U.S. recession and fluctuated during the recovery years that followed.

Table D.1 provides more detail on the growth of workers' wages over the last three decades. During the period of 1979-1990 covered in most previous studies, the wages of production workers and nonproduction workers increased at an average 4.99% and 5.42% per year, such that the relative nonproduction wage rose by an average 0.43% per year. During 1989-1996 covered in this chapter, production and nonproduction wages increased at an average 2.67% and 3.78% per year, respectively, leading to a marked rise in the relative wages of 1.11% per year. Although both wages continued to grow during 1997-2005, the average annual decline in relative wages of this period amounted to 0.74%, much of which occurred during 2001-2002.

14 This is a common measure of wage inequality in labor economics studies, e.g. Autor et al. (Forthcoming); Card and DiNardo (2002); etc. Other measures of wage inequality have been used in the past. For example, Feenstra and Hanson (1999), Haskel and Slaughter (2001, 2003), and others employ the ratio of total nonproduction wages to total production wages, which estimates wage inequality in nominal terms. I find little difference in my measure and this measure of wage inequality.

III.III. Empirical Methodology

The empirical studies estimating the effect of trade and technology on wage inequality have typically used a methodology derived from the Stolper–Samuelson theorem (SS theorem), which links product price changes to changes in factor prices, under zero-profit conditions.[15] This methodology relies on the production side of the Heckscher-Ohlin model which considers an economy with multiple sectors of different factor intensities and factors with complete mobility across sectors[16]. In this framework, aggregate demand for skilled workers relative to unskilled workers is horizontal and aggregate relative labor supply is upward sloping[17]. The aggregate relative labor demand is horizontal since a change in the demanded quantity of skilled (unskilled) labor can potentially be absorbed by a change in output in an unskilled (skilled) sector, and thus may be independent of relative wages[18]. Relative wages, in turn, are determined by product prices and/or productivity under zero profit conditions, which in turn are driven by exogenous forces, i.e. trade or technological innovation. When changes in exogenous forces alter intersectoral profitability, relative wages change to restore zero profits, factors flow to other sectors, and the relative aggregate demand curve shifts.

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15 Deardorff (1994) surveys all statements of the SS Theorem that have appeared during the past 50-plus years. One of the statements is the following: "For any vector of goods price changes, the accompanying vector of factor price changes will be positively correlated with the factor intensity-weighted averages of the goods price changes."

16 This is different from labor studies which assume that factors are immobile (Haskel 1999).

17 Note, that the relative demand curve in each sector is still downward-sloping, while the aggregate demand curve is flat.

18 This is the so-called Rybczynski effect (Rybczynski, 1957)

This process can be formalized by supposing that the economy, which in this case is U.S. manufacturing, produces *I* different traded goods, associated with *I* industries. Each industry employs some combination of *J* primary factors and *M* intermediate inputs. Under constant returns to scale technology, zero profit conditions for industry *i* can be written as

$$p_i = \sum_{m \in M} p_{mi} a_{mi} + \sum_{j \in J} w_{ji} a_{ji} \qquad \text{(III.1)}$$

where p_i is the domestic price of one unit of output, p_{mi} is the unit cost of *m*th intermediate input, a_{mi} is the quantity of *m*th input required for production of one unit of output, w_{ji} is the unit cost of *j*th primary factor, and a_{ji} is the quantity of *j*th factor required for production of one unit of output. Totally differentiating to express everything in instantaneous changes and allowing for changes in the technology of production, equation (III.1) can be rewritten as

$$\dot{p}_i^{VA} = \sum_{j \in J} \dot{w}_{ji} \theta_{ji} - T\dot{F}P_i \,, \qquad \text{(III.2)}$$

where $\dot{p}_i^{VA} = \dot{p}_i - \sum_{m \in M} \dot{p}_{mi} \theta_{mi}$ is change in value-added prices, $T\dot{F}P_i = -\sum_{j \in J} \dot{a}_{ji} \theta_{ji}$ is the primal measure of total factor productivity, and θ_{mi} and θ_{ji} are the cost shares of intermediate inputs and primal factors in total costs of industry *i*, respectively.

Since all factors are mobile across sectors, changes in wages of primary factors can be assumed to be equal across sectors. Then the existing differences between the industry wage changes and the manufacturing-wide changes are assumed to arise from the variations in factor qualities across sectors[19]. Expressing industry wage changes in equation (III.2) as differentials from manufacturing-wide changes, I obtain

$$\dot{p}_i^{VA}=\sum_{j\in J}\bar{\dot{w}}_j\theta_{ji}-\dot{TFP}_i+\sum_{j\in J}(\dot{w}_{ji}-\bar{\dot{w}}_j)\theta_{ji}, \qquad \text{(III.3)}$$

where $\bar{\dot{w}}_j$ is the effective manufacturing-wide wage change of primary factor *j* and $\dot{w}_{ji}-\bar{\dot{w}}_j$ is industry *i*'s wage change differential of *j*th primary factor. I combine industry wage differentials with changes in TFP and refer to them as changes in effective TFP, such that

$$\Delta\ln p_{it}^{VA}+\Delta\ln ETFP_{it}=\sum_{j\in J}\Delta\ln\bar{w}_j\ \tfrac{1}{2}(\theta_{jit-1}+\theta_{jit}), \qquad \text{(III.4)}$$

where instantaneous changes are expressed in first-log-difference and primary factor cost shares are averaged over two periods.

Equation (III.4) shows how manufacturing-wide factor prices adjust to changes in value-added product prices and/or effective productivity to restore zero profits in all sectors. This equation captures the wage adjustments to shifts in aggregate relative labor demand described above. Value-added price and/or effective productivity increases in a sector tend to raise (reduce) the relative wages of factors employed relatively intensively (unintensively) in that sector, where intensity is defined by $\frac{1}{2}(\theta_{jit-1}+\theta_{jit})$. Note, that productivity changes can be factor-biased or factor- neutral, as long there are changes in net productivity (or by duality net costs), which raises sectoral profitability and so necessitates wage changes[20].

19 See Feenstra and Hanson (1999) discussion on pg. 911.

20 This is different from labor studies focus, where only factor-biased technical change affects wages since it changes the relative productivity of factors within a sector. See Haskel (1999) for discussion.

In the framework discussed above, value-added prices and effective productivity changes are assumed to be exogenous. In a large country-setting, however, prices and productivity changes are determined by domestic and foreign forces. To model the endogeneity of prices and productivity changes, Feenstra and Hanson (1999) developed a two-stage procedure, in the first stage changes in prices and productivity are regressed on exogenous factors, which are then linked to changes in wages. I follow this procedure, as described it below.

In the first-stage, I regress changes in value-added price and effective productivity on a set of *K* causal factors, which are hypothesized to drive these changes over time:

$$\Delta \ln p_{it}^{VA} + ETFP_{it} = \sum_{k \in K} \gamma_k \Delta z_{ikt} + \eta_{it} \qquad \text{(III.5)}$$

where z_{ikt} is the *k*th causal variable, γ_k is a coefficient on *k*th causal variable, and η_{it} is a disturbance term that captures all other shocks to the value-added price and productivity, which are assumed orthogonal to z_{ikt}. Changes in a causal factor can affect changes in either only value-added prices, or both value-added prices and effective productivity. In addition to its direct effect on both prices and productivity changes, Δz_{ikt} can affect price changes indirectly through its impact on productivity changes, which are "passed through" to product prices (Feenstra and Hanson 1999; Krugman 2000).[21] Assuming a 100% pass-through rate, effective productivity changes are neutral if one finds γ_k equal to zero.

21 The latter result stems from the fact that productivity changes distort equilibrium in the goods market, by shifting goods supply, which in turn affect product prices (Haskel 1999). These changes in goods supply are possible either because the country in question is large in world markets or because the productivity shocks are common across countries (Krugman 2000)

Given the results of the first-stage regression (III.5), one can decompose the total change in value-added prices and effective productivity into those components due to each structural variable, namely $\gamma_k \Delta z_{itk}$. These decomposed changes, when individually regressed on the primary factor cost-shares, yield coefficients interpreted as predicted factor price changes due to that structural component. The second-stage regressions for each structural variable k is expressed as:

$$\gamma_k \Delta z_{ikt} = \sum_{j \in J} \delta_{jk} \frac{1}{2} (\theta_{it-1} + \theta_{it}) + u_{ikt} . \qquad \text{(III.6)}$$

The coefficients δ_{jk} obtained from these regressions can be seen as the economy-wide change in the price of jth primary factor that would have occurred if the change in kth structural variable had been the only source of changes in prices and effective productivity.

Only a handful of studies have used the two-stage procedure to identify causal factors of changes in prices and productivity and link them to wages. These studies find mixed contributions of trade-related variables, i.e., foreign outsourcing of materials, trade barriers, transportation costs, and changes in international product prices, on U.S., U.K., and Mexico's wages. For example, Feenstra and Hanson (1999) find that a rise in foreign outsourcing of materials accounts for 15%-25% of the rise in U.S. wage inequality in the 1980s. On the other hand, Haskel and Slaughter (2003) fail to identify a significant impact of other trade-related variables on U.S. wages of the 1970s and 1980s, although stronger results are found for U.K. and Mexico's wages (Haskel and Slaughter 2001; Robertson 2004). A number of studies have also looked at the effect of technology on wage inequality, where both factor-biased, i.e. skilled-biased technological change (SBTC), and sector-biased technological changes are considered. Feenstra and Hanson (1999) find that SBTC due to office equipment and computer investment explain over 35% of the rising U.S. wage inequality in the 1980s. On the other hand, industry innovation contributed the most to the increase in the skilled-unskilled U.K. wage gap during 1996-1990 (Haskel and Slaughter 2003). I contribute to their methods by using most recent data for 1989-2004 and exploring a broader set of trade- and technological change-related factors.

III.IV. Data and Descriptive Statistics

I apply the estimation technique described in the previous section to U.S. manufacturing industries for the period of 1989-2004. This sample period encompasses the changing nature of the U.S. wage inequality debated in the literature, which occurred after 1989, when the wage inequality either polarized (Autor et. al. Forthcoming) or substantially declined (Card and DiNardo 2002). One feature of the sample is that the data are classified under the Standard Industrial Classification (SIC) during 1989-1996 and North America Industrial Classification System (NAICS) during 1997-2004. This forces me to split the sample along the classifications distinction and run the estimation separately on each of the subsamples. While working with shorter time-series is less ideal, this approach circumvents the differences in the definition of manufacturing embedded in the classifications.[22] It is important to note that most industry-level studies

22 Other than the classifications differences, I have reasons to believe that the subsamples are roughly similar, in that they contain equal time-series panels of eight years and both encompass recession and post-recession recovery periods.

of the U.S. wage dispersion span the period of no later than early 1990s, thus I am able to go far later than the existing literature.

The data for prices, total factor productivity, and cost shares are obtained from the Bartelsman and Gray (1996) NBER PD for the period of 1989-1996 and the extended PD for the period of 1997-2004, which I constructed for the purposes of this chapter (see Appendix A for description of the extended PD). The descriptive statistics for these variables are reported in Table D.1, which also includes the data for 1979-1990 used in most previous studies as a basis of comparison. As shown in Table D.1, the period of 1997-2004 experienced the slowest growth in total factor productivity and value-added prices compared to the prior periods. Services appear to have gained more prominence by early 2000s.

Now I turn to data description of trade and technology-related causal factors. The trade-related variables that I identify include offshoring of materials, offshoring of selected business services, and finished goods imports openness. The set of technology-related variables consists of computer, office equipment, and other high-tech capital shares.

To measure offshoring of materials, I rely on standard construction methods, originally proposed by Feenstra and Hanson (1996, 1999), and an alternative method, which refines the original formula by utilizing new and previously unavailable data on trade in intermediate goods. To arrive at the original measure of offshoring, I combine data on total imports with data on inputs purchases. The data on U.S. imports for the period of 1989-2004 come from Feenstra (2002) and the Census Bureau. The inputs purchases are obtained from U.S. Input-Output tables provided by the BEA. For each industry *i*, the original measure of materials offshoring is constructed as follows:[23]

$$\frac{\sum_j [\, purchases\ of\ interm.\ inputs_{ij} \,] \cdot [\, \frac{imports_j}{dom.output_j + imports_j - exports_j} \,]}{Total\ Nonenergy\ Interm.\ Purchases_i}, \qquad \text{(III.7)}$$

where subscript *j* refers to an industry supplying input *j* to industry *i*, where $i,j = 1,\ldots N$. Each product term in the numerator of equation (III.7) is interpreted as industry *i*'s estimate of imported material inputs from industry *j*. Then equation (III.7) represents an industry's share of total imported intermediate inputs in the industry's total expenditure on non-energy intermediates. This measure is commonly referred to as a broad measure of materials offshoring. One can obtain a narrow measure of offshoring, by restricting attention to only those inputs that are purchased from the same two-digit SIC industry or three-digit NAICS industry as the good being produced.[24] I will include the narrow measure of offshoring and the difference between the broad and narrow measures as separate variables in my estimation. When averaged over all industries, the original measure of offshoring, defined narrowly and as a difference, increased at an average 0.29% and 0.23% per year during 1989-1996, and declined at an average 0.19% and 0.13% per year during 1997-2004, respectively, as is apparent in Table D.2.

23 This formula first appears in Feenstra and Hanson (1996), but has been originally used by the BEA in construction of imported input purchases for the Import Matrices.

24 The narrow measure is assumed to capture the precise definition of foreign outsourcing, which refers to the contracting out to overseas suppliers those production activities that can be done within a company (Feenstra and Hanson 1996, 1999).

The original measure of materials offshoring suffers from potentially serious measurement error. The measurement error arises from the inclusion of economy-wide import share to proxy for imports of intermediate goods. Since the total imports share consists of goods unrelated to intermediate inputs, the levels and changes of the offshoring measures are over or underestimated by the levels and variation of the share of the unrelated goods (see Chapter II). Therefore, the inclusion of the original offshoring measure as an explanatory variable may bias coefficient estimates.

In this chapter, I make use of unique data on imports of intermediate goods to refine the currently used measure of materials offshoring. These data are made possible as a result of a recently constructed Market Structure Index of HTS Imports (the Imports Index), which classifies imports into intermediate and finished goods (See Appendix A). I combine the Imports Index with detailed imports data obtained from Feenstra (2002) and the Census Bureau for 1989-2001 and 2002-2004, respectively, to derive imports of intermediate goods.[25] These are then incorporated into the following modified version of original measure of offshoring:

$$\frac{\sum_j [\,purchases\,of\;interm.\,inputs_{ij}\,]\cdot[\,\frac{interm.\,imports_j}{interm.\,dom.\,output_j + interm.\,imports_j - interm.\,exports_j}\,]}{Total\;Nonenergy\;Interm.\;Purchases_i} \qquad \text{(III.8)}$$

where subscript j refers to an industry from which industry i purchases its intermediate inputs, where $i,j = 1,\ldots N$. This refined measure of offshoring differs from the original measure by the right term of the numerator, where I use the share of imports of

25 The imports of intermediate goods include imports of parts, components, and raw materials, as well as final goods assemblies that go through the domestic industries before they enter the retail markets. These data provide a near perfect estimate of imports of goods subject to offshoring, in that they exclude imports of offshored assemblies of final goods, which enter the U.S. retail markets directly.

intermediate goods in the domestic supply of intermediate goods in place of the share of total imports in the total domestic supply. Comparing the original with the refined measure of offshoring, there appear to be considerable differences between the measures, as shown in Table D.2.

Another trade-related causal factor considered in this chapter is offshoring of services, which has recently attracted much interest in both academic and popular press circles. The services subject to offshoring commonly include information technology services; professional, scientific, and technical services; and administrative and support services (Amiti and Wei 2006). The construction of the measure follows the same formula as shown in equation (III.8), where intermediate inputs are now replaced with inputs of selected services. The data for services inputs and services imports come from the BLS input-output tables and are described in Appendix A. As shown in Table D.2, offshoring of services grew substantially in 1989-1996, with an average change of 0.04% or roughly a ten percent growth of the average level of 0.42%. During 1997-2004, however, the average growth of services offshoring was relatively stagnant.

Following Feenstra and Hanson (1999), I expect to find positive effects of materials offshoring on changes in value-added prices and effective productivity in the first-stage and the skilled-unskilled wage gap in the second-stage. Offshoring of services is likely to have a similar effect in the first-stage, if imported services stir the technology of production away from nonproduction workers in a productivity enhancing manner. This then should lead to a negative impact of services offshoring on the skilled-unskilled wage gap in the second-stage. However, if offshoring of services is merely an alternative to domestically outsourced services, then one should find a price reducing and negative effect of services offshoring in the first stage. The skilled-unskilled wage gap will increase (decrease) if sectors experiencing declining product prices are skilled-intensive (unskilled-intensive).

The measure of openness to imports of finished goods is constructed as the finished goods imports to industry value-added ratio. During 1989-1996 imports of finished goods constituted an average of 29.89% of industry value-added, while by 1997-2004 this percentage went up to 47.16%. Competition arising from imports of finished goods is expected to put a downward pressure on domestic product prices across all sectors of the economy in the first stage estimation. The skilled-unskilled wage gap will increase (decrease) if the sectors experiencing declining product prices are skilled-intensive (unskilled-intensive).

Finally, the technology-related variables are constructed from three measures of high-technology capital stock; i.e., (1) computers, 2) office, computing, and accounting machinery (office equipment); and (3) communications equipment; science and engineering instruments; and photocopy and related equipment (other high-tech equipment).[26] Combining these capital stock measures with "ex post" and "ex ante" user costs yields "ex post" and "ex ante" measure of services rendered by office equipment, computer, and other high-tech capital, or in other words, the opportunity cost of capital

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26 Previous literature incorporated investment in computer capital in the studies of the 1980s wages (Autor & Katz 1998, Feenstra and Hanson 1999, 2003). During the 1990s, these data were compiled only during 2002-2004, which makes it impossible to incorporate computer investment in this chapter. However, the inclusion of the computer services share variable should reasonably proxy for the impact of computerization on productivity, prices, and wages.

possession (Berndt and Morrison 1995, 1997; Feenstra and Hanson 1999).[27] I express these measures as shares in total capital services and use the first-difference of the "ex post" capital shares as the primary technology-related explanatory variables. I check the robustness of the results to the "ex ante" measures in the sensitivity analysis. The data for the construction of the technology variables are courtesy of the BLS and more detailed discussion of the construction methods can be found in Appendix A. As shown in Table D.2, the computer share increased continuously throughout the sample period. At the same time, office equipment share steadily declined, while other high-tech share rose during 1989-1996 and declined during 1997-2004. Previous studies found the technological change attributable to high-tech equipment diffusion as productivity enhancing and skill-biased (Berndt and Morrison 1995, 1997; Feenstra and Hanson 1999). I test the robustness of these findings in the section below.

III.V. Results

The estimation is performed over 458 U.S. manufacturing industries at the four-digit SIC level for the period of 1989-1996 and 473 six-digit NAICS industries for the period of 1997-2004. I utilize two methods of variable construction. The first method uses variables expressed as differences over 1989-1996 and 1997-2004 periods, divided by the number of years in each period to obtain annualized differences. The estimation then reduces to a cross-sectional analysis, which is common in the product-price

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27 The *ex post user costs* reflect the internal rate of return in each industry and capital gains on each asset, and the *ex ante user costs* reflect a "safe" rate of return (the Moody rate of Baa bonds) and excludes the capital gains on each asset. Feenstra and Hanson (1999) comment that ex ante measures might be preferred because they do not reflect the capital gains on the assets and the internal rates of return in the industry.

literature and is motivated by the log-run nature of the Heckscher-Ohlin theory and is often used to circumvent the limited availability of yearly data (Haskel and Slaughter 2001).

I contrast the results from the "annualized differences" estimation to those where variables are expressed as first-differences. Estimation is then performed using panel estimation techniques with fixed effects to control for year-specific unobservables. As will become apparent, the differences in the magnitudes of estimates from the two methods are considerable. These differences arise from the fact that the first-difference estimation captures both industry trends in the data and the time-series variation around these trends. On the other hand, the annualized differencing approach weeds out the time-series variation by construction and evaluate the coefficients based on industry trends alone. Thus, the additional noise captured by the first-differences estimation should yield smaller coefficients, which could potentially be interpreted as short-run estimates. Then the larger estimates from the annualized differences estimation could be evaluated as long-run effects.

III.V.1. Preliminary Regression

Before turning to estimating the two-stage procedure of linking price changes to wage changes, I check the consistency of equation (4) against the data. Table D.3, part b) presents the regressions of changes in value-added prices plus effective productivity on the average cost shares of production and non-production workers and capital. Regressions are run for changes in variables measured as annualized differences and first-differences, as discussed above. The estimated coefficients can be compared with the annual average changes in the prices of these primary factors shown in Table D.3, part a). Similar to the results reported in Feenstra and Hanson (1999) for the 1980s, the estimated coefficients are extremely close to the actual factor price changes and the regressions fit nearly perfectly. The wage of nonproduction labor rises faster than production labor during 1989-1996, indicating an increase in wage inequality, and slower during 1997-2004, indicating a decrease in wage inequality.

In Table D.3, Part c) I examine whether changes in value-added prices, changes in effective TFP or both are responsible for the increase in the skilled-unskilled wage gap during 1989-1996 and the decline in the wage gap during 1997-2004. Taking the differences between the predicted coefficients on non-production and production cost shares, it appears that changes in prices are concentrated in the unskill-intensive sectors in both periods, as they result in a relative decrease of the skilled-unskilled wage gap. On the other hand, changes in the effective productivity are concentrated in the skill-intensive sectors, as they result in the relative increase in the wage gap during both periods.[28] This contradicts the findings of Leamer (1998) who finds that both changes in prices and changes in productivity were concentrated in the skill-intensive sectors of U.S. manufacturing during 1980s.

28 Leamer (1998) runs similar regressions, but use changes in prices and changes in TFP to predict factor price changes for the U.S. during 1981-1991. He finds that both changes in prices and productivity are skilled-labor intensive. I rerun the regressions in Table 3, part c) using the same dependent variables, and find similar results to Table 3, part c), except that changes in TFP in fact decrease the skilled-unskilled wage gap during 1997-2004.

The results of these regressions are robust to the inclusion of market power controls, i.e. output/capital ratios and market concentration measures, and to the exclusion of the computer industry. The results of Table D.3 solidify theoretical predictions of the SS theorem of the link between prices and productivity and wages.

III.V.2. Stage 1

In this section, I report the first stage estimation results of the two-stage procedure, where I regress changes in value-added prices plus effective productivity on trade- and technology-related causal factors. The key variables of interest are the measures of outsourcing of intermediate goods in equations (III.7) and (III.8). As it will become apparent, these measures which are comparable to those used in the existing literature produce coefficients of varying magnitudes and significance, where the estimates on the refined measure are more robust to various specifications.

There are four estimation issues to be addressed. First, while the dependent variable is available only at a highly disaggregated level, the SBTC variables are available only at two-digit SIC level and three-digit NAICS levels in the respective periods, and the outsourcing variables are available only at three-digit SIC and four-digit NAICS levels. I cluster the errors at the most aggregated groups to avoid the possibility that errors are correlated within the more aggregated industry groups (Moulton 1986; Feenstra and Hanson 1999). Second, since the dependent variables in the second-stage regressions embody the same estimated coefficients, the standard errors of the second-stage coefficient estimates need to be corrected.[29] I follow the steps outlined in Dumont et

29 If not corrected, the second-stage regressions provide conditional estimates of the residuals that

al. (2005) to correct the standard errors of the second-stage estimation.[30] Third, if industries are not perfectly competitive then the measure of total factor productivity is biased because the capital share includes pure profits. I include the log change in the output-capital ratio as a regressor to absorb the market power effect (Domowitz et al. 1988; Feenstra and Hanson 1999; Haskel and Slaughter 2001, 2003). Finally, caution needs to be taken in comparing the coefficients from the 1989-1996 and 1997-1996 data samples, due to differences in SIC and NAICS classification during the respective periods. These classification vary considerably in their definition of U.S. manufacturing, and thus may change the behavior of manufacturing-specific variables across the two periods.

Table D.4 presents estimation results from the first-stage regression using the original specification proposed by Feenstra and Hanson (1999), which includes only materials offshoring and high-tech capital shares, excluding the computer share. Columns I-IV contrast estimates for original (I & III) and refined (II & IV) measures of offshoring, where variables are constructed either via annualized differences or first-differences methods using the 1989-1996 data sample. Similarly, Columns V-VIII present estimates for the period off 1997-2004. As mentioned earlier, I include year fixed effects in the estimation with first-differenced variables to account for time-varying unobservables.

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incorporate the additional variance of the residuals from the first-stage estimation. To test the significance of the second-stage coefficients, unconditional estimates of the standard errors accounting for this additional variance have to be computed.

30 Feenstra and Hanson (1997, 1999) propose a correction procedure which has been disputed in most recent work by Dumont et al. (2005), since the correction does not require that the computed variances are positive and may impose a negative bias on the standard errors. The procedure developed by Dumont et al. (2005), in turn, does guarantee positive variances of the second-stage estimates.

As is apparent from Table D.4, the signs and statistical significance of the coefficients are relatively robust to various specifications within each period. On the other hand, the magnitudes of the estimates vary considerably across specifications and sample periods. The most striking differences in magnitudes appear across annualized differences and first differences specifications, in particular for estimates on materials offshoring. These differences persist when year fixed effects are excluded from the first-differences estimation, not shown in Table D.4, although an F-test confirms the necessity of year fixed effects. Additionally, the negative sign on the office equipment share comes in contrast to the findings of Feenstra and Hanson (1999). The general lack of significance of the impact of offshoring measures during 1997-2004 is troubling.

In Table D.5 I present results of specifications with a full set of causal factors. The inclusion of other controls reveals the severity of the measurement error introduced in the original measure of materials offshoring. Unlike the estimates on the refined measure, the estimates on the original measure become insignificant in all specifications and shrink in magnitudes compared to those in Table D.4. As a result of such poor performance, I turn my focus to the specifications using the refined measure of materials offshoring of Columns II, IV, VI, and VIII.

Turning to trade-related causal factors first, the estimates on these factors come through with mixed signs and significance. The effect of materials offshoring, per refined measure, changes across time. While offshoring, defined as a difference of broad and narrow measures, drives the growth in changes in value-added prices and effective productivity during 1989-1996, it is the narrow measure of offshoring (within closely-related industries) that appears to have a significant effect during 1997-2004. Furthermore the effect of materials offshoring changes to negative, albeit very small, in the first-difference estimation of Column VIII. Services offshoring appears to have a negative impact on changes in value-added prices and effective productivity during 1989-1996, and positive effect during 1997-2004. Openness to finished goods has a very small and insignificant coefficient.

In order to make sense of the result in Table D.5, I find it useful to separate the dependent variable in the first-stage estimation into its respective components. Table D.6 shows independent regressions of changes in value-added prices and changes in effective productivity on causal factors. The first-differences specifications reveal a consistent picture, where trade-related variables, with the exception of services offshoring in the 1997-2004 sample, increase productivity and reduce prices. This is consistent with prior expectations that trade-driven market competition puts a downward pressure on prices and production-related inefficiencies in the short-run. In the long-run, expressed by annualized differences, however, the results are less consistent. Thus, materials offshoring appears to mostly increase both prices and productivity, services offshoring appears to decrease productivity with mixed effect on prices, and openness to imports has mixed effects on both prices and productivity across the two sample periods. The latter results may indicate perhaps that it is hard to predict a consistent impact of trade on prices and productivity when too many things are at play, e.g.., contracting and expansion of sectors, restructuring of production technologies, etc.

Next I turn attention to the effects of technology-related causal factors on changes in value-added prices and effective productivity, as shown in Table D.5. The inclusion of the computer share in the 1989-1996 specifications considerably affects the magnitudes, signs, and significance of the coefficients on other technology-related variables compared to those in Table D.4. The estimates on the computer share are, in turn, large and highly significant. However, the effect of computers goes away by 1997-2004, while office equipment and other high-tech capital shares retain their signs and significance. These results may be indicative of a changing role of computer technologies in U.S. manufacturing. While the computer revolution of late 1980s-early 1990s changed the technology of production in a productivity enhancing manner during 1989-1996, the Internet revolution of the late 1990s and early 2000s may in fact have introduced little change to the existing manufacturing processes. On the other hand, by the late 1990s, advances in computerization may have penetrated other high-tech technologies leading to higher productivity gains, shown by the estimates on other high-tech share in Columns V-VIII. These interpretations are also confirmed by larger productivity gains from other high-tech capital share and lower productivity gains from computer share of Table D.6.

Under zero-profit conditions, these estimated changes in value-added prices and effective productivity can be linked to changes in factor prices. In Table D.7 I rerun the regressions, only retaining those causal factors that had a non-neutral impact on the dependent variable in the full specification of Table D.6. Only significant coefficients signal actual changes in prices and productivity, which will then mandate changes in factor prices under the zero profit condition (Slaughter 2000).As can be seen, the coefficients on the remaining trade- and technology-related variables are robust to these changes. I use these final specifications in the second-stage analysis discussed below.

III.V.3. Stage 2

Before turning to the second stage of the estimation procedure, I first decompose the dependent variables of the first-stage regressions from Table D.7 into those components due to each causal factor. I then use these components as dependent variables in the second-stage regressions. The second stage regressions are run without a constant and are weighted by the average industry shipment in total manufacturing shipments. The standard errors are corrected using the Dumont et al. (2005) correction procedure, as discussed above.

The results of the second-stage estimation are presented in Table D.8. Consider, first, the changes in value-added product price plus effective productivity due to technological change and induced changes in factor prices. It appears that upgrading of computer capital is the only technical change variable that is skill-biased, that is it leads to a negative, albeit insignificant, change in production wages and a positive large change in the non-production wages during 1989-2004. In contrast, the office equipment share raises both the production and nonproduction wages in relatively equal amounts, while other high-tech share increases production wages and decrease non-production wages during 1997-2004. Taking the difference between the predicted changes in the nonproduction and production wages due to computerization, the relative wage of nonproduction labor increased by an astounding average 1.725% per year measured in the long-run, and 1.058% per year, measured in the short-run. In contrast, other high-tech share is responsible for an average 0.310% per year decline in relative wages measured in the long run, and 0.221% per year decline measured in the short-run during 1997-2004.

The estimates of Table D.8 can, in fact, be compared with the actual increase in relative non-production wages. Recall, that the average annual change in log non-production and log production real wages is 3.839% and 2.666% during 1989-1996 measured by annualized differences and 3.784% and 2.668% measured by first differences, as reported in Table D.3, Part a). The difference between these figures provides the actual increase in the relative wages of nonproduction to production workers of 1.173% and 1.116% per year, respectively over 1989-1996. Thus, computerization can individually account for over 147% and 95%, respective of the differencing approaches, of the observed annual increase in the relative wage of nonproduction labor during 1989-1996. During 1997-2004, the actual relative nonproduction wages declined by 0.256%, when measured in annualized differences, and 0.265%, when measured in first differences. Then the high-tech equipment diffusion explains over 119% and 85% of the actual decline in relative non-production wages, respectively, during 1997-2004.

Next, I consider the predicted changes in relative nonproduction wages due to changes in trade-related variables. Using the above approach of comparing the predicted wage changes to the actual wage changes, the changes in product price plus productivity due to materials offshoring explain 51% of wage changes, when measured in annualized differences, and 7% of wage changes when measured in first-differences, during 1989-1996. Materials offshoring fails to impact wages in a significant way during

1997-2004. At the same time, however, services offshoring has a strikingly large positive effect on the skilled-unskilled wage gap during 1989-1996, yet a large negative effect on the wage gap during 1997-2004. These findings are contradictory to each other and leave me puzzled, since the service offshoring comprise a very small percentage of total services outsourcing over the period of 1989-2004.

In summary, I find a very strong link between trade and technological change and relative wages. This link, however is highly sensitive to the nature of the trade and technology forces in play and the time period under inspection. I find a very strong and robust effect of materials offshoring on the skilled-unskilled wage gap during 1989-1996, but its effect during 1997-2004 appears to be statistically insignificant. Similarly, computerization is found to be the main driver of the relative wage inequality during the first half of the period, whereas other technological change plays the main role in determining wages during 1997-2004. Furthermore, one must be careful in considering all technological change as skill-biased. I find that other high-tech diffusion significantly raises wages of the unskilled and in fact lowers wages of the skilled during 1997-2004. These findings may be indicative of the diminishing role of computers in U.S. manufacturing, and a growing role of computerization of other high-tech equipment which works to enhance the productivity of the unskilled, thus raising their relative wages. The large role of services offshoring in both raising the skilled-unskilled wage gap during 1989-1996 and then reducing it during 1997-2004 is surprising due to its relatively low prevalence in manufacturing.

III.VI. Sensitivity Analysis

There are a number of points worth noting about my estimation in Tables D.4-D.8. First of all it may be argued that the computer industry has experienced an unusual productivity growth over the past decades and should be excluded from the industry-level analysis (Leamer 1998, Feenstra and Hanson 1999). I rerun the estimation without the computer industry and find that the coefficients are not qualitatively different from the ones presented in Tables D.4-D.8. Another potential concern that may arise is that trade and technology regressors in the first-stage estimation may be endogenously determined with value-added prices and productivity. I follow the previous literature in assuming that they are exogenous. Additionally, I check that the estimation is not sensitive to the weights employed in the analysis, by using employment and wage bill weights. The results are qualitatively the same. Furthermore, one may argue that both value added prices and cost shares need to be deflated by appropriate deflators to net out inflationary forces over 1989-2004. I rerun the estimation, using manufacturing wide producer price indexes to deflate product prices and wages, and find no significant changes in coefficient estimates. Finally, I check the sensitivity of the results using the alternative ex ante measures of technological change variables. The results are not qualitatively different and are available on request.

III.VII. Conclusion

This study is the first study of the impact of trade and technology on U.S. wages of 1990s. Using recently available data on industry statistics, I am able to document a near-continuous growth in the 1990s wage inequality within the U.S. manufacturing, where by some measures, the wage gap is growing more rapidly than that recorded in 1980s. I use these data to contribute to the on-going debate of the effects of trade and technology on U.S. wages.

My findings indicate that the relative contribution of trade is sensitive to the data and the type of variables used in the estimation. My preliminary estimation indicates that the standard measure of offshoring of materials, proposed by Feenstra and Hanson (1996, 1999) and commonly used in the literature, suffers from severe measurement errors that prohibit the estimation of the impact of trade in intermediate inputs on the wage dispersion of the 1990s. I address this issue by developing an improved measure of materials offshoring, which remarkably improves the performances of offshoring and other variables across all specifications. Furthermore, various trade-related variables have radically different effects on U.S. wage inequality of 1989-1996 and 1997-2004. Thus, I find that trade in intermediate inputs contribute dramatically to the increase in the wage inequality during 1989-1996 and 1997-2004, although the effect during the latter period is insignificant. On the other hand, trade in services inputs either raises or reduces the demand for skilled workers, and these effect are strikingly large.

Looking at the technology-related variables, I find that computerization remains the most appropriate measure of skill-biased technological change as it adversely affects the demand for the unskilled and positively impacts the demand for skilled labor. However, this effect could only be estimated in the 1989-1996 sample, as the extent of computerization failed to have a non-neutral effect on productivity during 1997-2004.

Furthermore, the changes in the share of other high-tech capital, i.e., communications equipment, photocopy equipment and various scientific and engineering instruments, in fact, are found to increase wages of production workers and decrease wages of nonproduction workers during 1997-2004.

In summary, I find much support for the hypothesis that both trade and technology are some of the factors responsible for the growing wage gap during the 1990s. A different type of technological change, in turn, is responsible for the declining gap during the 2000s.

CHAPTER IV

CONTRACTS, MARKET THICKNESS AND OUTSOURCING

IV.I. Introduction

There is a growing theoretical literature on the determinants of the extent and location of offshoring of intermediates' production (Grossman and Helpman 2002, 2005, Antras 2003, 2005). These models are built on the transaction costs and property rights literature, particularly because of the necessity of relationship specific investment (RSI) and the presence of incomplete contracts. Thus, the production of specialized inputs, tailored to the specific needs of a final goods producer, requires a specific investment from the supplier. Because of contract incompleteness, final goods producers fear being held up and choose locations of outsourcing where the probability of hold up is the lowest. All in all, these models show that the location of outsourcing is sensitive to market thickness, quality of legal systems, and extent of required specificity of investment.

Surprisingly, the existing empirical studies of outsourcing strategies fail to take the theoretical predictions described above into consideration all together. These studies model the determinants of the location and extent of outsourcing by exploring heterogeneities in countries' production costs, e.g. wages, trade costs, transportation cost, etc. Furthermore, due to the limited availability of data, a large share of their analyses considers the particular case of an industry or firm.[31] There are a number of empirical studies in the trade literature, however, which draw on the implications of the incomplete contracts literature to model the quality of legal systems as a source of comparative advantage in trade of final goods (e.g., Levchenko 2007 and Nunn 2007). These studies assume that final goods producing sectors, which require RSI from their input suppliers, rely on countries' legal systems more than others. As such, they empirically show that countries with superior legal systems specialize in exports of the final goods that are more institutionally-dependent in nature. To my knowledge, no empirical study considers the determinant role of market thickness on trade or outsourcing activities.

In this chapter of the dissertation I present the first empirical test of the determinants of international outsourcing described in models of incomplete contracts of Grossman and Helpman (2002, 2005) and Antras (2003, 2005). I evaluate the role of the quality of legal systems, specific investment, and market thickness in the location and extent of U.S. international outsourcing of intermediate inputs, while controlling for other country-level and industry level characteristics. While my focus is on the outsourcing strategy of the U.S., I improve on the data-constrained analyses of the existing studies by exploring a large cross-section of industries and countries which source intermediate inputs to the U.S. This is made possible due to a recently constructed comprehensive dataset of U.S. offshoring of intermediate inputs, which spans imports sourced from over 270 industries and over 170 countries. This study is the first study to test the impact of

31 See Girma and Görg (2004) for the United Kingdom (U.K.) manufacturing industries, Swenson (2004) for the United States (U.S.), Kimura (2001) and Tomiura (2005) for Japanese manufacturing firms and Holl (2007) and Díaz-Mora and Triguero (2007) for the Spanish economy.

market thickness on trade data and also the first to analyze the determinants of U.S. trade in intermediate inputs. Finally, I evaluate whether the determinants of the location of source countries and the extent of U.S. international outsourcing are different than those of U.S. imports of final goods. As such, this paper is the first to quantify whether outsourcing is just a form of trade or a qualitatively different phenomenon all together.

In the first section of the chapter, I present a partial equilibrium model of the determinants of the location of outsourcing and derive a number of testable hypotheses. This model is in spirit of the general equilibrium model of outsourcing proposed by Grossman and Helpman (2005). The model incorporates three essential features of a modern outsourcing strategy. First, final-goods producers in the North must search for input suppliers either in the North or South with the expertise that allows them to produce specialized inputs. Second, they must convince the potential suppliers in a region to customize products for their own specific needs. Lastly, final goods producers must induce the necessary investment in customization in an environment with incomplete contracting in both the North and South. In a partial equilibrium setting, where outsourcing happens in both the North and South, improvements in the quality of the contracting environment and/or market thickness affect the probability for each specialized final good producer of finding a suitable partner and successfully engaging in a contractual relationship. Since the expected profits of each specialized final producer depend on the profitability of matching, the improvements in contracting environment and/or market thickness in a country increase the prevalence of outsourcing in that country.

The central implication of the model is that differences in the quality of legal systems and the thickness of input supplier markets are important determinants of international outsourcing of inputs which require RSI. I test this prediction with the recently constructed data on U.S. import of intermediate inputs by country, which I disaggregate by six-digit industry in accordance with the Bureau of Labor Analysis I-O classification. I use a factor content of trade methodology, originally developed by Romalis (2004), and recently used by Levchenko (2007) and Nunn (2007) to test the institutional content of trade. The latter two studies test whether countries that have good quality of institutions capture larger shares of U.S. imports of final goods that exhibit institutional dependence. This chapter takes this specification and augments it with variation in industry-level measure of dependence of inputs on RSI and country level measures of legal system quality and market thickness.

The two main findings of the chapter are as follows. First, I find that the cross-country differences in the quality of contracting environment and market thickness are just as important in determining the location and extent of U.S. international outsourcing as factor endowments. Second, I find that the quality of contracting environment explains more of the patterns of trade in intermediate inputs, relative to patterns of trade in final goods. However, the opposite is true for market thickness and factor endowments.

The structure of the chapter is as follows. Section IV.II describes the theoretical model. Section IV.III explains the empirical methodology and the data. Section IV.V presents results. Section IV.VI concludes.

IV.II. The Model

In this section I develop a number of testable hypothesis of the determinants of outsourcing within the context of a partial equilibrium model. This model borrows heavily from the general equilibrium model of outsourcing proposed by Grossman and Helpman (2005).

IV.II.1 Model Set-Up

Since outsourcing may include both domestic and international outsourcing, consider a setting with two countries, North and South. There are two types of consumer goods, a homogeneous good *z* and a differentiated good *y(j,l)*, where *y(j,l)* represents the *j*-th variety of a continuum of varieties of an *l*-type good. The *l*-type good is associated with point *l* on the circumference of a unit circle.

Consumers in both countries share identical preferences and view the varieties of the good *y* as differentiated. Letting *z* and *y(j,l)* be consumption of the homogeneous good and the *j*-th variety of the *l*-type differentiated good, preferences of the representative consumer are of the form,

$$u = z^{1-\beta}\left[\int_0^1 \int_0^{\hat{n}(l)} y(j,l)^{\alpha}\, dj\, dl\right]^{\frac{\beta}{\alpha}}, \quad 0<\alpha,\beta<1 \qquad \text{(IV.1)}$$

where $\hat{n}(l)$ is the endogenously determined measure of varieties of the *l*-type differentiated good. Consumers allocate an optimal share β of their spending on the differentiated goods. The elasticity of substitution between any pair of varieties of good y is $\epsilon = 1/(1-\alpha)$.

There are two types of producers: final-goods producers and suppliers of intermediate inputs. Northern and Southern final producers of the homogeneous good z may enter their respective markets and incur the cost of w^i per unit of output, where w^i is the wage rate in country *i* and *i=N, S*. On the other hand, only the Northern final producers have the know-how to produce any varieties of good y. Such a firm must bear a fixed cost of product design and development, $w^N f_n$, where w^N is the Northern wage rate and f_n is the fixed labor requirement. Additionally, the Northern final producer needs one unit of a specialized input per unit of output, the production of which they must contract out to a local or overseas input supplier.

The entry of an input supplier in country *i* requires investment in expertise and equipment, which I refer to as a production know-how, the cost of which is $w^i f^i_m$, where *i=N, S.* Due to high relative costs of entry, only a limited number of suppliers, $m^i(f^i_m)$, enter a given market and each supplier serves multiple final producers in equilibrium.[32] A supplier's know-how is represented by a point on the unit circle, spaced at an equal distance $1/m^i$ from the next supplier's know-how. Final producers do not know the exact location of the supplier's know-how on the circle, but consider the nearest supplier to be at a random distance *x* from the producer's own production technology know-how, where x follows a uniform distribution on the $[0,1/2m^i]$ interval.

Finally, any supplier must develop a prototype before it can produce the customized inputs needed by a particular final producer. The full cost of this investment,

32 I assume that $\frac{\delta m^i}{\delta f^i_m} < 0$. For simplicity, m^i is assumed to be a continuous variable.

$w^i \mu^i x$, varies directly with the distance in expertise. Furthermore, the input supplier's compensation for the investment and the actual induced investment are subject to negotiation and depend on the nature of the contracting environment in country *i*. Once the prototype is completed, input suppliers employ one unit of local labor per unit of output.

The setting is one of incomplete contracts in both North and South. In particular, I assume that in country *i*, an outside party can verify a fraction $\gamma^i < \frac{1}{2}$ of the investment in customization undertaken by an input supplier for a potential specialized final good producer. In other words, γ^i captures the quality of the legal system in country *i*; the greater is γ^i, the more complete are the contracts that can be written there.

When a final producer approaches a potential supplier in a given market, negotiations between the final producer and input supplier involve bargaining over an *investment contract* and an *order contract*. When two firms negotiate an investment contract, they specify the extent of the supplier's investment in a prototype, $I^i(x)$, and the amount of compensation that the customer will pay for the investment, $P^i(x)$. Assuming Nash Bargaining, one can derive the equilibrium outcome of negotiations over $P^i(x)$ and $I^i(x)$.

Proposition 1: *Let* S^i *denote the profits that the parties will share if they reach a stage where a suitable prototype exists and if the two parties subsequently reach agreement on an order contract. Then Nash Bargaining results in final goods producer's payment to the input supplier of country i of*

$$P^i(x)=\begin{cases}\frac{1}{2}w^i\mu^i x & \text{if } \frac{S^S}{2w^S\mu^S}<x\leq\frac{S^S}{2w^S\mu^N(1-\gamma^S)}\\ 0 & \text{otherwise}\end{cases} \tag{IV.2}$$

and the induced investment level of

$$I^i(x)=\begin{cases}w^i\mu^i x & \text{if } x\leq\frac{S^S}{2w^S\mu^V(1-\gamma^S)}\\ 0 & \text{otherwise}\end{cases}. \tag{IV.3}$$

Proof: An enforceable contract stipulates an investment of $\gamma^i w^i \mu^i x$ and payment of P^i. Under Nash Bargaining, the input supplier expects to receive a prospective profit of $S^i/2$. Then, if $S^i/2<(1-\gamma^i)w^i\mu^i x$, the input supplier's perspective profits are not large enough to cover the cost of unenforceable investment and there is no incentive to engage in the development of a full prototype. If $(1-\gamma^i)w^i\mu^i x\leq S^i/2$, on the other hand, the supplier has an incentive to fully invest in a prototype. Furthermore, if $S^i/2\geq w^i\mu^i x$, the supplier's prospective profits cover the full cost of investment, which means that the supplier is willing to proceed with the full investment even if there is no contract and no initial payment whatsoever. Finally, if $(1-\gamma^i)w^i\mu^i x\leq S^i/2<w^i\mu^i x$, the input supplier commits to full investment only if the investment contract exists and there is a sufficiently large payment of P^i. In case of the latter, under Nash bargaining, joint surplus $S^i-w^i\mu^i x$ is split equally and $P^i=w^i\mu^i x/2$. □

Proposition 1 indicates that the investment contract and the induced investment behavior depend on the final producer's prototype requirements $w^i\mu^i$ and the distance between the supplier's production know-how, x. Furthermore, x depends on the the size of the potential profits that would be generated by an efficient order contract, and, in case of the Southern suppliers, the quality of the contracts in their home country, γ^S.

Once the input supplier has invested in the prototype, the parties negotiate an order contract. Equal profit sharing ensures that the partners have equal interests concerning the production and marketing of the final good. The preferences in equation (IV.1) provide a constant-elasticity demand function, which means that profits are maximized by fixed mark-up price $p^i = w^i / \alpha$.[33] Then, the optimal quantity of final goods/inputs specified by the order contract is

$$y^i = A\left(\frac{w^i}{\alpha}\right)^{-\epsilon} \tag{IV.4}$$

and the maximum joint profits, net of manufacturing costs, are

$$S^i = (1-\alpha) A\left(\frac{w^i}{\alpha}\right)^{1-\epsilon} . \tag{IV.5}$$

Now, I consider the search problem facing a typical final producer. The firm must decide whether to search for a supplier in the North or in the South. Suppose the firm searches in country *i*. The producer expects to acquire specialized inputs and earn profits only if he obtains a suitable prototype, that is if his distance, *x*, from an input supplier's production technology know-how is within the range indicated by equation (IV.3). Recall that the final producer considers *x* to be a random draw from a uniform distribution over the range from 0 to $1/2m^i$. Then for the limitations on contracting to have real effects, the range of distance, *x*, indicated by equation (IV.3) must be binding; that is lay within

33 The preferences in (1) imply that the producer of the *j*-th variety of the *l*-type good *y* faces a demand given by $y(j,l) = Ap(j,l)^{-\epsilon}$ when it charges the price $p(j,l)$, where $A = [\beta \sum_i E^i] / [\int_0^1 \int_0^{n(l)} p(j,l)^{1-\epsilon} dj\, dl]$ and E^i denotes spending on consumer goods in country *i*.

the $[0, 1/2\mathrm{m}^i]$ interval. This ensures that not every final producer finds a suitable input supplier which agrees to and fully invests in a prototype. Let r^i denote the greatest distance in input space between any producer that does not exit after having searched for a partner in country *i* and its supplier. Then the final producer engages in a relationship with an input supplier and expects to earn operating profits only if $x \in [0, r^i]$, where

$$r^i = \frac{S^i}{2\mathrm{w}^i \mu^i (1-\gamma^i)} \tag{IV.6}$$

The probability, with which a final good producer earns non-zero operating profits in country *i,* is equal to the density of suitable input suppliers on each side of the final good producer's production know-how or $2\int_0^{r^i} m^i\, dx$. It follows that the expected profits of a final good producer who searches in country *i* are

$$\pi_n^i = 2\mathrm{m}^i \int_0^{r^i} [\frac{S^i}{2} - P^i(x)]\, dx\,. \tag{IV.7}$$

Similar to above, the probability, with which an input supplier from country *i* earns non-zero operating profits, is equal to the density of final good producers searching in that country on each side of the input supplier's expertise or $2\int_0^{r^i} n^i\, dx$. The supplier's expected operating profits are

$$\pi_m^i = 2\mathrm{n}^i \int_0^{r^i} [\frac{S^i}{2} + P^i(x) - w^i \mu^i x]\, dx\,. \tag{IV.8}$$

IV.II.2 Partial Equilibrium Analysis

In this chapter I consider an equilibrium, where outsourcing occurs in both countries and there is free entry. While a number of other equilibria exit, this one allows me to explore the trade-offs of outsourcing in the South relative to the North. For outsourcing to occur in both countries, the final producers face equal expected profits in both North and South, $\pi_n^N = \pi_n^S$. To ensure zero expected profits, the expected operating profits for a typical final producer equal the fixed costs of entry, that is

$$\pi_n^i = w^N [f_n + f_s],\ i=N,S. \tag{IV.9}$$

Similarly, the expected operating profits for a typical input supplier equal the fixed costs associated with the investment in production know-how in country i, that is

$$\pi_m^i = w^i f_m^i,\ i=N,S. \tag{IV.10}$$

The volume of outsourcing can be defined as the total inputs/final output produced by all final producer-input supplier pairings in country i, that is $v^i = 2 m^i n^i r^i y^i$. In equilibrium, substituting in equations (IV.4)-(IV.6), (IV.8), and (IV.10) for $n^i r^i y^i$, the extent of outsourcing in country i is

$$v^i = \frac{4\alpha}{1-\alpha} \frac{1-\gamma^i}{1-\gamma^i-\frac{1}{2}(\gamma^i)^2} m^i f_m^i. \tag{IV.11}$$

Thus, outsourcing is a nonlinear function of the extent of contracting environment, market thickness, and the fixed cost of acquiring the production know-how in the region.

I assume a partial equilibrium setting, where the effects on labor and goods markets, other than specialized inputs markets, are ignored. From equation (IV.11), I can derive the following set of comparative statistics as well as the main results. Then, it can be shown that

$$\frac{\delta v^i}{\delta \gamma^i} = \frac{4\alpha}{1-\alpha} \frac{\gamma^i(1-\frac{1}{2}\gamma^i)}{[1-\gamma^i-\frac{1}{2}(\gamma^i)^2]^2} m^i f_m^i > 0, \tag{IV.12}$$

$$\frac{\delta v^i}{\delta m^i}=\frac{4\alpha}{1-\alpha}\frac{1-\gamma^i}{1-\gamma^i-\frac{1}{2}(\gamma^i)^2}f^i_m>0 \text{, and} \qquad \text{(IV.13)}$$

$$\frac{\delta v^i}{\delta f^i_m}=\frac{4\alpha}{1-\alpha}\frac{1-\gamma^i}{1-\gamma^i-\frac{1}{2}(\gamma^i)^2}m^i[1+\frac{\delta m^i}{\delta f^i_m}\frac{f^i_m}{m^i}]>\text{ or }<0\text{,} \qquad \text{(IV.14)}$$

where $\gamma^i<\frac{1}{2}$ and $\frac{\delta m^i}{\delta f^i_m}\frac{f^i_M}{m^i}<0$.

The intuition behind the comparative statics of equations (IV.12)-(IV.14) is as follows. An increase in γ^i, everything else held constant, affects the probability, for each specialized final good producer, of finding a suitable partner and successfully engaging in a contractual relationship. Since the expected profits of each specialized final producer depend on the profitability of finding a partner, the improvements in contracting environment in country *i* increase the prevalence of outsourcing in that country. In the same vein, market thickness affects the probability of matching between final goods producers and input suppliers, which in turn raises the volume of outsourcing. On the other hand, the input supplier's fixed cost of acquiring the production technology know-how, f^i_m, has an ambiguous effect on the volume of outsourcing in country *i*, as shown in (IV.14). As the fixed cost of entry increases, the market thickness in country *i* declines, which, in turn affects the relative profitability of search in country *i*. The volume of outsourcing in country *i* declines if market thickness is elastic with respect to fixed costs of entry.

With these predictions in hand, I now turn to data of U.S. outsourcing of intermediate goods to test their plausibility.

IV.III. Empirical Methodology and Data Description

The basic model described in the previous section illustrates the determinants of the extent of outsourcing, with a particular focus on the supplier's country contracting environment, market thickness, and the fixed cost of obtaining the production know-how, i.e. expertise and equipment. The impact of institutions on trade has been a topic of much interest in the recent empirical literature. These studies rely on implications of the incomplete contracts literature to examine the role of institutions as a source of comparative advantage in trade of final goods (e.g., Levchenko 2007; Nunn 2007). The starting point of their analysis is the assumption that some sectors rely on institutions more than others. This would be the case, for example, in sectors which cannot rely on spot markets for inputs, and instead require establishing complex relationships with the input suppliers. Then, institutionally superior countries specialize in exports of the institutionally dependent final goods. The commonly used empirical test of institutional comparative advantage of trade in final goods relies on the factor content of trade specification of Romalis (2004). However, since data on trade in final goods is not available, these studies test the importance of institutions using data on bilateral total trade flows.

Unlike Levchenko (2007) and Nunn (2007), I aim to examine the role of institutions and market thickness as sources of comparative advantage in international outsourcing of intermediate inputs. I then contrast my finding to those for trade in final goods. Similar to prior studies, the empirical strategy exploits variation in country characteristics, i.e., quality of contracting environment and market thickness, and industry characteristics, i.e., dependence on institutions. Using data on U.S. imports disaggregated by industry and country, my analysis reveals stark differences in the determinants of patterns of trade in intermediate inputs and trade in final goods.

IV.III.1. Specification

The empirical framework I follow was developed by Romalis (2004). In this model, endowments of skilled labor, unskilled labor, and capital across countries are interacted with the production intensities of these factors across industries. The model tests the Heckscher-Ohlin prediction, which states that countries specialize in the production of those goods that use factors in which they are most abundant. Following Levchenko (2007) and Nunn (2007), I augment Romalis (2004) model to include institutional intensity. Unlike the previous studies, however, my specification also includes interactions with country-level measures of market thickness. Thus, I estimate

$$\ln(\text{imports})_{ci}=\theta+[\delta_1 contr_c+\delta_2 thick_c]CONTR_i+\delta_3 sk_c*SK_i+\delta_4 cap_c*CAP_i+\lambda_c+\eta_i+\epsilon_{ci} \quad \text{(IV.16)}$$

where *i* indexes industries and *c* countries. In particular, $\ln(\text{imports})_{ic}$ denotes U.S. imports of intermediate inputs from industry *i* of country *c*, normalized by the average U.S. imports from country *i*. Country-level variables $contr_c$ and $thick_c$ measure the quality of contracting environment and market thickness. These variables are interacted with $CONTR_i$, which denotes the industry-level measure of contractual dependence. I assume that the cost of acquiring production know-how from equation (IV.11) is highly correlated with the country endowments of skilled labor and capital. Consequently, per Romalis (2004), I include the interactions of country-level measures of skilled labor and capital endowments, sk_c and cap_c, with industry-level measures of skill and capital production intensities, SK_i and CAP_i. These interaction terms are meant to test the third theoretical prediction of the importance of the suppliers' ability to acquire expertise and equipment, expressed in equation (IV.14). Finally, I include country and industry fixed effects, λ_c and η_i, respectively.

Motivated by equations (IV.12) and (IV.13), I am most interested in the coefficients on the contracting environment and market thickness. Positive estimates of δ_1 and δ_2 would provide evidence consistent with the predictions of the model: inputs requiring complex specialized relationships with suppliers (as proxied by $CONTR_i$) originate from countries governed by good contracting environments ($contr_c$) and countries with a large number of specialized inputs suppliers ($thick_c$). As a further test of the importance of contracting environment and market thickness, in some specifications I include an additional interaction term, $contr_c thick_c CONTR_i$. A negative estimate on this interaction term would indicate that when contracting environment is very good (markets are thick), the importance of contracting environment (market thickness) diminishes. This result stems from the model described in the previous section, where better contracting environment and market thickness improve the probability of matching with the suitable specialized input supplier and successfully engaging in a contractual relationship.

IV.III.2 Data Sources and Variable Definitions

I use data on the 1997 U.S. imports classified by 10-digit Harmonized System (HS) commodities and country of origin from Feenstra (2002). I disaggregate these data into manufacturing intermediate input and non-intermediate goods according to the recently developed Market Structure Index of HTS Imports (See Appendix F). Using the BEA mapping of 6-digit IO industries to 10-digit HS codes, I aggregate the import data into 6-digit IO industries. Overall, there are imports data for 171 countries and 315 industries. The dependent variables in each of the specifications, is the natural logarithm of U.S. imports sourced from country *c*'s industry *i*. Because a large number of imports are zero, I replace missing observations on $\ln(imports_{ic})$ with zeros. The fit of the model improves dramatically when zero observations are dropped, however, the signs of the coefficients remain the same, as I show in Table E.5.

Country-level measures of the quality of the contracting environment are adopted from Kaufmann (2004) measure of the rule of law.[34] This measure is meant to capture the quality of contract enforcement, security of property rights, and predictability of the judiciary.[35] To proxy for input supplier market thickness across countries, I rely measure of market size, i.e. real GDP (in constant 2000 U.S. dollars) and labor supply from World Development Indicators. These are available for 108 and 120 countries, respectively. Labor supply is perhaps a better measure of market thickness, as GDP is likely to be

34 Same measures of the quality of the contracting environment are used in Levchenko (2007) and Nunn (2007).

35 My results are robust to the use of other measure of the quality of legal systems, such as those from Gwartney and Lawson (2007) and World Bank's [2004] Doing Business Database

correlated with countries' quality of contracting environment and level of development. Finally, to measure the input suppliers' cost of acquiring production know-how, i.e. expertise and equipment, I rely on standard measures of factor endowments, such as skilled labor and capital. These are adopted from Hall and Jones (1999) and are natural logarithms of human and physical capital per worker, respectively.[36] These measures are available for 116 countries.

The empirical strategy requires an industry-level measure that captures the contractual dependence of intermediate inputs sourced from overseas. In other words, this measure captures the importance of relationship-specific investment required in the production of intermediate inputs. To construct this measure, I use 1997 U.S. input-output tables from the BEA to determine which downstream industries purchase and in what proportions the imported inputs. Next, I use data from Rauch (1999) to identify which downstream industries may require specialized relationships with their upstream input suppliers. These data classify industry output according to three categories: sold on an organized exchange, reference-priced in a trade publication, or neither. I follow previous studies to assume that goods which are neither sold on an organized exchange or reference price in a trade publication, are more complex (e.g. Berkowitz et al. 2006; Ranjan and Lee 2004). Then downstream industries with more complex production are more likely to require relationship-specific investment from their input suppliers. Using this information, along with information for the input-output table, I construct for each

36 I test the robustness of results to alternative measure of factor abundance provided by Antweiler and Trefler (2002). These measures are available for only 69 countries and considerably reduce the sample size. The inclusion of these alternative measures does not qualitatively alter the results.

imported input i a measure of contractual dependence as $\sum_{j=0}^{J} s_{ij} R_j^{neither}$, where s_{ij} is the share of input i used by the downstream final good producer j, and $R_j^{neither}$ is the proportion of downstream good j that is neither sold on an organized exchange or reference priced in a trade publication.[37]

The measure of contractual dependence described above is similar to a measure proposed by Nunn (2007), which aims to capture the importance of relationship-specific investment in explaining the patterns of trade in final goods. Nunn (2007) shows that the effect of institutional quality on the patterns of trade of final goods is the greatest for goods that use larger proportions of intermediate goods that require relationship-specific investment. My measure of contractual dependence is symmetrically different from that of Nunn (2007). Rather than trying to identify the market thickness of upstream intermediate inputs, my measure captures the market thickness of downstream final good producer that require relationship-specific investment of their input suppliers.

Finally, I control for factor intensity differences in production, which are expected to capture the extent of required industry-level production know-how. The construction of factor intensities follows the baseline three-factor model developed by Romalis (2004). Capital intensity of an industry is measured as 1 minus the share of total compensation in value added. Skilled labor intensity is then the ratio of nonproduction workers to total

37 The data from Rauch (1999) are classified according to the 4-digit SITC Rev. 2 system. Each industry is coded as being in one of the following three categories: sold on an exchange, reference prices, or neither. I aggregated Rauch data into 315 manufacturing industries classified according to the BEA's 6-digit I-O industry classification. To match each SITC industry to I-O industry, I use a SITC4-HS10 codes concordance from Feenstra (2002) and the HS10-IO6 concordance from the BEA. Equal weights are used when in the final SITC4-IO6 concordance. The final data contains the fraction of each input that is neither sold on an organized exchange nor reference priced.

employment multiplied by the total share of labor in value added, or 1 minus capital intensity. Unskilled labor is not included in the regression because by construction of capital and skill intensities, it is absorbed into the constant term. These are calculated from the U.S. manufacturing statistics available in the extension of the NBER Productivity Database for 1997-2004 (See Appendix F). While all factor intensity measures are calculated using U.S. data, the estimated coefficients are interpretable as long as there are no factor intensity reversals (Romalis 2004; Levchenko 2007).

The final sample contains 108 countries and 315 industries, where U.S. imports of intermediate inputs and imports of non-intermediates are sourced from 273 and 303 of these industries, respectively. Table E.1 summarizes the explanatory variables used in the analysis and Table E.2 provides correlations of interactions employed in the regression analysis. The countries in the sample are listed in Table E.3.

IV.IV. Results

I now turn to my estimation of (IV.16). In addition to presenting the results for patterns of U.S. imports of intermediate inputs, I contrast these to the estimates for patterns of U.S. imports of non-intermediate goods. My estimates suggests that judicial quality, market thickness, factor abundance are important determinants of patterns of intermediate goods. Furthermore, while market thickness and factor endowments explain less of the patterns of trade in intermediates relative non-intermediates, in most specification, the quality of contracting environment is more important for trade in intermediates.

IV.IV.1. Trade in Intermediate Inputs

The baseline estimates are presented in Table E.4. Column 1 reports a specification commonly used in the recent literature on the determinants of trade patterns. The coefficient on the contracting quality interaction is of the expected sign and highly significant. This estimate changes little with the inclusion of market thickness interactions in Columns II and III. Because I report standardized beta coefficients, one can directly compare the relative magnitudes of the contracting quality interaction with the market thickness interaction. A one standard deviation increase in the contracting quality interaction increases imports by .163 standard deviations, while one standard deviation increase in market thickness, increases the dependent variable by 0.06 standard deviations, when market thickness is measured by labor supply in Column III. I consider these figures as my baseline estimates. These effects are even larger, when I add the additional interaction of market thickness with the quality of contracting environment.. However, the coefficient on the latter is not statistically significant. The GDP interactions with contracting quality compare poorly to those of labor supply. As noted earlier, GDP is, perhaps, a poor measure of market thickness, as it is highly correlated with the quality of the contracting environment in a country. The correlations on the GDP interactions with contracts-related measures range from .72 to .92, as shown in Table E.2.

The results presented in Table E.4 confirm the model predictions that both the extent of contracting environment and market thickness of suppliers are important determinants of patterns of trade in specialized inputs. Nevertheless, the combined effects that factor endowments have on the pattern of trade are greater than those of the contracting quality and market thickness.

To ensure that I am really picking up the effect of institutional quality and market thickness, I now conduct a number of robustness checks. One concern might be that the contracting environment measure is a proxy for some other feature of countries with good contracting environment. For example, perhaps the more specialized inputs require higher endowments of skilled labor or capital. To address this issue, Table E.5 presents results for several alternative specifications and subsamples, where I use labor supply as the ultimate measure of market thickness. In Column I, I report results for a full set of interaction terms, where contract-dependence measure is interacted with skill and capital abundance, and factor dependence measures are interacted with the quality of the contracting environment. The coefficients on the key interactions of interest remain virtually unchanged. However, the interaction terms of factor dependence and the quality of contracting environment seem to pick up all the significance from other interaction terms. This suggests that the quality of contracting environment is relatively more important than factor abundance for patterns of trade in skill and capital intensive inputs.

To test robustness further, I examine whether the results are driven by certain subsets of the sample. Column II of Table E.5 reports results where I retain only non-zero observations of imports volumes. The coefficients retain their sign and significant, although now the combined effects of contracting quality and market thickness dominate those of factor endowments. In Column III, I run estimation on a subsample of only countries of the South, where the South is defined as countries with real per capita GDP of less than 50% of the U.S. level. The list of countries belonging to the North and the South are provided in Table E.3. It is clear from Column III that the results are not driven simply by the Northern countries. Neither are they driven by the poorest countries in the sample, as reported in Column IV where I exclude the countries of Sub-Saharan Africa. Additionally, I omit China and South East Asia in Columns V and VI to test whether the effect of labor supply is driven by China's or South East Asia's large population sizes. The results remain qualitatively the same. Finally, I check whether the estimates are driven by outlier industries, such as the top contract-dependent industries. The exclusion of the top 20 contract-dependent industries does not qualitatively alter the results.[38]

One obvious concern is whether the results are sensitive to my choice of variables. I test the robustness of the coefficients by using alternative measures of contract-dependence employed in prior studies. For example, Berkowitz et al. (2006) and Ranjan and Lee (2004) apply Rauch (1999) data directly to total trade volumes, and find that the effect of institutional quality on the volume of trade is greatest for goods that are not sold on an organized exchange. In unreported findings, I test the effect of this alternative measure of contract-dependence on patterns of trade in intermediate goods. I find that the estimated effect of the contract-dependence interaction with the quality of contracting environment is statistically significant in all specifications, although roughly three times as small as the baseline results of Table E.4. Furthermore, the estimated effect of the market thickness interactions are not statistically significant. I attribute this result to the fact that high levels of aggregation of Rauch's data make them better suited for

38 Neither does the exclusion of top 40 contract-dependent countries, as I attest to in the unreported findings.

characterizing trade in final goods, rather than trade in intermediate inputs.[39] Additionally, I use alternative measures of factor endowments, which qualitatively do not change the results.[40]

IV.IV.2 Comparison with Non-Intermediate Imports

Next, I aim to examine the importance of the determinants of the patterns of trade in intermediate goods relative to their importance in explaining the patterns of trade in final goods. The impact of contract enforcement on trade in final goods is tested in recent works of Levchenko (2007) and Nunn (2007). These studies construct measures of contractual dependence, as described earlier, specifically for trade in final goods. Due to the lack of data on trade in final goods, they rely on data on total trade flows and find a positive impact of institutional quality on contract dependent final goods. The mechanism of the impact of the contracting environment and market thickness on trade in final goods is similar to the one for trade in intermediates described in the model in Section IV.II. For example, the model can be extended to allow the South to produce differentiated final goods, which require outsourcing of specialized inputs. Similar to the North, the Southern final good producers engage in search of suppliers, with whom the probability of entering in successful investment contracts depends on the extent of contracting environment and market thickness in the inputs supply markets. Furthermore, allowing for the Heckscher-

39 Additionally, Levchenko (2007) uses Herfindahl index of inputs usage concentration to determine the contractual dependence of traded final goods. The idea behind this measure is that the lower concentration of input usages implies a higher complexity of production technology and higher contractual dependence. It is unclear whether a symmetrically opposite measure of concentration of downstream industries purchases is an appropriate measure of contract dependence of intermediate inputs. Thus, it is ambiguous whether an input that serves more downstream industries is more relationship-specific than an input that serves a single final producer.

40 These data are from Anteiler and Trefler (2002) and cover 69 countries.

Ohlin world with multiple countries, the differences in contracting environments and market thickness across countries may serve as sources of comparative advantage in the production of final goods that require varying degree of relationship specificity of investment.

It is difficult to theoretically pin down the differences in the importance of contracting environment and market thickness between trade in inputs and final goods. On the other hand, it is easy to estimate the extent of these differences empirically. Table E.6 contrasts the separate regression results of equation (IV.16) for U.S. imports of intermediate and non-intermediate goods.[41] The construction of the contract-dependence measure for imports of non-intermediate goods follows the one proposed by Nunn (2007), which is the weighted average of product differentiation of inputs employed by the source industries (see the data section for more detail). As shown in Table E.6 Column II, in addition to different magnitudes of the coefficients, market thickness appears to have no effect on imports of non-intermediate goods. In Column III, I replace the dependent variable of the Column II specification with total U.S. imports and obtain coefficients similar to those in Column II. The new regression is similar to the one estimated by Levchenko (2007) and Nunn (2007), where total trade is used as a proxy for trade in final goods. Finally, in Column IV, I use a weighted average of the contract

41 Imports of non-intermediate goods are calculated as total U.S. imports net of imports of intermediate inputs, and contains the following product categories: consumer goods, non-manufacturing supplies, and capital investment goods.

dependence of source industries and find that both the institutional quality and market thickness are important determinants of the patterns of total U.S. imports.[42]

Next, I combine the samples containing U.S. imports of intermediate and non-intermediate goods, in order to gauge the relative importance of the institutional quality, market thickness, and factor endowments for the two types of goods. Similar to Column IV of Table E.6, the measure of contract dependence of the source industry is the weighted average of product differentiation of inputs employed by and the final output of the source industry. The results are presented in Table E.7, where specifications include interactions with a dummy, which takes a value of 1 if goods are intermediate in nature and 0 otherwise (*Materials Dummy*). It can be be seen from Columns I and II that there are statistically significant differences in the determinants of the patterns of imports of intermediate input relative to non-intermediates. In Column II, the sample is restricted to only those industries that source both intermediate and non-intermediate goods. The common picture that emerges is that the quality of contracting environment, market thickness, and factor endowments explain less of the patterns of U.S. import of intermediates relative to non-intermediates. However, the magnitudes of the coefficients are relatively small. This indicates that the patterns of imports of intermediate inputs and of non-intermediate goods are explained reasonably well by the same set of determinants.

42 The weighted average of contract dependence of source industries is measured as a weighted average of contract dependence of inputs employed by the industry and contract dependence of final production of the industry. The weight for inputs is calculated as the share of input costs in total output, while the weight for final production is calculated as one minus the inputs weight or the share of value-added in total output.

Next, I test the robustness of the results of Columns I and II to the nature of the imported products. As such, I restrict the sample to only those imported products that are predominantly intermediate or non-intermediate in nature.[43] Columns III-IV, V-VI, and VII-VIII of Table E.7 present results for samples where 25%, 50%, and 75% of the volume of each imported product enter either intermediate or non-intermediate U.S. markets, respectively. As can be seen, market thickness and factor endowments continue to explain less of the patterns of U.S. imports of intermediate goods relative to non-intermediate goods, irregardless of the nature of the imported products. However, as imported products become more intermediate or non-intermediate in nature, the quality of contracting environment appears to explain more of the patterns of imports of contract-dependent intermediates, relative to imports of contract-dependent non-intermediates. If one restricts attention only to those industries which source both intermediate and non-intermediate goods, the contracting environment is roughly 50% more important in explaining the patterns in U.S. imports of intermediate goods relative to non-intermediate goods as shown in Columns IV, VI, and VIII. A one standard deviation increase in the contracts interaction term, increases U.S. imports of non-intermediate goods by 0.103-0.183 standard deviations and U.S. imports of intermediate goods by 0.155-0.295. As can be seen, the importance of the quality of contracting environment grows as imported products become more intermediate or non-intermediate in nature.

43 According to the Imports Index, a large share of imported commodities are purchased, to some extent, by both U.S. manufacturing and final goods markets, e.g. consumers, government, etc. Some examples of these goods are tires, repair parts, fabric. The Import Index assigns weights to commodities that serve multiple end-use markets, allowing one to determine how much of import volumes of a given good enter a specific market. Thus, it is possible, that the similarity in the determinants of the patterns of imports of intermediates and final goods stems from the fact that most commodities tend to serve both intermediate and final goods markets.

In summary, my findings suggest that while patterns of imports of intermediate inputs and of non-intermediate goods are explained well by the same set of determinants, the institutional quality explains more of the patterns of trade in those goods that tend to be contract dependent and mostly intermediate in nature.

IV.V. Conclusion

In this chapter I have tested whether a country's contracting environment, market thickness, and factor endowments explain the pattern of U.S. trade in specialized intermediate inputs. I found that countries with good contract enforcement and thick markets of inputs suppliers specialize in intermediate inputs for which relationship-specific investments are most important. Contract enforcement and market thickness are equally important determinants of the patterns of U.S. imports of intermediates, as are countries' endowments of skilled labor and physical capital. Furthermore, my findings indicate that countries with better quality of contracting environment specialize in the production of goods that tend to be more intermediate, e.g., manufacturing inputs, than non-intermediate, e.g. consumer goods, in nature. Market thickness and factor endowments, on the other hand, explain less of the patterns of trade in intermediate inputs, relative to patterns of trade in non-intermediates. This study is the first comprehensive study to analyze the determinants of U.S. trade in intermediate inputs and to do so in the context relative to trade in final goods. Furthermore, this is the first paper to analyze the impact of source country market thickness on international trade.

CHAPTER V

CONCLUSION

This dissertation examines trends, effects, and determinants of U.S. imports of intermediate goods, otherwise known as outsourcing in popular press. Previous attempts to shed light on the nature of outsourcing of intermediate production have been largely constrained by the fact that trade data do not differentiate between trade in intermediate and finished goods. I introduce a newly constructed dataset that clearly distinguishes between U.S. imports of manufacturing materials, consumer goods, and others, during 1989-2004. With these data in hand, previous findings on the nature of trade in intermediate inputs are confirmed, revised, and added to. For example, in Chapter II I find that contrary to common speculation the magnitude of U.S. international outsourcing of intermediate production is larger than previously thought. In Chapter III, I use new data to refine the existing industry-level of measure of imported inputs to find a significant impact of international outsourcing on the U.S. skilled-unskilled wage gap of 1989-2004. Finally, in Chapter IV, I find support for existing theoretical predictions and reveal that intermediate inputs which require relationship-specific investment are sourced from countries with better institutional quality and thick supplier markets.

Much hype in the popular press and political circles revolves around adverse effects that international outsourcing of production may have on U.S. economy. These claims rely on a prevailing notion that offshoring is a phenomenon distinct from trade in finished goods. A major contribution of this dissertation is to objectively analyze the validity of this assumption. My results suggest that while the differences between the patterns of international outsourcing of intermediate production and the patterns of trade in finished goods do exist, they are relatively small. However, the effects that the two types of trade have on importers' home markets are distinct.

The reasoning behind these results is straightforward. The similarities in the patterns of trade are driven by the fact that international specialization of production is guided by the same mechanisms irregardless of whether goods are intermediate or finished in nature. This explains why in Chapter II I find that superior varieties of intermediate and consumer goods are produced in high-income countries; and why in Chapter IV, I find that specialized intermediate and consumer goods are sources from countries with better quality of institutions, more inputs suppliers, and larger skill and capital endowments. At the same time, the effect of trade on U.S. labor markets depends on the nature of the commodities. This stems from the fact that trade in finished goods affects all worker in all sectors of U.S. manufacturing, while imports of intermediate goods, due to their lesser skill requirements, are substitutes to lesser-skilled workers. This explains why in Chapter III I find that international outsourcing is a one of the main drivers of the growing wage gap during the 1990s, while trade in finished goods has no effect on the wage gap whatsoever.

Despite the significant contribution to the current literature on outsourcing, the analyses and results offered in this dissertation should be deemed as mostly preliminary in nature. A number of issues come to mind. First, the analysis performed in Chapter II relies on the commonly accepted assumption that observed prices of imports, i.e., unit values, are a good predictor of the quality or the extent of vertical differentiation of goods. Since in addition to quality, prices reflect costs of production and exchange rate mechanics, they may be poor instruments in gauging the differences between the determinant of international specialization of production of intermediate goods and finished goods. Second, the empirical methodology of Chapter III relies on the long-run general equilibrium theory of trade, which holds labor supply as constant. However, the empirical methodology fails to hold constant the supply of labor over the period of 1989-2004 and may be the reason why the predicted changes in the wage gap exceed the actual changes in the U.S. wage gap. Finally, Chapter IV, relies on the assumption that the characteristics of U.S. source industries and countries are taken exogenous of their exports to the U.S. Some recent studies show the reverse causality between country characteristics, i.e., quality of institutions, and trade which points to a potentially severe endogeneity in the estimation performed in Chapter IV. These and other issues are commonly ignored in the current methods employed in trade-related research. Addressing these issues is a goal of my future research.

APPENDIX A

MARKET STRUCTURE INDEX OF HTS IMPORTS

A.1. Introduction

The Market Structure Index of Manufacturing Imports (the Imports Index) decomposes U.S. manufacturing imports into two market groups, (1) finished products and (2) materials. Finished products are subdivided into consumer goods, equipment, and nonindustrial supplies (which are inputs to nonindustrial sectors). Materials are industrial inputs in the manufacturing of finished products. The Import Index contains market structure information on over 22,000 manufacturing import codes described by the Harmonized Tariff Schedule of the United States (HTS). The HTS import codes follow a hierarchical structure for describing all goods in trade for duty, quota and statistical purposes, and, at ten-digit level of disaggregation, contain a detailed description allowing one to gauge an import's end use market(s). The Import Index covers all HTS codes describing U.S. manufacturing imports over the period 1989 to 2004. Manufacturing imports refer to HTS codes that map into the manufacturing industries included in the North American Industrial Classification system (NAICS) definition of manufacturing. Currently, this does not include those industries such as logging and newspaper, periodical, book and directory publishing that have traditionally been considered to be manufacturing and included in the industrial sector under the Standard Industrial Classification system (SIC). This appendix describes the methods and source data used in the construction of the market structure classification and relative importance weights of the Import Matrix.

The methods used in this appendix have been inspired, for the most part, by the methods utilized in the construction of the Industrial Production Index (IP index), published in G.17 Statistical Release of the Federal Reserve, and the End-Use Commodity Classification System (End-Use system), published by the BEA.[44] The Industrial Production Index classifies U.S. industrial production into market groupings based on the concept of end-use demand, i.e. intermediate and final demand. The U.S. input-output tables are used to refine the end-use demand further into industrial materials and non-industrial supplies, equipment and consumer goods. The input-output data are also used to construct the relative importance weights for each of these market groups,

44 The Industrial Production Index can be found on http://www.federalreserve.gov/releases/G17/ip_notes.htm

when goods are assigned more than one end-use market. The FR uses the market detail provided by the IP index to illuminate structural developments in the economy. The BEA used the same concept of end-use demand to classify commodity trade data provided by the U.S. Census Bureau into broad end-use categories, such as industrial supplies and materials; capital goods, except automotive; automotive vehicles, parts and engines; consumer goods; food, feeds, and beverages, and other goods, including government defense imports. Both the IP Index and the End-Use system are available at a relatively aggregated industry and imported commodity levels (six-digit NAICS and five digit End-Use codes, respectively).

Following the use of the input-output tables in the construction of the IP Index by FR, my construction of the Import Index relies heavily on the 1997 U.S. Import-Matrix published by the BEA. The import-matrix is a supplementary table to the U.S. input-output accounts and shows the value of imports of that same commodity used by each industry. The data from the BEA import-matrix can be used both to define the market structure of each of the HTS import codes and to derive the relative importance weights for each market group that comprises the U.S. imports end-use market structure. I supplement the BEA import-matrix data on commodity market classification with stage-of-processing data on products comprising these commodities. I obtain these data from the Stage-of-Processing Index (SOP) provided by the BLS, which classifies major products comprising six-digit NAICS commodities/industries into a relevant stage of processing, i.e. crude materials, intermediate materials, finished consumer goods, and capital equipment.[45] The BLS products descriptions parallel the overall content of the descriptions of the HTS import codes and the products' stage of processing information is used to supplement the information on the end-use markets obtained from the detailed HTS imports descriptions.

The construction of the market structure classification of HTS imports involved an individual examination of the over 14,000 code descriptions, which document the physical nature of the imported product and its stage of processing or the industry categories associated with its production. As the result of these efforts, I am able to construct a market classification of HTS imports that decomposed imports into industrial materials, non-industrial supplies, consumer goods, and capital investment. The relative importance weights for multiple market groups were derived from the BEA import-matrix by setting up and solving a set of constrained matrix equation problems.

The Import Index can be used in a wide variety of research projects where trade data by the type of imports is needed. For example, trade in intermediate imports has been reported to have increased dramatically in the past four decades. Some economists attribute it to the rising levels of foreign outsourcing, where U.S. firms contract intermediate parts and components at arms-length from foreign suppliers. However, previous proxies of foreign outsourcing incorporate an estimate of imported intermediate

45 The Commodity-Based Stage of Processing Index can be found on ftp://ftp.bls.gov/pub/special.requests/ppi/sopnew07.txt.

goods based on the share of total U.S. imports in domestic supply. Thus, the Import Index allows the derivation of more accurate measure of imported intermediate goods.

The Import Index is likely to be updated as more data become available or as difficulties with the data are noted and clarified. For example, currently the Import Index relies on data from the 1997 BEA import-matrix for the derivation of the relative importance weights of market groups over the period of 1989-2004. It is reasonable to assume that industrial technologies and consumer demand is subject to fluctuations, and the market structure of imported production changes with time. I intend to update the relative importance weights as new import-matrices become available in the future.

The remainder of the appendix is structured as follows. A.2 describes the methods and data used to derive the market structure classification of HTS imports. A.3 describes the methods and data used to derive the relative importance weight of market groups. A.4 contains a discussion of some of the conceptual and practical problems involved in deriving the Import Index. A.5 concludes.

A.2. Classification Data

A.2.1 BEA Import-Matrix Data

The BEA develops the import-matrix as a supplementary table to the input-output accounts in order to distinguish domestic production from imported production, which the input-output accounts do not do. However, since the data on the use of imports by industries and final uses are not available, the BEA develops its import matrix by making the assumption that imports are used in the same proportion across all industries and final uses. As described below, this is a major shortcoming with the BEA's approach. A commodity's imports are then decomposed into inputs for an industry and final uses by multiplying the share of the commodity imports in total domestic supply (domestic shipments or receipts plus imports less exports and change in private inventories) by each of the commodity inputs in the input-output tables. As a result, the market structures of the import-matrix and input-output tables are conceptually the same. When looking at the import-matrix, however, the relative magnitudes of inputs in the import-matrix are different than the ones in the input-output tables. I attribute these differences to the BEA's ability to recognize that some imports may not serve the same markets as the domestic inputs. As the result of these small differences, I use the 1997 import-matrix, rather than the 1997 benchmark input-output table, as the basis for construction of the Import Index.[46]

The BEA import-matrix is used to derive the market structure classification and relative importance weights for each market for the six-digit commodity codes (I/O codes) used in the import-matrix. Table A.1 describes the market structure layout, which I borrow from the definition developed by the Federal Reserve Board (FRB) and used in

46 In the case of a small number of commodities, I find that the data from the input-output tables do a better job of describing the market structure of the HTS imports. As a result, I substitute the data from the import-matrix with the data from the input-output tables and record these commodities in A.4.

Table A 1: Market Structure of Imports from the BEA Import-Matrix

Import Type	End-use Demand
Intermediate Goods	**Intermediate Demand**
Industrial Materials	*Industrial Sectors*
	Manufacturing
Final Goods	**Final Demand**
Non-Industrial Supplies	*Non-Industrial Sectors*
	Agriculture, forestry, fisheries
	Mining
	Construction
	Transportation
	Communications
	Utilities
	Trade
	Finance, insurance and real estate
	Services
	Government
	Special Industries
Consumer Goods	*Consumption*
	Personal consumption expenditures
	Federal government consumption
	State and local government consumption
Capital Goods	*Fixed investment*
	Private investment in equipment, software, and structures
	Federal government investment
	State and local government investment

the Industrial Production Index. The market structure classification is based on the concept of end-use demand, comprised of intermediate and final demand. The intermediate demand consists of end-user industries that belong to the U.S. manufacturing sector, while the final demand is comprised of end-users in the U.S. non-industrial sector, i.e. private consumers and the government. Businesses and government investments into equipment, software, and structures are also included in the final demand market group to comply with national accounting standards even though equipment and software are inputs into production of final goods.[47] The imported commodities purchased by the suggested end-use markets can then be decomposed into intermediate goods, i.e. industrial materials, and final goods, i.e. non-industrial supplies, consumer goods, and capital goods.[48]

47 Imports of structures constitutes only a small percentage of capital investment goods and include imports of mobile homes, bridge sections, and others. Imports are not distributed to the change in private inventories. See U.S. Department of Commerce (2006), pg. 12-6 for more detail.

48 See Industrial Production Index developed by FRB for more detail, which can be found on The Industrial Production Index can be found on http://www.federalreserve.gov/releases/G17/ip_notes.htm

It is important to note that an imported commodity may be included in more than one end-use market group. This occurs because some goods are used by businesses as inputs and are also purchased by consumers for personal consumption, eg. gasoline. At the BEA import-matrix commodity level, the relative importance weights of each of market group are derived as the share of imports going to that market in total imports. I find that the markets capturing the largest amount of imported inputs in the import-matrix closely compare to the markets indicated in the BEA's End-Use Classification, which is a 5-digit coding system of U.S. exported and imported merchandise that judges the principal final use of the traded commodities.[49]

I use the market structure classification and the relative importance weights from the BEA import-matrix as the basis of the market structure classification for the HTS imports falling into the I/O commodity codes of the import matrix. An additional helpful feature of the import matrix is that it provides information on all the detailed industries consuming an imported commodity. This more refined detail on market structure compliments the description of the HTS codes and validates the end-use markets suggested in the HTS description.

One of the disadvantages of using the BEA import-matrix to derive the volume of imported commodities by type, i.e. materials, supplies, consumer goods, and capital goods, is that the import-matrix itself provides only a rough estimate of imported inputs. As mentioned earlier, since the data of import purchases by industry are not available, the BEA assumes that the ratio of total imports to domestic supply is the same as the ratio of imported inputs to total inputs produced in an industry. This methodology is rather crude, since imports of an import-matrix six-digit commodity consist of a range of products that may relate to their domestic supply in the same way as the total imports relate total domestic supply. In other words the assumption made by the BEA in the import-matrix may grossly over- or under-estimate the imported inputs end-use demand. In order to arrive at a more accurate decomposition of imports by the type of end-use markets they serve, I need to examine the imported commodities at a higher level of detail, i.e. the ten-digit HTS coding system used to record products on U.S. custom forms.

A.2.2 BLS Stage of Processing Index Data

Another important data source used in the construction of the market structure classification of imports is the Stage-of-Processing Index used by the BLS in its efforts to compile the Producer Price Indexes (PPI). The BLS constructs the Producer Price Index (PPI) to measure change over time in the selling of domestic producers of goods and services. The product price indexes are developed by identifying one or multiple major commodity(s) produced by each of the four-digit SIC industries prior to 1997 and six-digit NAICS industries as of 1997. I will refer to the BLS commodities as products, in order to avoid the confusion with BEA six-digit commodities, which the products

49 The End-Use Classification divides imports and exports into the following markets: industrial supplies and materials; capital goods, except automotive; automotive vehicles, parts and engines; consumer goods; food, feeds, and beverages, and other goods, including government defense imports.

comprise. These products are classified by six-digit BLS product codes and price information is collected on each of the products from a sample of industries. Over 10,000 different price indexes are offered by the BLS for individual products and services and their groupings. One set of such groupings is the products aggregated by their stage-of-processing (SOP).

The BLS had identified three SOP categories that consist of crude materials for further processing; intermediate materials, supplies, and components; and finished goods. The crude materials for further processing include products that are entering the market for the first time and have not been processed. The intermediate category includes partially processed materials that require further processing and components that require only assembly or installation. In addition, this category includes fuels and lubricants, containers, and supplies consumed by businesses as inputs into the production of outputs. Final goods are those that are ready to be sold to consumers for personal consumption or to businesses as capital investment. As can be seen, the SOP methodology follows the same line of reasoning as the end-use demand concept developed in the FR Industrial Production Index. Unlike the FR, however, which considers non-industrial supplies as final goods, the BLS refers to them as intermediate goods. This distinction is rather arbitrary, thus I develop the market structure classification of imports in such a way as to allow the practitioners to draw the line between intermediate and final goods as they deem appropriate.

The SOP index of product end-use markets compliments the data from the BEA import-matrix in that it provides information on the product composition of BEA commodities which are missing from the BEA import-matrix. Using the concordance provided by the BLS, I combine the I/O commodity codes from the import-matrix and the BLS product codes from the SOP index to compare the market structure composition of commodities and products from each of the data sources, respectively. I find that when aggregated, the BLS products structure parallels that of the BEA import-matrix commodity end-use demand structure. Additionally, I are fortunate to find that the BLS products description can be easily matched with the HTS imports descriptions. Thus, while the BEA import-matrix gives us a rough idea of market structure of the HTS imports at the six digit I/O commodity level, the BLS SOP index provides further detail on the market structure of individual products that closely match HTS imports within the I/O commodities.

A.2.3. HTS Codes and Descriptions Data

The U.S. Census Bureau is the gatekeeper of the Harmonized System of commodity classifications, which records imports and exports as they cross U.S. customs boundaries. The Harmonized System of commodity classification comprises a hierarchical structure for describing all goods traded for duty, quota and statistical purposes. The HS was developed under the auspices of the International Customs Cooperation Council, which sought to establish an internationally accepted standard for the classification of internationally traded goods in order to eliminate one source of nontariff trade barriers. Currently, the HS system is administered by the World Customs Organization in Brussels, which assigns 4- and 6-digit HS product categories to all products traded world-wide. The U.S. subdivides these products further into 10-digit non-legal statistical reporting categories. The particular application of the Harmonized System to U.S. imports is called the Harmonized Tariff Schedule (HTS). Currently over 12,000 HTS codes describe U.S. imports of manufacturing goods. Each code is supplemented by a highly detailed description of the physical nature of products and their stage of processing or the industry categories associated with their production.

I compile a dataset of manufacturing HTS import codes over the period of 1989-2004 from two sources. I make use of the HTS imports data from the NBER Trade Database for 1989-2001 and the Census Bureau imports data for 2002-2004, from which I derive manufacturing HTS codes and their detailed descriptions.[50] I use HTS-NAICS concordance files from Census Bureau to identify the manufacturing HTS codes as those falling into the NAICS definition of manufacturing sector.

I proceed with constructing the market structure classification by studying the detailed description of over 14,000 codes and classifying them by end-use market type, i.e. materials, supplies, consumer goods, and capital goods. This is done by cross-referencing my classification with the overarching market structure of the six-digit commodity codes derived from the BEA import matrix and stage-of-processing structure of the matched BLS products descriptions.[51] I find that roughly 75%-85% of the HTS import descriptions provided sufficient detail on the physical nature of imports, including their stage of processing and/or industry-related information, to establish the HTS imports end-use demand with reasonable certainty. Another 10%-15% of the HTS codes descriptions entailed highly technical specification which permitted us to turn to specialists in the relevant fields for help in classifying their end-use demand. The remaining portion of the descriptions rendered little if any information on products end-use demand. The most easily accessible type of product descriptions referred to commodities such as textiles, household goods and appliances, heavy machinery and transport equipment, arms and ammunition, raw materials, and items described as "parts" or "in a retail package meant for the ultimate consumer". The next level of description difficulty referred to commodities such as instruments and appliances for technical uses, fertilizers and agricultural chemicals, construction materials, and some food items. Commodities such as chemicals, paper products, some electronic and mechanical equipment and their parts and accessories, wood products, and some other miscellaneous manufactured goods required us to turn to the help of specialists in these fields. Many of the pharmaceutical, food items and products labeled as "others" provided us with little

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50 I use the Census Bureau HTS concordances for 2000 and 2006 to derive the code descriptions over the period of 2002-2004, since these are not included in the Census Bureau imports data (HTS concordances: http://www.census.gov/foreign-trade/reference/codes/index.html).

51 The BEA I/O codes are mapped to the ten-digit HTS codes by using the I/O-HTS concordance provided by the BEA.

information on the imports' end-use and had to be assigned the market structure of the overarching six-digit commodity code from the import-matrix.

As the result of these efforts, I am able to construct a Market Structure Index of HTS Imports that decomposed imports into industrial materials, non-industrial supplies, consumer goods, and capital investment. I describe each of these import categories in more detail below.

Industrial materials consist of goods that are incorporated into final goods produced by a manufacturing industry and those that are used during the production of final goods. The first category of industrial materials incorporates materials for non-durable and durable manufacturing. For example, materials for food manufacturing encompass processed foods such as flour, vegetable oils, and confectionery materials. Materials for other nondurable manufacturing include wood pulp, lumber, industrial chemicals, plastics, textiles, and others. Metal mill products and parts and components of machinery and equipments are example of materials for durable manufacturing. The second category of industrial materials are materials that compliment the production of final goods. These materials include processed fuel and lubricants, packaging materials, some administrative supplies, and others.

Non-industrial supplies consist of materials for construction, agriculture, utilities, and other businesses. Materials for construction include a wide range of commodities, i.e. lumber, plywood, millwork, glass, plumbing fixtures, water heaters, and furnaces. Materials for the agricultural industry include feeds, processed fuels, machinery repair parts and so forth. Other business supplies include telecommunication supplies, packaging materials, office supplies, repair parts, and processed fuels.

Consumer goods consist of consumer foods, other nondurable goods, durable goods, and defense- and non-defense related government supplies. The consumer foods category is made up of a range of processed food items, examples of which include bakery products, processed meats, canned and frozen items, and so on. Other consumer nondurable goods consist of items with a shelf life of less than three years and that are ready for final demand (SOP). Some examples of these goods are children's apparel, prescription drugs, cosmetics, sanitary papers, and energy goods such as gasoline, home heating oil, and residential electric power. Consumer durable goods include products that have a much longer shelf life than nondurables. Items in this category include passenger cars, light trucks, household appliances, and home electronic equipment. Government supplies consist of defense and non-defense related consumption. Examples of defense-related supplies include ammunition, certain chemicals compounds, repair parts for military equipment and machinery, and others. Items in the non-defense-related supplies include education-related products, office supplies, and repair parts for non-military equipment and machinery owned by the government, e.g. snowplows.

Capital goods consist of products that are used to manufacture or transport other goods in the manufacturing sector and includes machine tools for cutting and stamping metals, other specialized machinery (such as farm machinery and textile machinery), heavy trucks, ships, and boats. In addition, this grouping includes non-manufacturing industry and non-defense related government products, such as computers, office furniture, and heating equipment, that are used in the operation of businesses. Defense-related government investment such as military weapons and transportation equipment are also included in this category.

A.3. Market Weights Data and Methods

Having obtained the market structure classification of HTS imports, I proceeded to derive relative importance weights for the end-use markets that define each import. HTS imports that have only one end-use market are assigned a weight of one. HTS imports that are purchased by more than one market are assigned market weights that sum up to one. The initial weights at the six-digit I/O commodity level are derived from the 1997 BEA import-matrix and are used to calculate weights at the ten-digit HTS import code level. Ideally, I would like to have an import-matrix weight for every year in my sample, 1989-2004. However, so far only the 1997 import-matrix had been made publicly available by the BEA. Since the import-matrix weights and market structure parallel those of the U.S. input-output tables, I can also use U.S. input-output table to construct the weight. However, the most disaggregated input-output data is available only for benchmark years during which the U.S. Census is conducted. During my sample period, the benchmark data are available for 1992 and 1997 years only, as the 2002 data have yet to be published. Therefore I focus only on the 1997 import-matrix data and leave the revision of the Import Index that incorporates the 1992 and 2002 input-output data for future work. When incorporating the 1992 data, which is available at SIC industry detail, I plan to expand the index to include industries that match the SIC definition of manufacturing sector as well.

In the derivation of the market weights, I limit my focus to HTS codes that have non-zero imports in 1997, which, theoretically, are the imports that are embedded in the 1997 U.S. input-output tables and import-matrix. Additionally, I utilize the 1997 NBER import data to derive the relative importance of each of the HTS codes within the I/O commodity code. The relative importance is calculated as the share of 1997 imports volume of an HTS code import in total imports of HTS codes within the I/O commodity code.[52]

The first step in deriving the relative importance weights for each of the HTS codes is to recognize that many of the HTS codes within each I/O commodity code have identical market structure compositions. For example, a number of HTS codes within the same overarching I/O code are classified as materials and supplies, and another set may be classified as supplies and consumer goods. I assume that HTS codes with identical market composition within the same I/O code are purchased by end-use markets in the

52 I restrict attention to imports based on the "general imports" classification of imports at foreign port values, similar to the imports in the import-matrix.

same proportion relative to each other. I have to make this assumption, as there are data on the unique market shares of each of the HTS codes which do not exist.

Using the assumption discussed above, I aggregate HTS import codes with identical market structure classification within the same six-digit I/O commodity code to form a HTS cluster. I find that each I/O commodity code contains at most seven HTS clusters. My original intention was to calculate the relative importance weights for HTS clusters within each of the I/O commodity code by setting up a matrix equation and solving it for the market weights. However, since each unique market weight represents an unknown, I found that for some of the I/O commodity codes, the matrix equation does not have a solution, since there are more unknown market weights to be calculated than there are equations (the matrix subject to inversion is not full rank).

I proceeded to solve this problem by netting out the known market weights from the import-matrix weights and then distributing the remaining I/O code weights to markets in the same proportion as they appear in the import-matrix weights. It is best to illustrate this using an example. Suppose a hypothetical I/O commodity code 333333 is found to have three HTS clusters with markets assigned as shown in Table A.2. Table A.2 also shows the percentage of imports that each cluster contributes to total imports. Additionally, not shown in Table A.2, the market structure of the I/O commodity in the BEA import matrix is represented by "materials, supplies, and consumer goods" with relative weights of 0.35, 0.60, and 0.05, respectively.

Table A 2: Hypothetical Example of Market Structure

I/O Commodity	HTS Cluster	Markets	Import Share
333333	1	Mat.	0.25
333333	2	Mat. – Supp.	0.60
333333	3	Mat. – Supp. – Cons.	0.15

Data Sources: HTS Cluster are HTS codes withing the I/O code aggregated by similarity in market composition; markets have been assigned as described in Section 3; import share is from 1997 NBER Trade Dataset and is calculated as imports for the HTS cluster over total imports for the I/O commodity code.

From the market structure in Table A.2, one can see that the HTS cluster 1's materials market has a weight of one, and the HTS cluster 3's consumer goods market has a weightof 0.05/0.15≈0.33. The remaining import-matrix weights then become 0.10 for materials [=0.35-0.25], still 0.60 for supplies and 0 for consumer goods. These remaining weights are used to establish the proportions in which materials and supplies weights will be calculated in clusters 2 and 3. Thus, the weight for materials becomes 0.14 [=0.10/(0.10+0.60)] and 0.86 for supplies. In cluster 2, the materials and supplies weights then become 0.14 and 0.86, respectively. In cluster 3, one must subtract 0.33 of the consumer goods weight, which results in roughly 0.66 of joint weight distributed to materials and supplies. Multiplying this by 0.14 and 0.86, I obtain the actual weights for materials and supplies. Multiplying this by 0.14 and 0.86, I obtain the actual weights for materials and supplies in cluster 3, which are and supplies weights become roughly 0.09 and 0.57, respectively. I check that the weights assigned to clusters' markets add up to those of the import-matrix in Table A.3 as the last step of the process.

Table A.3: Import-Matrix Weights vs. My Weights

Weights	Materials	Supplies	Consumer Goods
Import-Matrix	0.35	0.60	0.05
Imports Index	1*0.25+0.14*0.60+0.09*0.15=0.35	0.86*0.6+0.57*0.15=0.60	0.33*0.15=0.05

This method of calculating market weights worked well for all combinations of clusters encountered in the market structure classification of imports. Table A.4 lists the frequency of six-digit I/O commodity imports with one, two, and three clusters (excluding multiple clusters containing single markets), the market composition of and the number of HTS imported products within the clusters in 1997. As can be seen, my method of calculating the relative importance weights applies to all of the HTS imports in 1997.

Having figured out a way to calculate market weights, as described above, I ran into another somewhat anticipated hurdle. Since the data in the BEA imports matrix are roughly estimated by assuming that the ratio of total imports to domestic supply is the same as the ratio of imported inputs to total inputs produced in an industry, the weights derived from the import matrix result in crude approximations of the actual weights of markets that the imports serve. Consequently, in the process of estimating relative importance weights at the level of detail provided by the 10-digit HTS codes, I am bound to run into situations where the BEA import-matrix weights need to be slightly modified, moderately adjusted, or completely replaced by a better weight measurement. I found that HTS imports within 16 I/O commodity codes do not serve a market indicated by the commodity code, and two do not serve multiple markets[53]. I remedy this situation by distributing the weights of the missing market to other markets, while maintaining the proportions in which the other markets relate to each other. Additionally, HTS imports within 26 I/O commodity codes have a market either under- or over-represented by the import-matrix weights, and multiple markets are under or over-represented for HTS imports within six other I/O codes[54]. I deal with the former situation by redistributing the

53 No materials:335222, 336212, 337121, 337124; no equipment: 313100, 335929 , 336211, 333299, 325180, 334613; no supplies: 313310; no consumer goods: 325212 , 333611, 334113; no supplies or consumer goods: 331312, 336611.

54 Less materials: 315200, 315900, 322226, 325520, 33451A, 33712A; less equipment: 336999, 333313, 333315, 339113, 33999A; more materials:323118, 332211, 333293, 333991, 334210, 335129, 335211, 335212, 336110, 337122, 337127; more consumer goods: 325221, 325222; more equipment: 333993, 336120; more or less of multiple markets: 333298, 334210, 334300, 335224, 335228, 335228, 325520.

Table A.4: Types and Frequency of HTS Clusters

One Cluster	# of I/O Comm.	# of HTS imports	Two Clusters	# of I/O Comm.	# of HTS imports	Three Clusters	# of I/O Comm.	# of HTS imports
ec	13	133	ec, mec	1	6	ec, ms, msc	1	8
mc	2	21	ec, mse	1	16	ec, msc, sc	1	30
me	6	59	mc, msc	1	60	me, sc, sec	1	21
mec	1	2	me, mse	1	15	ms, msc, mse	1	11
ms	18	201	me, msec	2	23	ms, sc, sec	6	606
msc	61	3399	me, sec	1	59	msc, sc, sec	5	252
mse	12	102	mec, mse	1	43			
msec	11	280	ms, msc	28	1876			
sc	21	612	ms, mse	4	25			
se	3	30	ms, msec	9	459			
sec	2	12	ms, sc	4	39			
			ms, sec	1	54			
			msc, mse	3	229			
			msc, msec	1	41			
			msc, sc	47	3312			
			msc, sec	6	218			
			mse, msec	1	12			
			mse, sc	1	16			
			mse, se	1	2			
			mse, sec	4	110			
			msec, sc	2	45			
			msec, se	1	22			
			msec, sec	1	36			
			sc, sec	2	54			
Total	*150*	*4851*		*53*	*2621*		*15*	*928*

Note: m – materials, s – supplies, e – equipment, c – consumer goods

extra weight from other markets or to other markets, respectively, while maintaining the proportions in which the other markets relate to each other. In the latter situation, I recalculate weights for each HTS cluster based solely on the relationship that the markets in the cluster hold when compared to each other in the import-matrix. Lastly, some HTS imports market weights were better described by the weights in the input-output tables, which, while very similar to the import-matrix weights, contain enough of a difference to better fit the HTS imports market composition.[55] In these cases, I substituted the import-matrix weights in the corresponding I/O codes with the weights from the input-output matrix.[56]

55 These correspond to I/O codes 311119, 316200, 326290, 332994, 333120, 333210, 333313, 333131, 33351A, 333913, 333921, 333992, 333924, 334516, 335212, 335224, 335228, 335999, 336999, 339112, 339115.

56 Additionally, two HTS imports in 333319 and 339111 I/O codes belong to a different I/O code. I made

Having completed the derivation of relative importance weights for HTS imports in 1997, I assign these weights to all the HTS import codes for the period of 1989-2004. During this period, some HTS imports codes became obsolete and some new ones may have been introduced due to changes in tariff margins and introduction of new imported products to the U.S. markets. It is interesting to note that the end-use markets of many of the pre-1997 HTS codes and post-1997 HTS codes are not different from products imported in 1997. I find that most of the newly introduced imports mimic the old imports in their general physical characteristics or stages of processing, or industries with which they are associated. The differences between the new and old import are predominantly determined by aspects of product differentiation, such as size, incorporation of new materials (plastics vs. metal), and others. For the most part, this can be explain by the efforts the Census Bureau makes in improving the detail by which goods are described at U.S. customs. As the result, even though the number of HTS codes in the Import Index expands from 15,283 in 1997 to 22,660 during 1989-2004, I find that only 48 HTS codes have market compositions that differ from other HTS codes within their I/O commodity code. The weights that I assign to these 48 HTS codes are proportional to the weight of the corresponding markets from the import-matrix.

A.4. Complications

There are a number of complications that I encountered in the construction of the Import Index. All of them have to do with the difficulties involved in merging the various data sources used in the appendix when utilizing the concordance files obtained from the agencies maintaining the data. All in all I have had to use concordance files for the four industry and products coding systems discussed in the previous sections: BEA's six-digit I/O commodity coding system, the 1997 and 2002 six-digit NAICS industry coding system, 1987 four-digit SIC industry coding system, and 1989-2004 ten-digit HTS imports coding system. Other complications involved the finding that the imports reported by the BEA import-matrix do not correspond to the aggregated HTS imports from the NBER trade dataset. I describe these issues and my solutions to them in the subsections below.

A.4.1 BEA I/O vs. NAICS vs. HTS Codes

One of the steps described in the methods of constructing the Imports Index required merging data from the import matrix to the HTS imports descriptions. The data in the import-matrix follows an I/O commodity coding system comprised of 382 series and constructed by the BEA on the basis of the 1997 NAICS. Consequently, the majority of the I/O codes are identical to NAICS codes from which they are derived (262), a number of them are equivalent to five-digit NAICS (82) and four-digit NAICS (13), and the remaining codes map into two or more six-digit NAICS codes (25). Since the import-matrix follows a coding system different from the HTS system, I use the 1997 BEA HTS-I/O concordance file to establish a mapping of I/O codes to the HTS codes. One issue that comes up when I attempt to use the concordance file is that a number of HTS import codes do not have an I/O code mapping, as the concordance file incorporates HTS's applicable only to 1997 import flows. I deal with this problem in two steps. First, I utilize the Census Bureau HTS-NAICS Concordance File for 1997, 2000-2004 to map 1989-2004 HTS import codes to six-digit NAICS codes.[57] I find that all of the HTS codes, with an exception of only a handful, have an HTS-NAICS mapping.[58] Next, I use the BEA NAICS-IO concordance file to arrive at a mapping of NAICS to I/O codes, and consequently HTS to I/O codes. This gives an HTS-I/O code mapping that allows us to merge the import-matrix data to the HTS imports descriptions data. One last step in the concording sequence is to make sure that the BEA HTS-I/O mapping corresponds to the HTS-I/O mapping I derive as the result of the two-step procedure discussed above. I find that a large number of HTS codes that have two sets of I/O codes from the two sources do not have matching I/O codes (1193 I/O codes). A number of the BEA I/O codes that map to the HTS do not belong to the manufacturing sector, while the I/O codes from the two-stage procedure do (143 I/O codes). This is problematic because the market classification and weights are roughly based on the BEA's data and I would prefer that only the HTS codes that are considered by the BEA be included in the manufacturing sector are in fact included. I deal with the issue of mismatching I/O codes by utilizing the hierarchical structure of the HTS descriptions. By examining the HTS descriptions with mismatching I/O codes and the descriptions of the neighboring HTSs, I am able to correct the I/O codes derived from the two-stage concording procedure to the I/O codes derived from the BEA HTS-I/O concordance file. I find that for a large majority of the HTS codes, BEA's I/O codes derived from the BEA concordance file, if different, tend to describe the HTS imports more accurately than the ones derived from the two-stage procedure. This finding indicates the the Census Bureau's classification of HTS imports according to the NAICS coding system is incorrect for over 1600 HTS imports codes over the period of 1989-2004.

As the result of the process described above, the Import Matrix contains a concordance of manufacturing HTS codes to BEA's I/O codes and an improved concordance of manufacturing HTS codes to NAICS codes over the period of 1989-2004. Manufacturing HTS codes are those falling under the I/O and NAICS definition of the manufacturing sector (codes within the 300000-399999 range). These manufacturing HTS codes exclude used and second-hand goods, scrap and waste, and goods under special classification, i.e. reimports.

57 The Census Bureau HTS Concordance Files for 1997 come from Feenstra (2000) and for 2000-2004 from the Foreign Trade Division website http://www.census.gov/foreign-trade/schedules/b/2004/imp-code.txt. The NAICS industry coding system had undergone a series of revisions since its introduction in 1997. The first revision took place in 2002 and focuses on non-manufacturing industries. None of the manufacturing industries from the 1997 NAICS differ from the 2002 NAICS. The next revision took place in 2007 and does not affect my analysis.

58 I was easily able to fill NAICS codes, for the handful of HTS that had them missing, from the neighboring HTS codes.

A.4.2. NAICS vs. SIC

The HTS codes included in the Import Index cover the period of 1989 to 2004, during which the U.S. followed two different systems of industrial classification: the four-digit SIC system during 1989-1996 and six-digit NAICS system during 1997-2004. The Census Bureau HTS Concordance File for 1997 contains the mapping of HTS codes to SIC codes. I am able to extend the SIC system to classify all the HTS import codes in the Import Index by comparing the HTS imports descriptions that do not have SIC mapping to the HTS imports descriptions that do have an SIC mapping. Currently, the Import Index does not contain all the HTS imports that fall under the SIC definition of the manufacturing sector and not under the NAICS definition of the manufacturing sector. This limitation is imposed by the fact that I use the 1997 import-matrix that follows the NAICS system to derive the market structure classification and market weights. Additionally, since the market classification and weights of the ten-digit HTS imports are derived on individual basis, I am not concerned that the Import Index is biased by the differences between the NAICS and SIC system. The conversion weights included in the Import Matrix should enable researchers to use the index in both NAICS and SIC industry-based research of international trade. However, in future work I do plan to extend the Import Index to include market classification and weights for the manufacturing import on SIC-basis by utilizing the 1992 input-output tables and intend to compare the results to the ones currently derived from NAICS data.

A.4.3. BEA Imports vs. HTS Imports

I compare the HTS imports provided by the U.S. Census Bureau and available in the 1997 NBER imports data with the import figures reported in the BEA import-matrix. I find that when aggregating the HTS imports up to the BEA I/O codes level of aggregation using the BEA concordance file, the aggregated HTS imports can be considerably different from the imports figures reported in the BEA import matrix. The difference between the imports estimated by BEA and actual imports reported in the 1997 NBER imports data does not exceed 10% of the value of the latter for 81% of the six-digit I/O commodities, with 77.3% of these imports being overestimated by the BEA. For 11% of the six-digit I/O commodities, the difference constitutes between 10% and 20% of value of imports from the NBER data, of which 66% are overestimated by the BEA. For 5% of the six-digit I/O commodities, the differences are between 20 and 50% of the value of imports from the NBER data, with 77% overestimated by the BEA. Lastly, the difference of the remaining commodities exceed 50% of the import values, with 75% overestimated by the BEA. In total, however, the BEA overestimates imports for the manufacturing sector only by 4% of the value of the NBER import data. These differences between import levels of the import-matrix and the HTS imports may lead some to argue hat the import-matrix should not be used for the purposes of constructing the Import Index, if the differences result in differences in the market structure and relative importance weights. I examine the causes of these differences and potential consequences for the market structure below.

These differences in the data may be attributed to a number of different sources, all stemming from the methods by which the BEA tabulates U.S. Census Bureau import data. The primary source for the BEA import-matrix estimates of trade in goods and services is the International Transactions Accounts (ITAs), which are prepared by the BEA's Balance of Payments Division (BP division) (U.S. Department of Commerce 1990). The BP division uses the HTS imports data provided by the U.S. census to classify import data in broad commodity categories based on the concept of end-use demand. This end-use commodity classification system was developed to make it easier to relate changes in merchandise trade to production and income data. Additionally, the U.S. Census Bureau import data are retabulated to correct for time discrepancies, which arise when exports or imports of goods are reported by the Census Bureau in one period, but are actually shipped or received in another. Then, the BEA adjusts the data for coverage and valuation to bring them into conformity with the BP concepts and for seasonal variation. The seasonally adjusted and tabulated import data on the end-use basis are then incorporated into the BEA input-output and import-matrix accounts by mapping the end-use codes to the BEA I/O codes (U.S. Department of Commerce 1990). Any stage of this process may result in the BEA import-matrix imports figures deviating from the raw U.S. Census Bureau HTS data I use in my import-index classification.

However, given the nature of construction of the import-matrix, where the output of each commodity in the input-output tables is multiplied by the import ratio of the commodity in total domestic supply of the commodity, one should not see differences in the market structure and market relative importance weights for the commodity from those of the input-output tables (U.S. Department of Commerce 2006). When comparing the input-output tables with the import-matrix, indeed, I see that the market structure and the relative importance weights parallel each other, with only small differences for some of the commodities. Since all that I derive from the import matrix is the market composition and weights, expressed as shares, I do not worry about the differences between the import levels of the import-matrix and the HTS data.

A.5. Conclusion

The Market Structure Index of HTS Imports is to date the most complete classification of imports by their end-use demand, i.e. intermediate and final demand. The Imports Index spans manufacturing imports for the period of 1989 to 2004 and can be easily extended to more recent years, adjusting for changes in the HTS as reported by the US Trade Commission on their website. The Index is highly reliable, as the market groups are assigned strictly according to the ten-digit HTS imports descriptions, that specify the imports physical characteristics and stage of processing and/or the related industries that the imports serve. Additionally, the market classification in the Imports Index was cross-referenced against official government sources of market classifications of commodities and industries at highly disaggregated levels. The most notable sources are the 1997 BEA import-matrix, the BLS commodity-based stage-of-processing classification, the FRB's Market Structure Index of Industrial Production, and the BEA's End-Use classification of imports.

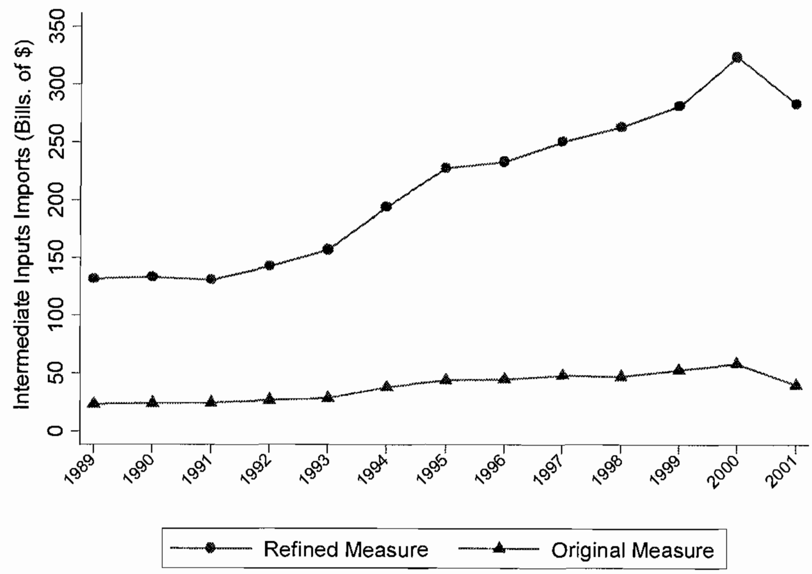
The documentation provided in this appendix should be considered a working document to be used in conjunction with the Imports Index. Over time, changes will be made to the document as the Imports Index is updated, new years are added, methodology is changed, and NAICS redefinitions take place. One major revision to be expected soon is the inclusion of the SIC-based assignment of market classification and weights for Import Index's years prior to 1997 and expansion of the index to include imports in the SIC definition of the manufacturing sector.

APPENDIX B

FIGURES AND TABLES FOR CHAPTER II

Figure B.1: Comparison of New and Old Data of Trade in Intermediate Inputs

1) Imports of Intermediates (Refined) vs. "Part" and "Components" (Original)



2) Refined vs. Original Feenstra and Hanson (1996)' Measure of Imported Inputs

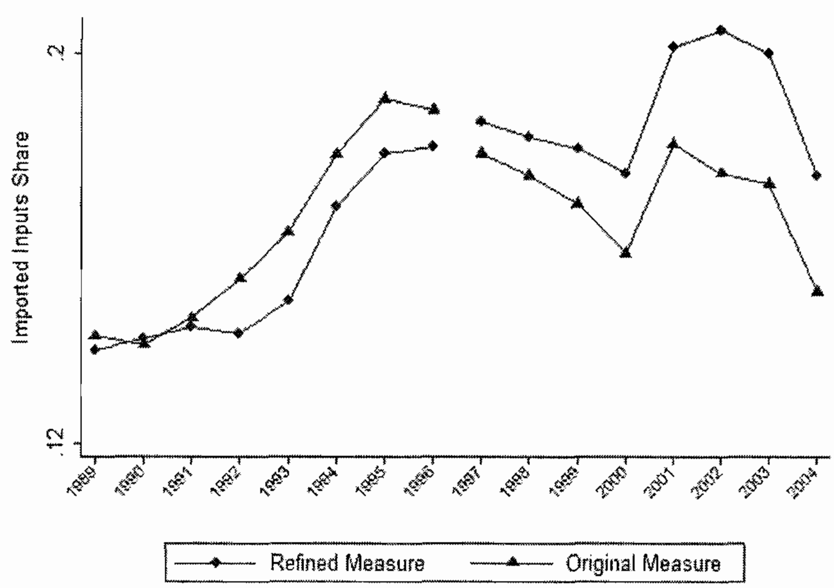


Figure B.2: U.S. Manufacturing Imports by Category, 1989-2004

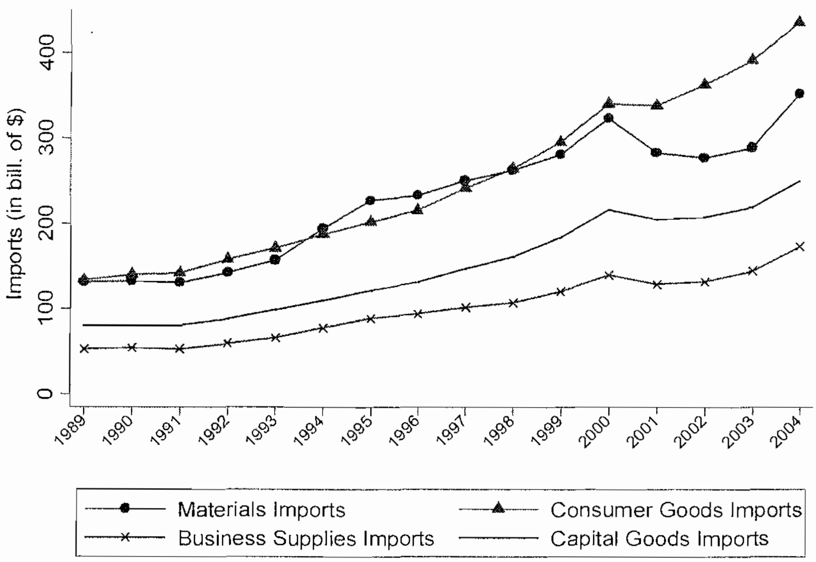


Figure B.3: U.S. Imports by 3-digit NAICS Industry, 1989-2004

Non-Durable Manufacturing

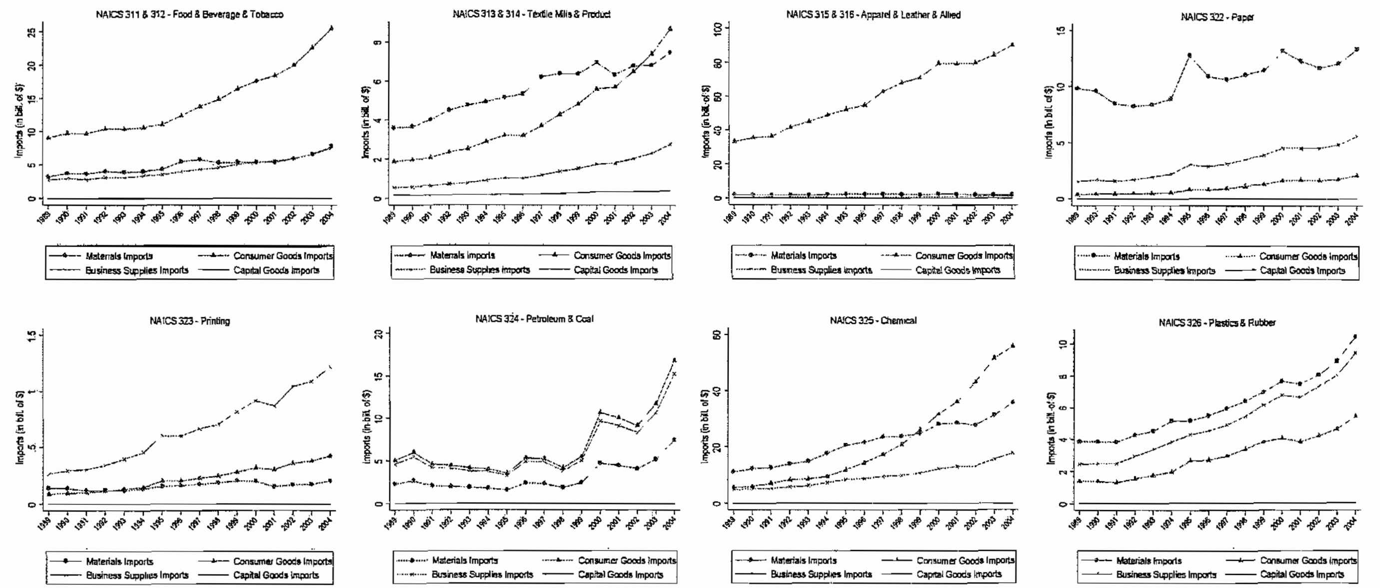


Figure B.3: U.S. Imports by 3-digit NAICS Industry, 1989-2004 (Cont.)

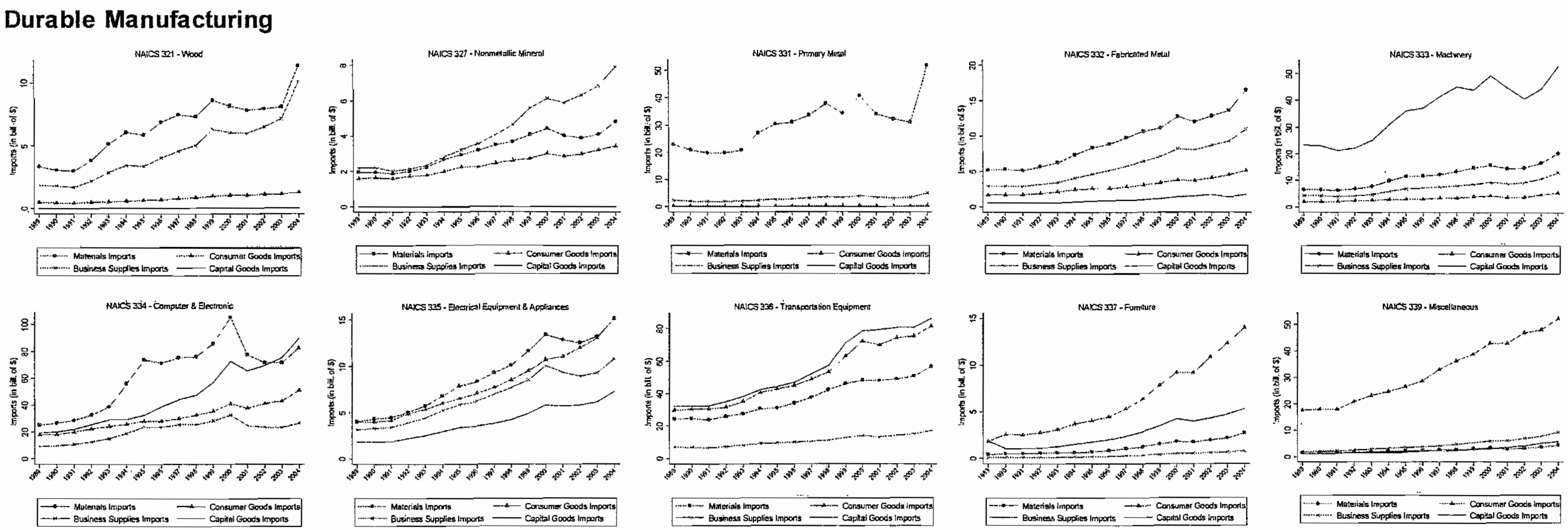


Table B.1 Breakdown of Imports by Utilization Weights, 1989-2004

U.S. Materials Imports

	Products				Volume			
Year	25%	50%	75%	100%	25%	50%	75%	100%
1989	73	63	40	16	91	84	57	25
2004	74	64	40	16	89	80	52	21

U.S. Consumer Goods Imports

	Products				Volume			
Year	25%	50%	75%	100%	25%	50%	75%	100%
1989	52	45	35	0	91	84	58	0
2004	49	42	33	0	91	85	62	1

Note: The columns show the share of products (import volumes) in total products (total import volumes) by each category, that have more than 25%, 50%, 75%, 100% utilization rate as intermediate or consumer goods.

Table B.2: U.S. Imports Relative Importance, 1989-2004

U.S. Materials Imports

Year	Volume $	Volume % Δ	Volume Sh^M	Volume Sh^Y	Products #	Products % Δ	Products Sh^M
1989	131.7	7.2	33.0	4.8	8497	1.5	71.2
2004	351.9	7.2	29.1	8.4	10615	1.5	73.9

U.S. Consumer Goods Imports

Year	Volume $	Volume % Δ	Volume Sh^M	Volume Sh^Y	Products #	Products % Δ	Products Sh^M
1989	133.7	8.3	33.5	4.9	9921	1.2	83.1
2004	435.2	8.3	35.9	10.3	11792	1.2	82.1

U.S. Total Imports

Year	Volume $	Volume % Δ	Volume Sh^Y	Products #	Products % Δ
1989	399.1	7.9	14.6	11932	1.3
2004	1210.8	7.9	28.8	14366	1.3

Note: Imports are expressed in billions of U.S. dollars. The % Δ refers to average annual growth. The Sh^M refers to import share in total manufacturing imports and Sh^Y refers to import share in total manufacturing output. # refers to the number of distinct import products.

Table B.3: U.S. Top 10 Industry Imports

U.S. Materials Imports

1989				2004			
NAICS	Description	Sh^M	Sh^Y	NAICS	Description	Sh^M	Sh^Y
334	Computer & electronics	19	10	334	Computer & electronics	24	23
336	Transportation equipment	18	6	336	Transportation equipment	16	9
331	Primary metals	17	16	331	Primary metals	15	30
325	Chemical products	8	4	325	Chemical products	10	7
322	Paper products	7	8	333	Machinery	6	8
333	Machinery	5	4	332	Fabricated metal products	5	7
332	Fabricated metal products	4	3	335	Elec. eq., appl., & compnts	4	15
335	Elec. eq., appl., & compnts	3	5	322	Paper products	4	9
326	Plastics & rubber products	3	4	321	Wood products	3	11
313	Textile mills & products	3	5	326	Plastics & rubber products	3	6

U.S. Consumer Goods Imports

1989				2004			
NAICS	Description	Sh^M	Sh^Y	NAICS	Description	Sh^M	Sh^Y
315	Apparel, leather & allied	25	50	315	Apparel, leather & allied	21	258
336	Transportation equipment	22	7	336	Transportation equipment	19	12
334	Computer & electronics	13	7	325	Chemical products	13	11
339	Miscellaneous	13	26	339	Miscellaneous	12	39
311	Food, beverage & tobacco	7	2	334	Computer & electronics	12	14
325	Chemical products	4	2	311	Food, beverage & tobacco	6	4
324	Petroleum & coal products	4	4	324	Petroleum & coal products	4	5
335	Elec. eq., appl., & compnts	3	5	335	Elec. eq., appl., & compnts	3	15
333	Machinery	2	1	337	Furniture & related prod.	3	18
313	Textile mills & products	1	3	313	Textile mills & products	2	12

Note: Sh^M refers to materials/consumer goods import share in total materials/consumer goods imports and Sh^Y refers to materials/consumer goods import share in industry output.

Table B.4: Pro-Cyclical Behavior of U.S. Imports

Correlations

	Δ Materials Imports	Δ Consumer Imports
Δ Output	0.48	0.20
Δ GDP	0.26	0.35

Dependent Variable: Δ Ln (Imports)

	I	II
Δ Ln (Output)	0.127***	
	[0.031]	
X Materials Dummy	0.071***	
	[0.039]	
Δ Ln (GDP)		0.054***
		[0.007]
X Materials Dummy		0.000
		[0.009]
Observations	540	540
Number of Years	15	15
Number of Industries	18	18
R-squared	0.11	0.20

Note: Standard errors are given in parenthesis. Dependent variable is first-difference of natural log of U.S. imports of intermediate inputs and consumer goods. Sample data contain U.S. imports from three-digit NAICS industries for 1990-2004. Imports are deflated by CPI. GDP and Output are measured in chained 2000 dollars.

Table B.5: List of Sample Countries

ASEAN	SWEDEN	EAST GERMANY	LITHUANIA	SOUTH YEMEN
BRUNEI & BHUTAN	SWITZERLAND	ECUADOR	MACEDONIA	SRI LANKA
CAMBODIA	U.K.	EGYPT	MADAGASCAR	ST. KITTS-NEVIS
INDONESIA		EL SALVADOR	MALAWI	ST. PIERRE & MIQ.
SOUTH KOREA	**OTHER**	EQUATORIAL GUIN	MALI	SUDAN
LAOS	AFGANISTAN	ESTONIA	MALTA	SURINAME
MALAYSIA	ALBANIA	ETHIOPIA	MAURITANIA	SYRIA
MYANMAR	ALGERIA	FALKLAND ISLS.	MAURITIUS	TAJIKISTAN
PHILIPPINES	ANGOLA	FIJI	MONGOLA	TANZANIA
SINGAPORE	ARGENTINA	FORM. YUGOSLAV.	MOROCCO	TOGO
THAILAND	ARMENIA	FRENCH GUIANA	MOZAMBIQUE	TRINIDAD & TOB.
VIETNAM	ARUBA & N. ANT.	GABON	NEPAL	TUNISIA
CANADA	AZERBAIJAN	GAMBIA	NEW CALEDONIA	TURKEY
	BAHAMAS	GEORGIA	NICARAGUA	TURKMENISTAN
CHINA	BAHRAIN	GHANA	NIGER	U S OUTL. ISLS.
CHINA (MAINLAND)	BANGLADESH	GIBRALTAR	NIGERIA	UGANDA
HONG KONG	BARBADOS	GREENLAND	NORTH KOREA	UKRAINE
MACAU	BELARUS	GUADELOUPE	OMAN	U. A. EMIRATES
TAIWAN	BELIZE	GUATEMALA	PAKISTAN	URUGUAY
JAPAN	BENIN	GUINEA	PANAMA	USSR
	BERMUDA	GUINEA-BISSAU	P. N.GUINEA	UZBEKIST
MEXICO	BOLIVIA	GUYANA	PARAGUAY	VENEZUELA
	BOSNIA-HERZEG.	HAITI	PERU	YEMEN ARAB REP.
OECD	BRAZIL	HONDURAS	POLAND	ZAIRE
AUSTRAL	BULGARIA	HUNGARY	PUERTO RICO	ZAMBIA
AUSTRIA	BURKINA	INDIA	QATAR	ZIMBABWE
BELGIUM	BURUNDI	IRAN	R. OF MOLDOVA	
DENMARK	CAMEROON	IRAQ	REUNION	
FINLAND	C. AFRIC. REP.	ISRAEL	ROMANIA	
FRANCE	CHAD	IVORY COAST	RUSSIA	
GERMAN	CHILE	JAMAICA	RWANDA	
GREECE	COLOMBIA	JORDON	SAMOA	
ICELAND	CONGO	KAZAKHSTAN	SAUDI ARABIA	
IRELAND	COSTA RICA	KENYA	SENEGAL	
ITALY	CROATIA	KIRIBATI	SERBIA & MONT.	
LUXEMBURG	CUBA	KUWAIT	SEYCHELLES	
NETHERLANDS	CYPRUS	KYRGYZSTAN	SIERRA LEONE	
NEW ZEALAND	CZECH REPUBLIC	LATVIA	SLOVAKIA	
NORWAY	CZECHOSLOVAKIA	LEBANON	SLOVENIA	
PORTUGAL	DJIBOUTI	LIBERIA	SOMALIA	
SPAIN	DOMINICAN REP.	LIBYA	SOUTH AFRICA	

Table B.6: U.S. Import Value Market Share by Region, 1989-2004

	Canada		CHINA		Japan		Mexico		ASEAN		OECD		OTHER	
U.S. Materials Imports														
Industry	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004
Chemicals (325)	21	24	3	6	13	9	4	5	2	5	48	38	9	13
Machinery (333)	11	10	3	7	28	23	3	12	3	3	45	39	6	7
Comp. & Elec. (334)	7	5	12	30	35	11	7	11	27	30	10	9	2	3
Electric. Equip. (335)	11	9	11	17	28	12	19	32	5	6	22	20	4	4
Transp. Equip. (336)	32	25	2	5	27	18	10	24	2	3	25	22	2	4
Nondurable Manuf.	35	31	5	9	8	6	3	5	6	6	29	28	14	15
Durable Manuf.	23	18	6	16	24	11	7	14	9	12	23	18	7	12
Total Manuf.	26	21	6	14	19	10	6	12	8	10	25	20	9	13
U.S. Consumer Goods Imports	Canada		CHINA		Japan		Mexico		ASEAN		OECD		OTHER	
Industry	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004
Chemicals (325)	9	7	2	2	14	6	2	2	1	2	63	76	9	5
Machinery (333)	10	6	7	33	43	22	4	11	8	7	25	18	4	2
Comp. & Elec. (334)	3	1	15	37	43	12	11	19	22	21	5	8	0	1
Electric. Equip. (335)	5	6	36	50	16	4	8	15	15	9	17	12	3	2
Transp. Equip. (336)	28	28	2	3	43	26	3	10	4	7	20	25	1	2
Nondurable Manuf.	5	8	26	21	3	2	3	6	19	10	23	32	21	22
Durable Manuf.	13	12	15	28	33	14	5	10	11	11	18	17	5	8
Total Manuf.	10	10	20	25	20	8	4	8	14	10	20	24	12	14

Note: Figures express import shares of each country/region in total U.S. imports by the specified industry and year. Rows add up to 100 per year. CHINA refers to mainland China, Hong Kong, Taiwan, and Macao. The six country groupings are mutually exclusive.

Table B.7: Largest Gains in Market Share, 1989-2004

U.S. Materials Imports					U.S. Consumer Goods Imports				
Country	Market Share		Abs. Δ	% Δ	Country	Market Share		Abs. Δ	% Δ
	1989	2004				1989	2004		
China	1.01	10.27	9.26	919	China	5.88	21.18	15.30	260
Mexico	6.04	11.70	5.66	94	Mexico	4.26	8.27	4.01	94
Russia	0.00	1.65	1.65	N/A	Ireland	0.41	3.94	3.53	866
Malaysia	1.47	2.86	1.39	94	Germany	4.12	5.09	0.97	24
Ireland	0.33	1.13	0.80	247	Vietnam	0.00	0.88	0.88	N/A
India	0.39	0.85	0.46	119	Israel	1.29	1.98	0.68	53
Thailand	0.65	1.10	0.45	70	Indonesia	0.68	1.26	0.58	85
S. Korea	3.21	3.56	0.35	11	Honduras	0.09	0.66	0.57	637
Philippines	0.65	0.99	0.34	53	U.K	2.66	3.21	0.55	21
Peru	0.21	0.54	0.33	158	India	1.65	2.15	0.51	31

Note: Here China refers to only mainland China. Percentage changes are not available if a country's share of U.S. imports in 1989 was zero.

Table B.8: Product Penetration by Region, 1989-2004

U.S. Materials Imports

Industry	Canada 1989	Canada 2004	CHINA 1989	CHINA 2004	Japan 1989	Japan 2004	Mexico 1989	Mexico 2004	ASEAN 1989	ASEAN 2004	OECD 1989	OECD 2004	OTHER 1989	OTHER 2004
Chemicals (325)	60	56	35	74	74	65	31	36	23	39	97	93	45	69
Machinery (333)	94	94	79	89	95	93	59	74	66	82	99	99	66	87
Comp. & Elec. (334)	78	75	94	95	94	90	68	72	86	86	97	94	65	75
Electric. Equip. (335)	83	85	89	95	94	88	69	77	78	85	99	97	64	81
Transp. Equip. (336)	92	91	79	91	86	88	68	75	66	80	98	97	59	84
Nondurable Manuf.	59	60	46	66	59	49	30	41	39	49	93	89	49	69
Durable Manuf.	85	83	73	86	85	78	56	65	65	73	96	95	59	78
Total Manuf.	70	69	57	75	70	61	41	51	50	60	94	92	54	73

U.S. Consumer Goods Imports

Industry	Canada 1989	Canada 2004	CHINA 1989	CHINA 2004	Japan 1989	Japan 2004	Mexico 1989	Mexico 2004	ASEAN 1989	ASEAN 2004	OECD 1989	OECD 2004	OTHER 1989	OTHER 2004
Chemicals (325)	59	55	35	74	73	64	30	35	23	37	96	93	47	69
Machinery (333)	91	92	79	92	93	87	50	64	62	74	98	99	60	82
Comp. & Elec. (334)	65	68	89	93	87	86	51	62	76	79	97	96	56	73
Electric. Equip. (335)	85	86	91	97	95	87	70	78	82	90	99	98	65	83
Transp. Equip. (336)	85	84	72	76	82	81	60	60	63	72	100	98	59	75
Nondurable Manuf.	58	62	60	74	55	48	32	46	51	58	92	90	55	74
Durable Manuf.	80	81	82	90	84	76	56	65	71	77	96	96	63	80
Total Manuf.	66	68	67	80	65	58	40	53	58	65	93	92	58	76

Note: Figures express import product shares of each country/region in total U.S. import products by the specified industry and year. A product is included in the share if it is imported in the U.S. by at least one country in the region. CHINA refers to mainland China, Hong Kong, Taiwan, and Macao. The six country groupings are mutually exclusive.

Table B.9: Largest Gains in Product Penetration by Country, 1989-2004

U.S. Materials Imports					U.S. Consumer Goods Imports				
Country	Market Share		Abs. Δ	% Δ	Country	Market Share		Abs. Δ	% Δ
	1989	2004				1989	2004		
China	34	70	37	108	China	45	76	32	71
Mexico	19	44	24	127	Mexico	22	49	26	116
Russia	6	20	14	223	Ireland	10	25	15	141
Malaysia	8	20	12	143	Germany	14	27	13	94
Ireland	17	28	12	69	Vietnam	6	19	13	212
India	6	17	11	175	Israel	24	36	13	53
Thailand	41	51	10	25	Indonesia	40	53	12	31
S. Korea	7	17	10	129	Honduras	7	20	12	164
Philippines	11	21	9	83	U.K	33	44	11	34
Peru	31	40	9	30	India	15	23	8	56

Note: Here China refers only to mainland China.

Table B.10: Decomposed Import Growth by Region, 1989-2004

U.S. Materials Imports

Industry	Canada Int.	Canada Ext.	CHINA Int.	CHINA Ext.	Japan Int.	Japan Ext.	Mexico Int.	Mexico Ext.	ASEAN Int.	ASEAN Ext.	OECD Int.	OECD Ext.	OTHER Int.	OTHER Ext.
Chemicals (325)	65	35	46	54	65	35	75	25	42	58	61	39	61	39
Machinery (333)	60	40	52	48	74	26	62	38	37	63	70	30	74	26
Comp. & Elec. (334)	13	87	14	86	253	-153	24	76	7	93	25	75	27	73
Electric. Equip. (335)	56	44	46	54	27	73	47	53	42	58	44	56	61	39
Transp. Equip. (336)	34	66	57	43	65	35	60	40	67	33	69	31	67	33
Nondurable Manuf.	48	52	60	40	63	37	52	48	39	61	52	48	45	55
Durable Manuf.	59	41	36	64	83	17	52	48	16	84	61	39	62	38
Total Manuf.	55	45	39	61	78	22	52	48	19	81	58	42	57	43

U.S. Consumer Goods Imports

Industry	Canada Int.	Canada Ext.	CHINA Int.	CHINA Ext.	Japan Int.	Japan Ext.	Mexico Int.	Mexico Ext.	ASEAN Int.	ASEAN Ext.	OECD Int.	OECD Ext.	OTHER Int.	OTHER Ext.
Chemicals (325)	43	57	58	42	34	66	28	72	55	45	21	79	27	73
Machinery (333)	84	16	25	75	63	37	35	65	32	68	75	25	57	43
Comp. & Elec. (334)	11880	-11780	37	63	17	83	13	87	27	73	83	17	38	62
Electric. Equip. (335)	88	12	84	16	376	-276	93	7	60	40	80	20	72	28
Transp. Equip. (336)	96	4	67	33	98	2	91	9	71	29	99	1	92	8
Nondurable Manuf.	46	54	74	26	33	67	73	27	74	26	26	74	66	34
Durable Manuf.	93	7	59	41	114	-14	56	44	56	44	91	9	95	5
Total Manuf.	73	27	64	36	86	14	62	38	63	37	47	53	77	23

Note: Figures express shares of U.S. imports growth attributable to intensive or extensive margin by the specified source country/region, industry, and year.CHINA refers to mainland China, Hong Kong, Taiwan, and Macao. The six country groupings are mutually exclusive.

Table B.11: Product Shares by Source Country Income Levels, 1989-2004

U.S. Materials Imports

Income Breakdown	H		M		L		LMH		MH		LM	
	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004
World Bank	22	15	1	1	0	0	29	50	48	33	0	0
World Bank*	22	15	1	1	0	0	10	17	48	33	0	0
$L<40^{th}, 40^{th}\leq M<60^{th}, 60^{th}\leq H$	34	30	0	0	0	0	38	55	27	14	0	0
$L<40^{th}, 40^{th}\leq M<60^{th}, 60^{th}\leq H$*	34	30	0	0	0	0	18	25	27	14	0	0
$L<30^{th}, 30^{th}\leq M<70^{th}, 70^{th}\leq H$	28	21	1	1	0	0	31	50	41	28	0	0
$L<30^{th}, 30^{th}\leq M<70^{th}, 70^{th}\leq H$*	28	21	1	1	0	0	11	16	41	28	0	0
$L<30^{th}, 30^{th}\leq M<90^{th}, 90^{th}\leq H$	6	7	3	4	0	0	30	49	60	39	1	1
$L<30^{th}, 30^{th}\leq M<90^{th}, 90^{th}\leq H$*	6	7	3	4	0	0	11	16	60	39	1	1
$L<20^{th}, 20^{th}\leq M<80^{th}, 80^{th}\leq H$	18	15	2	2	0	0	7	9	73	74	0	0
$L<20^{th}, 20^{th}\leq M<80^{th}, 80^{th}\leq H$*	18	15	2	2	0	0	1	2	73	74	0	0

U.S. Consumer Goods Imports

Income Breakdown	H		M		L		LMH		MH		LM	
	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004	1989	2004
WDB Breakdown	20	13	1	1	0	0	36	57	43	28	0	0
WDB Breakdown*	20	13	1	1	0	0	16	27	43	28	0	0
$L<40^{th}, 40^{th}\leq M<60^{th}, 60^{th}\leq H$	31	25	0	0	0	1	46	62	23	12	0	0
$L<40^{th}, 40^{th}\leq M<60^{th}, 60^{th}\leq H$*	31	25	0	0	0	1	25	35	23	12	0	0
$L<30^{th}, 30^{th}\leq M<70^{th}, 70^{th}\leq H$	26	18	1	1	0	0	37	57	36	24	0	0
$L<30^{th}, 30^{th}\leq M<70^{th}, 70^{th}\leq H$*	26	18	1	1	0	0	17	27	36	24	0	0
$L<30^{th}, 30^{th}\leq M<90^{th}, 90^{th}\leq H$	5	5	5	4	0	0	36	56	53	33	1	2
$L<30^{th}, 30^{th}\leq M<90^{th}, 90^{th}\leq H$*	5	5	5	4	0	0	17	26	53	33	1	2
$L<20^{th}, 20^{th}\leq M<80^{th}, 80^{th}\leq H$	16	13	2	2	0	0	12	17	70	68	0	0
$L<20^{th}, 20^{th}\leq M<80^{th}, 80^{th}\leq H$*	16	13	2	2	0	0	4	8	70	68	0	0

Note: Figures express import product shares by countries grouped into income levels. The income level breakdown follows the one indicated in the first column, where number refer to percentiles and H – high income, M-middle income, L -low income countries. LMH products originate simultaneously from at least one low- or one high-income countries. MH products originate from at least one middle- and one high-income countries. LM products originate from at least one low-income and one middle-income countries. The six source country groupings are mutually exclusive. * refers to an extra restriction in the construction of LMH products, where products which originate from only one low-income country are dropped.

Table B.12: Regression of Unit Values on Income, 1989-2004

Dependent Variable: Log(Unit Values)

	All I	25% II	50% III	75% IV	LMH V
Total Manufacturing					
Log(Real GDPpc)	0.171***	0.189***	0.191***	0.186***	0.170***
	[0.032]	[0.035]	[0.036]	[0.034]	[0.032]
Obs.	1628940	1203789	1003836	650399	1535165
Num. Of Products	14082	10533	9123	5625	10727
R-squared	0.08	0.08	0.08	0.10	0.08
Non-Durable Manufacturing					
Log(Real GDPpc)	0.171***	0.157***	0.123***	0.124***	0.169***
	[0.027]	[0.027]	[0.031]	[0.032]	[0.026]
X Consumer Dummy	0.002***	0.019***	0.071***	0.061***	0.002***
	[0.000]	[0.007]	[0.022]	[0.021]	[0.000]
Obs.	2300591	1558263	1413440	1098902	2184750
Num. Of Products	12410	12196	11241	7795	9624
R-squared	0.10	0.12	0.14	0.19	0.11
Durable Manufacturing					
Log(Real GDPpc)	0.170***	0.163***	0.143***	0.144***	0.170***
	[0.041]	[0.044]	[0.047]	[0.049]	[0.042]
X Consumer Dummy	0.000*	0.016	0.044*	0.029	0.000*
	[0.000]	[0.011]	[0.026]	[0.035]	[0.000]
Obs.	1575327	887844	699630	466340	1518529
Num. Of Products	6872	6020	4961	3478	5667
R-squared	0.10	0.10	0.11	0.11	0.11

Units of observation are product-country-year. Unit Values data comes from Feenstra (2002) and U.S. Census Bureau (2004), real per capita GDP are from WDI (2007), Consumer dummy takes a value of 1 if a product is a consumer goods, and zero otherwise. Each regression includes product and year fixed effects, as well as regional dummies (see Table B.5 for description of regional breakdown). Columns II-IV restrict the sample to only those products that have more than 25%, 50%, 75% use, respectively, as intermediates or consumer goods. Column V restricts the sample to only those products that are sourced simultaneously from one low- and one high income country, where income breakdown follows World Bank classification. Robust standard errors adjusted for source country clustering are noted below coefficients. Results for fixed effects and constant are suppressed. ***, **, and * refer to statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Table B.13: Regression of Unit Values on Income by Select Industries, 1989-2004

Dependent Variable: Log(Unit Values)

	All I	25% II	50% III	75% IV	LMH V
Chemicals Manufacturing					
Log(Real GDPpc)	0.235***	0.239***	0.237***	0.209***	0.235***
	[0.041]	[0.044]	[0.045]	[0.044]	[0.040]
X Consumer Dummy	-0.000*	-0.006	0.046*	0.054*	-0.000*
	[0.000]	[0.019]	[0.024]	[0.033]	[0.000]
Machinery Manufacturing					
Log(Real GDPpc)	0.174***	0.148**	0.168***	0.217***	0.176***
	[0.062]	[0.057]	[0.063]	[0.078]	[0.062]
X Consumer Dummy	0.000	0.052	0.040	-0.268***	0.000
	[0.000]	[0.072]	[0.091]	[0.099]	[0.000]
Computers and Electronics Manufacturing					
Log(Real GDPpc)	0.146***	0.156***	0.161***	0.158***	0.146***
	[0.042]	[0.054]	[0.055]	[0.055]	[0.042]
X Consumer Dummy	0.000	-0.025	-0.039	-0.036	0.000
	[0.000]	[0.044]	[0.047]	[0.049]	[0.000]
Electrical Equip./Appliances Manufacturing					
Log(Real GDPpc)	0.139**	0.150**	0.147**	0.199**	0.139**
	[0.061]	[0.064]	[0.065]	[0.091]	[0.061]
X Consumer Dummy	0.000	-0.002	-0.007	-0.099	0.000
	[0.000]	[0.003]	[0.041]	[0.075]	[0.000]
Transportation Equipment Manufacturing					
Log(Real GDPpc)	0.172***	0.148**	0.147**	0.146***	0.175***
	[0.060]	[0.060]	[0.060]	[0.038]	[0.061]
X Consumer Dummy	0.000	0.077	0.086*	0.116**	0.000
	[0.000]	[0.047]	[0.049]	[0.045]	[0.000]

Units of observation are product-country-year. Unit Values data comes from Feenstra (2002) and U.S. Census Bureau (2004), real per capita GDP are from WDI (2007), Consumer dummy takes a value of 1 if a product is a consumer goods, and zero otherwise. Each regression includes product and year fixed effects, as well as regional dummies (see Table B.5 for description of regional breakdown). Columns II-IV restrict the sample to only those products that have more than 25%, 50%, 75% use, respectively, as intermediates or consumer goods. Column V restricts the sample to only those products that are sourced simultaneously from one low- and one high income country, where income breakdown follows World Bank classification. Robust standard errors adjusted for source country clustering are noted below coefficients. Results for fixed effects and constant are suppressed. ***, **, and * refer to statistical significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

APPENDIX C

DATA APPENDIX TO CHAPTER III

C.1. Productivity Database Extension

Most of the data used in construction of the non-structural variables are obtained from the NBER Productivity Database (PD). The NBER PD extends as far as 1996 on 1987 SIC basis and incorporates data on shipments, employments, materials, inventory, energy, investment, capital stock, deflators, and TFP measures for 458 industries. Since my analysis goes as far as 2004, I extend the NBER PD following the methodology outlined in Bartelsman and Grey (1996). I describe the construction of each of the variables of the PD extension and the data issues encountered on the way below. The final PD extension spans 1997-2005 and in addition to the NBER PD variables, includes two versions of output price deflators, cost of selected services, and services deflators for 473 six-digit NAICS industries.

C.1.1 Industry Statistics

Data on shipments, employment, materials, inventory, energy, and investment come from the Annual Survey of Manufacturers, which are currently available for 1997-2005 and can be downloaded from the Census website. I have identified two issues with the ASM data. First, while the industries in the1997-2001 ASM data follow six-digit NAICS, the industries in the 2002-2005 data follow NAICS-based code which aggregates some six-digit NAICS industries into two to five grouped Census-defined industry code. In order to break down the Census-code industries data into data for each of the embedded six-digit NAICS industries, I aggregate the data from 2001 ASM into the corresponding Census code industries. Then, for each industry statistic of six-digit NAICS industries in 2001, I calculate its share in the respective aggregated industry statistic of the corresponding Census-code industry of 2001. These shares are then used to impute the six-digit NAICS industry data from the Census-code industry data in 2002-2005. Since energy data is available as total energy, fuel and electricity purchases, I first break down fuel and electricity and then aggregate these to create the broken down total energy purchases. The break-down method for investment, which is subdivided into structures and equipment investment, is slightly different. I first used the method described above to obtain total investment for the six-digit NAICS industries. The broken down structures and equipment investment are constructed by applying the shares of equipment and structures of the corresponding Census-code industry in its total investment for 2002-2005 to the broken down total investment for the six-digit NAICS industries within the Census-code. Thus, I assume that the six-digit NAICS industries embedded in the Census-code industry invest in structures and equipment in the same proportions as the overarching Census-code industry. I justify this method by noting that since investment in structures and equipment takes place in discrete amounts, one cannot assume that proportions of 2001 will hold up during 2002-2005.

The second issue is similar to the one experienced by Bartelsman and Gray (1996), where some industries in the ASM data have missing information due to the disclosure reasons. I were able to approach the issue in two ways. For some missing observations of six-digit NAICS industries, I were able to subtract the existing data for other six-digit NAICS from the data of the overarching five-digit NAICS industries. If data for five-digit NAICS were not disclosed, I used the same method to first obtain the missing five-digit NAICS data from the overarching four-digit NAICS data. This method took care of all the missing observations but the ones due to energy and investment, where multiple industries within a five-digit NAICS would have missing information. I remedied this issue by first obtaining the aggregated data for the multiple industries with missing observations by the method of subtraction the existing data of six-digit NAICS from five-digit NAICS. Then the aggregated data was broken down for total energy, fuel, and electricity, by the average shares of these variables in the aggregated data of the nearby years, for which full data was available. The aggregated data for investment, equipment, and structures, was broken down by the share of the aggregated equipment and structures in the aggregated total investment of the same years. Once again, I did not use the data from the nearby years for the investment variables, since investment of one year does not have to follow the investment patterns of the previous year.

C.1.2 Shipment Price Deflators

In the NBER PD, output price deflators data come from the BEA shipments price deflator data. While the BEA produces the shipment price deflators for 1997-2005, the data come with a disclaimer about the lack of precision in the data. This is true because the BEA basis its shipment price deflator data on the BLS producer price index data for each six-digit NAICS industry, where 130 observations are missing for some industries and years. Since the changes in product prices are integral to the two-stage estimation, upon consulting the BLS, I construct my own output price deflators from the producer price indexes. I replace the missing observations with the related commodity price indexes or converting the existing SIC indexes into NAICS. While the differences between my deflators and BEA deflators is notable, the TFP calculations using each of the deflators yield near identical values. The PD extension includes my version of the output price deflators as the default prices, and the BEA shipment price deflators as alternative prices.

C.1.3 Materials Deflators

Materials deflators are constructed for each industry as the sum of materials supplying industry PPI's weighted by the share of material purchases from that supplying industry in total material purchased of the purchasing industry. The weights are obtained from the 1997 input-output tables, since this the only benchmark input-output table available to date. The 2002 benchmark input-output tables have been released as of the writing of this dissertation. The six-digit NAICS materials include materials from manufacturing and non-manufacturing sectors, where the latter includes agriculture, logging, mining and utilities. The BLS does not post PPI's for the agriculture industry. Having consulted the BLS staff, I average out the price indices of the commodities produced by each six-digit NAICS agriculture industry. While the BLS staff had provided us with the BLS commodity code – NAICS mapping, the concordance does not contain relative importance weights for multiple commodity codes mapped in the one NAICS industry. As the result, the constructed agricultural PPI's are the equally weighted average of commodity price indexes, provided by the BLS. There were a number of six-digit NAICS, for which some commodities had missing price indexes either partially or entirely[59]. A small number of NAICS had no commodity price index data, which I excluded from the material deflator calculations[60]. One drawback of the material deflator construction method described above, which is outlined in Bartelsman and Grey (1996), is that the PPI data does not contain changes in the shipment and retail margin prices. This implies that the materials deflator data does not reflect the actual price changes experienced by the materials purchasing industries.

C.1.4 Services Deflators

Services deflators are constructed for each industry as the sum of services supplying industry PPI's weighted by the share of services purchases from that supplying industry in total services purchases of the purchasing industry. The weights are obtained from the 1997 input-output table, since this is the only benchmark input-output table available to date. I restrict services to only those related to the information services (NAICS 5112, 518, 514); professional scientific support services (NAICS 5411-5119); and administrative and support services (NAICS 5614). PPIs are available for only a limited number of these services (5112, 518, 514, 5411, 5412, 5413, and 5418). Services deflators are not available in the NBER PD and could not be constructed for years prior to 1997.

C.1.5 Capital Stock and Investment Deflators

As described in the NBER Productivity Database, the starting point for the process of creating real capital stock series is a set of less aggregated industry capital stock estimates. I use FRB 4-digit NAICS net capital stocks as the basis for my 6-digit NAICS estimates[61]. The FRB 4-digit net capital stock data are based on 4-digit

59 These NAICS codes and their respective commodity codes are listed as follows: 111199:01220415; 111320:01110107; 111334:01110225; 111335:01190105; 111339:01110206; 114111:02230102, 02230103,02230134,02230135; 114112:02230503,02230504

60 The following NAICS do not have a commodity code mapping, which prevents us from constructing PPI data: 111160, 111136, 1114, 111910, 111930, 111991, 111998, 112111, 112130, 111234, 112420, 112511, 112512, 112519, 112910, 112920, 112930, 112990, 114119, 113110, 113220, 2213, 230320

61 I thank John Stevens of FRB for providing me with these data

investment series for plant, equipment, and software of the Annual Survey of Manufacturers, and the 1997 industry-asset type investment flow matrix, producer durable equipment deflators, and a table of mean service lives by asset type from the BEA. The 4-digit data are converted to the 6-digit level by assuming that the industry-asset type flows are the same for all 6-digit industries within a 4-digit. With this assumption in mind, I are able to use the FRB 4-digit data on real and nominal investment by asset type (structures, equipment, software) and create investment deflators, which I use to create real investment at 6-digit NAICS level. The initial 6-digit real capital stocks for 1997 are created using the ratio of 6-digit to 4-digit real (net capital) from the Annual Survey of Manufacturers. I construct the implied "depreciation" from the 4-digit capital stock and and real investment data by using $K_{it}=(1-\delta_i)\,K_{it-1}+I_{i\,t}$.. Now I can successively add real investment in equipment and structures and subtract the "depreciation" to create real net capital stocks from 1997-2005.

C.2 Non-Structural Variables

C.2.1 Factor Cost-Shares

I calculate factor cost-shares by dividing payment to each factor by the value of shipments, in nominal terms. The factor cost-share of services cannot be derived from the ASM data. I assume that six-digit NAICS industries have the same share of services costs as the over-arching four-digit NAICS. The data for the latter comes from the BLS input-output tables for 1997-2004, which are provided on four-digit NAICS levels. The services cost-shares for years prior to 1997 are obtained at three-digit SIC level from the BLS input-output table for 1989-1996.

C.2.2 Factor Prices

I proxy prices of unskilled and skilled labor by the ratio of production and nonproduction wages to the number of production and nonproduction workers employed, respectively. The price of capital is calculated by dividing the payments to capital in each industry (which equals value of shipments less payments to labor and materials) by the quantity of capital. In the specifications where services are netted out from value added prices and TFP calculations, payments to services are also netted out from the payments to capital. Materials, energy, and services price deflators are used to calculate log change in the respective prices.

C.2.3 Value-added product prices

The log change value-added product price is measured by the formula provided in the text, $\Delta \ln p_{it}^{VA} \equiv [\Delta \ln p_{it} - \frac{1}{2}(r_{it-1}+r_{it})' \Delta \ln p_{it}^{m}]$, where r_{it-1} and r_{it} are the materials cost-shares of industry i=1, ..., N, averaged over the two periods and $\Delta \ln p_{it}^{m}$ is the change in log price of intermediates. The product price data comes from the output deflator data, and the price of intermediates comes from the materials deflator data from the NBER PD and PD extension An alternative specification of value-added prices is the change in log product price net of the average cost-share weighted change in log price of intermediates and services.

C.2.4 Primal TFP

Primal total factor productivity is constructed as the difference in the growth of value added (log change) and cost-share weighted growth of primary factors (log change). The value-added is calculated as the growth in real shipments (log change) minus the average cost-share weighted growth in real materials payments (log change). In the alternative specification of TFP net of services, the growth of value-added is constructed as the growth of real shipments net of weighted growth of real materials and services payments.

C.3 Structural Variables

C.3.1 Technology

The data I use for technology variables, i.e., *office equipment share, other high-technology share,* and *computer share*, have been supplied to us by Randal Kinoshita of BLS. These data are available in 2000 constant dollars and distinguish capital by asset type for 1948-2002 on 2-digit SIC level and 1987-2005 on 3-digit NAICS level.

Berndt and Morrison (1995) define high-technology capital to include office, computing, and accounting machinery; communications equipment; science and engineering instruments; and photocopy and related equipment. This definition of high-technology capital does not incorporate computers. The data currently available to us breaks assets up slightly differently. On SIC level, the high-technology capital is broken up into the following: office, computing, and accounting machinery (asset 14) and communications equipment (asset 16) had stayed the same, while instruments category is broken up into photocopy and related equipment (asset 27); medical equipment and related (28); electromedical (29); and other medical (30). On NAICS level, the high-tech capital is broken up into the following: office and accounting machinery (asset 4); communications equipment (6), photocopying and related equipment (26); medical equipment and related equipment (27); electromedical instruments (28); nonmedical instruments (29). Similarly to Berndt and Morrison (1995), I separate high-technology capital into office equipment (SIC asset 14 and NAICS asset 4), and other high-tech capital. I also define computer capital to include SIC assets 32-42 and NAICS assets 33-43, which is not considered in Berndt and Morrison (1995).

To calculate the technology shares, I first calculate the capital services incurred from each type of high technology capital (office equipment, computer, and other high-tech capital) by summing the production of the productive stock of assets and the assets' user costs over all assets in each type of high-technology capital. I then divide the office equipment, computer, and other high-tech capital services by the total productive stock services, obtained using the same method. I use two measures of use costs, ex post and ex ante user costs. Ex post use cost (or internal rental price) is provided by BLS and are calculated as in Hall and Jorgenson (1967), and reflect the internal rate of return in each industry and capital gains on each asset. On the other hand, ex ante use cost used by Berndt and Morrison (1995) reflect a "safe" rate of return and excludes capital gains on each asset. The "safe" rate of return is measured by Moody's Baa Corporate Bond rate, which I obtain from St. Louise FRB on monthly basis and average out to get the annual rate.

A practical problem arises when capital income in national accounts (gross operating surplus) becomes negative or assets undergo a very high revaluation. In such cases, the measured rental prices using internal rate of return may also become negative, which is theoretically inconsistent. One way of eliminating such negative rental prices is to employ an external rate of return. Following Harper, Berndt and Wood (1989) I take a constant rate at 3.5%, which is the difference between nominal discount rate and inflation rates in the US as calculated by Fraumeni and Jorgenson (1980) (see Harper et al. 1989 or Erumban 2004, pg 13). Thus I substitute internal rate of return in rental price formula (13) with a 3.5. Note that the 3.5 rate of return is assumed to be a real rate of return (net of capital gains).

C.3.2 Outsourcing and Import Openness

The construction of these measures of outsourcing and import openness follows the descriptions provided in Appendix A.4 and A.5. The data for the measures come from the BLS input-output tables, U.S. imports from Feenstra (2000) and the Census Bureau, and the Market Classification of HTS Imports provided in this appendix. Foreign services outsourcing is constructed using the services inputs and imports information from the BLS input-output tables. The services are limited to information; professional, scientific, and technical; and administrative and support services. The corresponding NAICS and SIC industries are provided in the Table C.1.

Table C.1: Selected Services

Services Break-Down on 2002 NAICS-basis	
Information	
Software publishers	5112
Internet and other	518[1]
Professional, scientific, and technical services	
Legal	5411
Accounting, tax preparation, bookkeeping, & payroll	5412
Architectural, engineering, & related	5413
Specialized design	5414
Computer systems design & related	5415
Management, scientific, & technical consulting	5416
Scientific research & development	5417
Advertising	5418
Other professional, scientific, & technical	5419
Administrative and support	
Business support services	5614
Services Break-Down on 1987 SIC- basis	
Information; professional, scientific, and technical services; administrative and support	
Legal	81
Accounting, auditing, & related	872, 89
Engineering, architectural, & related	871
Computer, data processing, & related	737
Management & public relations	874
Research & testing	873
Advertising	731
Miscellaneous business	732, 733, 738

[1]Note, that this 2002 NAICS translates to 514 1997 NAICS

Price data found for 5112, 518, 5411, 5412, 5413, 5418 only

APPENDIX D

FIGURES AND TABLES FOR CHAPTER III

Figure D.1: U.S. Wage Inequality, 1963-2005

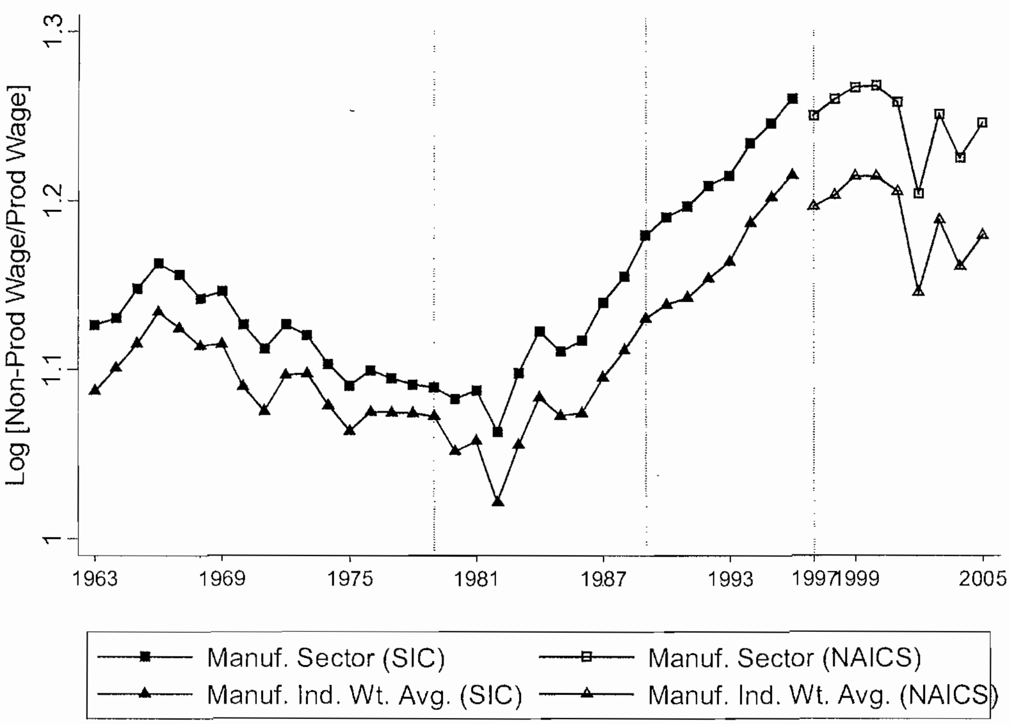


Table D.1: Summary Statistics of Non-Structural Variables

	1979 – 1990		1989 – 1996		1997-2004	
	Average (percent)	Annual change	Average (percent)	Annual change	Average (percent)	Annual change
Change in log factor prices						
Production labor		4.99		2.67		3.02
Nonproduction labor		5.42		3.78		2.76
Capital		3.98		2.91		0.27
Materials		3.29		0.88		1.66
Energy		3.31		2.00		4.55
Selected Services						2.62
Factor cost-shares:						
Production labor	13.41	-0.18	12.03	-0.17	11.44	-0.12
Nonproduction labor	10.66	0.01	10.14	-0.15	8.91	0.01
Capital	32.06	0.33	35.12	0.32	38.30	0.25
Materials	53.41	-0.06	52.95	-0.02	50.55	-0.08
Energy	2.45	-0.01	1.86	-0.02	1.83	0.03
Selected Services			2.53	0.02	4.38	0.19
Change in productivity						
Primal TFP		0.80		0.70		0.43
Primal ETFP		0.78		0.68		0.40
Change in product prices						
Value-added		1.53		0.67		0.12

Note: Both averages and changes are weighted by the industry share of total manufacturing shipments, except changes in log primary factor prices, which are weighted by the industry share of total manufacturing payments to that factor. All variables are computed over 452 four-digit SIC industries in 1979-1988 and 1989-1996 and 472 six-digit industries in 1997-2004. The data come from the NBER PD (Bartelsman and Gray 1996) and the PD extension of it for 1997-2005 based on the data from Annual Survey of Manufacturers, Federal Reserve Board, and Bureau of Labor Statistics.

Table D.2:Summary Statistics for Structural Variables

	1979-1990		1990 – 1996		1998 – 2004	
	Average (percent)	Annual change	Average (percent)	Annual change	Average (percent)	Annual change
Trade						
Materials Offshoring						
Original measure (Br)			14.98	0.52	15.73	-0.32
Original measure (Nr)			7.64	0.29	8.35	-0.19
Original measure (Br – Nr)			7.34	0.23	7.38	-0.13
Refined measure (Br)			14.56	0.46	17.54	-0.06
Refined measure (Nr)			7.68	0.23	9.71	-0.02
Refined measure (Br – Nr)			6.88	0.23	7.84	-0.04
Services Offshoring						
Selected Business Services			0.42	0.04	0.51	0.0003
Openness to Imports						
Finished Goods Imports/VA			29.89	0.87	47.16	4.61
Technology						
With Ex Post User Costs						
Computer Share	4.75	0.32	7.17	0.16	12.20	0.48
Office Equipment Share	0.83	-0.05	0.45	-0.03	0.10	-0.03
Other Hi-Tech Share	4.01	0.20	5.12	0.03	4.76	-0.11
With Ex Ante User Costs						
Computer Share	2.87	0.23	5.14	0.19	9.67	0.48
Office Equipment Share	0.48	-0.03	0.33	-0.01	0.08	-0.02
Other Hi-Tech Share	3.01	0.18	4.32	0.07	4.23	-0.08

Note: Both averages and changes are weighted by the industry share of total manufacturing shipments. All variables are computed over 453 four-digit SIC industries in 1989-1996 and 473 six-digit industries in 1997-2004. The data come from the BLS input-output tables and Ray Roshita of BLS.

Table D.3: Consistency of Data with Equation (III.4)

a) Descriptive Statistics: Mean Changes in Log Factor Prices

	1989-1996		1997-2004	
	Annualized Diff.	First Diff.	Annualized Diff.	First Diff.
Production labor	2.666	2.668	3.025	3.022
Nonproduction labor	3.839	3.784	2.769	2.758
Capital	2.900	2.771	0.418	0.274

b) Regression of $\Delta p_i^{VA} + \Delta ETFP_i$ on primary factor cost shares

	1989-1996		1997-2004	
	Annualized Diff.	First Diff.	Annualized Diff.	First Diff.
Prod. Cost Share	2.631***	2.667***	3.010***	3.032***
	[0.022]	[0.013]	[0.015]	[0.012]
Non-Prod. Cost Share	3.689***	3.644***	2.777***	2.744***
	[0.172]	[0.161]	[0.040]	[0.025]
Capital Cost Share	2.941***	2.798***	0.422***	0.275***
	[0.030]	[0.029]	[0.008]	[0.005]
Observations	458	3206	473	3311
R-squared	1.00	0.99	1.00	0.99

Note: Standard errors are in parenthesis. All regressions are weighted by the industry share of total manufacturing shipments.

Table D.3: Consistency of Data with Equation (4) (Cont.)

c) Regression of Δp_i^{VA} and $\Delta ETFP_i$ on primary factor cost shares

	1989-1996				1997-2004			
	Annualized Diff.		First Diff.		Annualized Diff.		First Diff.	
	Δp_i^{VA}	$\Delta ETFP_i$	Δp_i^{VA}	$\Delta ETFP_i$	Δp_i^{VA}	$\Delta ETFP_i$	Δp_i^{VA}	$\Delta ETFP_i$
Prod. Cost Share	11.516	-8.885	10.317**	-7.650*	4.986	-1.976	5.099*	-2.067
	[9.095]	[9.110]	[4.396]	[4.397]	[6.256]	[6.251]	[2.956]	[2.953]
Non-Prod. Cost Share	-4.037	7.725	-0.970	4.614	-2.713	5.490	-6.781*	9.525***
	[8.659]	[8.684]	[3.715]	[3.719]	[4.834]	[4.828]	[3.675]	[3.672]
Capital Cost Share	-0.482	3.423	-0.628	3.426	-0.204	0.626	0.601	-0.325
	[2.757]	[2.765]	[2.087]	[2.087]	[2.529]	[2.524]	[1.395]	[1.393]
Observations	458	458	3206	3206	473	473	3311	3311
R-squared	0.06	0.09	0.03	0.03	0.02	0.03	0.01	0.01

Note: Standard errors are in parenthesis. All regressions are weighted by the industry share of total manufacturing shipments.

Table D.4. Stage I – Original Feenstra and Hanson (1999) Specification

	1989-1996				1997-2004			
	Annualized Difference		First Difference		Annualized Difference		First Difference	
	Original Measure	Refined Measure	Original Measure	Refined Measure	Original Measure	Refined Measure	Original Measure	Refined Measure
	I	II	III	IV	V	VI	VII	VIII
Trade								
Materials Offsh. (Nr)	0.067	-0.021	0.016	0.000	0.136	0.135	0.002	-0.001
	[0.083]	[0.077]	[0.012]	[0.017]	[0.151]	[0.184]	[0.003]	[0.001]
Materials Offsh. (Br-Nr)	0.440**	0.533*	0.081*	0.061*	0.133	0.296	0.001	0.010*
	[0.208]	[0.263]	[0.046]	[0.030]	[0.348]	[0.218]	[0.007]	[0.005]
Technology								
Office Equip. Share	-3.820*	-4.835**	-3.337**	-3.476**	-2.903**	-2.975***	-1.749***	-1.754***
	[2.095]	[2.277]	[1.530]	[1.595]	[1.067]	[0.799]	[0.569]	[0.557]
Other Hi-Tech Share	-0.322	-0.415	-0.251	-0.262	0.440**	0.560***	0.332*	0.334*
	[0.386]	[0.423]	[0.325]	[0.333]	[0.186]	[0.193]	[0.163]	[0.164]
Other Controls								
Year Fixed Effects	-	-	Yes	Yes	-	-	Yes	Yes
Constant	1.167***	1.150***	1.038***	1.020***	0.554***	0.542***	0.476***	0.476***
	[0.113]	[0.137]	[0.151]	[0.161]	[0.072]	[0.045]	[0.069]	[0.069]
Observations	458	458	3206	3206	473	473	3311	3311
R^2	0.18	0.17	0.08	0.07	0.14	0.18	0.08	0.08

Note: Standard errors in brackets are robust to heterosckedasticity and correlation in the errors within two-digit SIC industries for 1989-1996 and three-digit NAICS industries for 1997-2004. Variables expressed as annualized differences are constructed as differences over end-years of each period, divided by the number of years in the period. Variables expressed as first-difference are constructed as differences over year t and t-1. Regressions are weighted by an average industry share of the manufacturing shipments.

Table D 5. Stage I – Full Specification

	1989-1996				1997-2004			
	Annualized Difference		First Difference		Annualized Difference		First Difference	
	Original Measure	Refined Measure	Original Measure	Refined Measure	Original Measure	Refined Measure	Original Measure	Refined Measure
	I	II	III	IV	V	VI	VII	VIII
Trade								
Materials Offsh. (Nr)	-0.030	-0.030	0.010	0.001	0.153	0.361**	-0.004	-0.004***
	[0.066]	[0.044]	[0.010]	[0.015]	[0.174]	[0.137]	[0.005]	[0.001]
Materials Offsh. (Br-Nr)	0.260	0.510**	0.066	0.057*	0.071	0.103	-0.007	0.006
	[0.171]	[0.186]	[0.039]	[0.031]	[0.339]	[0.162]	[0.008]	[0.006]
Services Offsh.	-17.100**	-17.263**	-0.993***	-1.039***	-0.115	5.932**	0.755	0.686
	[6.834]	[6.136]	[0.276]	[0.281]	[2.493]	[2.341]	[0.676]	[0.639]
Import Openness	0.001	-0.001	0.000	0.000	-0.001	-0.001	0.000	0.000
	[0.004]	[0.004]	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]
Technology								
Office Equip. Share	0.004	-0.129	-1.848	-1.914	-2.438**	-2.300***	-1.710***	-1.714***
	[2.798]	[2.827]	[1.519]	[1.527]	[0.903]	[0.701]	[0.545]	[0.534]
Other Hi-Tech Share	-0.358	-0.424	-0.280	-0.285	0.372*	0.491***	0.326*	0.326*
	[0.310]	[0.283]	[0.289]	[0.290]	[0.191]	[0.159]	[0.171]	[0.171]
Computer Share	0.567*	0.603**	0.323***	0.330***	0.085	0.077	0.013	0.015
	[0.281]	[0.242]	[0.103]	[0.101]	[0.088]	[0.074]	[0.028]	[0.027]
Other Controls								
Market Power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	-	-	Yes	Yes	-	-	Yes	Yes
Observations	458	458	3206	3206	473	473	3311	3311
R^2	0.33	0.36	0.16	0.16	0.24	0.30	0.09	0.09

Note: Standard errors in brackets are robust to heterosckedasticity and correlation in the errors within two-digit SIC industries for 1989-1996 and three-digit NAICS industries for 1997-2004. Variables expressed as annualized differences are constructed as differences over end-years of each period, divided by the number of years in the period. Variables expressed as first-difference are constructed as differences over year t and $t-1$. Regressions are weighted by an average industry share of the manufacturing shipments.

Table D.6: Stage I – Decomposed Dependent Variable (Refined Measure)

	1989-1996				1997-2004			
	Annualized Difference		First Difference		Annualized Difference		First Difference	
	Δp_i^{VA}	$\Delta ETFP_i$	Δp_i^{VA}	$\Delta ETFP_i$	Δp_i^{VA}	$\Delta ETFP_i$	Δp_i^{VA}	$\Delta ETFP_i$
	I	II	III	IV	V	VI	VII	VII
Trade								
Materials Offsh. (Nr)	-1.603***	1.573***	-0.008	0.009	0.093	0.268	-0.175	0.171
	[0.404]	[0.424]	[0.153]	[0.147]	[1.204]	[1.250]	[0.113]	[0.114]
Materials Offsh. (Br-Nr)	0.070	0.440	-0.698*	0.755*	0.403	-0.300	-0.356	0.362
	[0.846]	[0.789]	[0.390]	[0.395]	[1.032]	[1.078]	[0.339]	[0.344]
Services Offsh.	-8.693	-8.570	-3.014	1.975	155.304***	-149.372***	81.825***	-81.139***
	[24.890]	[23.649]	[7.457]	[7.396]	[23.045]	[22.050]	[10.553]	[10.104]
Import Openness	0.015	-0.015	-0.019	0.019	-0.012**	0.011**	-0.003	0.003
	[0.031]	[0.031]	[0.012]	[0.012]	[0.006]	[0.004]	[0.005]	[0.005]
Technology								
Office Equip. Share	3.183	-3.312	2.686	-4.600	1.943	-4.243	-3.457	1.742
	[10.265]	[9.614]	[7.123]	[6.231]	[3.401]	[3.484]	[3.004]	[3.222]
Other Hi-Tech Share	-2.301*	1.877*	0.912	-1.197	-1.225	1.716	-1.178	1.505
	[1.133]	[0.912]	[1.667]	[1.426]	[1.632]	[1.625]	[1.219]	[1.264]
Computer Share	0.112	0.491	-0.324	0.654	-0.099	0.176	0.349	-0.334
	[0.615]	[0.519]	[0.561]	[0.491]	[0.342]	[0.369]	[0.245]	[0.249]
Other Controls								
Market Power	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	-	-	Yes	Yes	-	-	Yes	Yes
Observations	458	458	3206	3206	473	473	3311	3311
R^2	0.72	0.73	0.22	0.23	0.43	0.42	0.15	0.14

Note: Standard errors in brackets are robust to heterosckedasticity and correlation in the errors within two-digit SIC industries for 1989-1996 and three-digit NAICS industries for 1997-2004. Variables expressed as annualized differences are constructed as differences over end-years of each period, divided by the number of years in the period. Variables expressed as first-difference are constructed as differences over year t and $t-1$. Regressions are weighted by an average industry share of the manufacturing shipments.

Table D.7. Stage I – Final Specification (Refined Measure)

	1989-1996		1989-1996	
	Annualized Difference	First Difference	Annualized Difference	First Difference
	I	II	III	IV
Trade				
Materials Offsh. (Nr)[1]			0.390**	-0.003***
			[0.178]	[0.001]
Materials Offsh. (Br-Nr)[2]	0.433**	0.056*		
	[0.164]	[0.028]		
Services Outs.	-16.158**	-1.086***	6.120**	
	[6.933]	[0.344]	[2.751]	
Technology				
Office Equip. Share			-2.394***	-1.722***
			[0.650]	[0.549]
Other Hi-Tech Share			0.484***	0.327*
			[0.154]	[0.166]
Computer Share	0.668***	0.373***		
	[0.166]	[0.067]		
Other Controls				
Market Power	Yes	Yes	Yes	Yes
Year Fixed Effects	-	Yes	-	Yes
Constant	1.774***	1.209***	0.526***	0.476***
	[0.222]	[0.090]	[0.040]	[0.068]
Observations	458	3206	473	3311
R^2	0.33	0.12	0.28	0.09

Note: [1,2] Materials Offshoring measures are constructed using the refined formula. Standard errors in brackets are robust to heterosckedasticity and correlation in the errors within two-digit SIC industries for 1989-1996 and three-digit NAICS industries for 1997-2004. Variables expressed as annualized differences are constructed as differences over end-years of each period, divided by the number of years in the period. Variables expressed as first-difference are constructed as differences over year *t* and *t-1*. Regressions are weighted by an average industry share of the manufacturing shipments.

Table D.8: Stage II – (Refined Measure)

Dependent Variable: $\Delta \ln p_i^{VA} + \Delta \ln ETFP_i$ **explained by causal variables**

	1989-1996			1997-2004			
	Materials Offsh. (Br-Nr)	Services Offsh.	Computer Share	Materials Offsh. (Nr)	Service Offsh.	Office Equip. Share	Other Hi-Tech Share
Annualized Difference							
Prod. Cost Share	0.305**	-2.413***	-0.237	-0.119	0.182	0.243**	0.270***
	[0.122]	[0.288]	[0.326]	[0.161]	[0.125]	[0.110]	[0.073]
Non-Prod. Cost Share	0.898***	0.546	1.488**	0.066	-0.159	0.234***	-0.040
	[0.224]	[0.499]	[0.656]	[0.242]	[0.169]	[0.090]	[0.095]
Capital Cost Share	0.013	-1.131***	0.137	-0.028	-0.002	0.122***	-0.221***
	[0.044]	[0.146]	[0.132]	[0.052]	[0.035]	[0.022]	[0.030]
Observations	458	458	458	473	473	473	473
R^2	0.59	0.86	0.36	0.04	0.03	0.63	0.61
Net Coefficient[1]	**0.593*****	**2.959*****	**1.725*****	**0.185**	**-0.341****	**-0.009**	**-0.310*****
	[0.180]	**[0.407]**	**[0.518]**	**[0.206]**	**[0.149]**	**[0.100]**	**[0.085]**
First Difference							
Prod. Cost Share	0.031	-0.172***	-0.112	0.001		0.198***	0.160***
	[0.025]	[0.034]	[0.105]	[0.008]		[0.041]	[0.023]
Non-Prod. Cost Share	0.113**	-0.004	0.946***	-0.005		0.174***	-0.061*
	[0.058]	[0.052]	[0.202]	[0.014]		[0.038]	[0.032]
Capital Cost Share	0.005	-0.062***	0.041	0.001		0.079***	-0.139***
	[0.007]	[0.015]	[0.034]	[0.002]		[0.010]	[0.009]
Observations	3206	3206	3206	3311		3311	3311
R^2	0.11	0.23	0.20	0.00		0.44	0.50
Net Coefficient[1]	**0.082***	**0.168*****	**1.058*****	**-0.006**		**-0.024**	**-0.221*****
	[0.045]	**[0.044]**	**[0.161]**	**[0.011]**		**[0.040]**	**[0.028]**

Note: [1]Net coefficient refers to the difference between the coefficients on non-production and production cost shares. Coefficient estimates used to construct the dependent variable for 1989-1996 and 1997-2004 are those from respective columns of Table 6. Standard errors are in brackets and are adjusted using Dumont et al. (2005) method described in the text. All regressions are weighted by an average industry share of total manufacturing shipments.

APPENDIX E

TABLES FOR CHAPTER IV

Table E.1: Summary Statistics of Explanatory Variables

	Mean	S.D.	Min	Max
Contractual Dependence	0.72	0.26	0.02	1.00
Skill Dependence	0.10	0.05	0.02	0.28
Capital Dependence	0.66	0.10	0.41	0.95
GDP (in $bill.)	176.18	514.38	0.26	4607.76
Labor Supply (in $mill.)	20.38	77.42	0.14	716.91
Contracts Quality	0.53	0.21	0.11	0.97
Ln Human Capital/Worker	0.58	0.29	0.07	1.21
Ln Physical Capital/Worker	9.22	1.60	5.76	11.59

Table E.2: Correlation Matrix of Interaction Terms

		I	II	III	IV	V	VI	VII
I	(Contr. Dep.) * (Contr. Quality)	1.00						
II	(Contr. Dep.) * (ln GDP)	0.72	1.00					
III	(Contr. Dep.) * (Contr. Quality)*(ln GDP)	0.83	0.92	1.00				
IV	(Contr. Dep.) * (ln Lab. Supply)	0.21	0.70	0.48	1.00			
V	(Contr. Dep.) * (Contr. Quality)*(ln Lab. Supp.)	0.45	0.83	0.75	0.89	1.00		
VI	(Skill Dep.) * (ln Skill Endow.)	0.53	0.47	0.54	0.09	0.26	1.00	
VII	(Cap. Dep.) * (ln Cap. Endow.)	0.22	0.29	0.38	-0.12	0.08	0.13	1.00

Table E.3: Sample Countries

North	BOLIVIA	INDONESIA	PORTUGAL
AUSTRALIA	BRAZIL	IVORY COAST	ROMANIA
AUSTRIA	BURKINA FASO	JAMAICA	RWANDA
BELGIUM/LUX.	BURUNDI	JORDON	SALVADR
CANADA	CAMEROON	KENYA	SAUDI ARABIA
DENMARK	CHAD	AUSTRALIA	SENEGAL
FINLAND	CHILE	MADAGAS	SIERRA LEONE
FRANCE	CHINA	MALAWI	SPAIN
GERMANY	COLOMBIA	MALAYSIA	SRILANKA
HONG KONG	CONGO	MALI	SUDAN
ICELAND	COSTARICA	MALTA	SURINAM
IRELAND	CYPRUS	MAURITN	SYRIA
ISRAEL	C. AFRICAN REP.	MEXICO	S. FRICA
ITALY	ECUADOR	MOROCCO	TANZANIA
JAPAN	EGYPT	MOZAMBQ	THAILAND
NETHERLANDS	FIJI	MRITIUS	TOGO
NORWAY	GABON	NEW GUINEA	TRINIDAD
SINGAPORE	GAMBIA	NEW ZEALAND	TUNISIA
SWEDEN	GHANA	NICARAGA	TURKEY
SWITZERLAND	GREECE	NIGER	UGANDA
U.K.	GUATMALA	NIGERIA	URUGUAY
	GUINEA	OMAN	VENEZUELA
South	GUYANA	PAKISTAN	YEMEN
ALGERIA	GUINEA BISSAU	PANAMA	YUGOSLAV
ANGOLA	HAITI	PARAGUA	ZAIRE
ARGENTINA	HONDURAS	PERU	ZAMBIA
BENIN	HUNGARY	PHILLIPINES	ZIMBABWE
BANGLADESH	INDIA	POLAND	

Table E.4: Contracts and Market Thickness

	I	II	III	IV	V
(Contr. Dep.) * (Contr. Quality)	0.161***	0.117***	0.163***	0.042	0.182***
	[0.026]	[0.034]	[0.026]	[0.054]	[0.037]
(Contr. Dep.) * (ln GDP)		0.063**		-0.021	
		[0.026]		[0.063]	
(Contr. Dep.) * (ln Lab. Supp.)			0.060***		0.096*
			[0.019]		[0.057]
(Contr. Dep.) * (Contr. Qual.) * (ln GDP)				0.129	
				[0.087]	
(Contr. Dep.) * (Contr. Qual.) * (ln Lab. Supp.)					-0.040
					[0.061]
(Skill Dep.) * (ln Skill Endow.)	0.110***	0.109***	0.108***	0.109***	0.108***
	[0.023]	[0.023]	[0.023]	[0.023]	[0.023]
(Cap. Dep.) * (ln Cap. Endow.)	0.176***	0.189***	0.172***	0.185***	0.172***
	[0.041]	[0.042]	[0.041]	[0.041]	[0.042]
Constant	-0.252***	1.217***	1.098***	-0.450***	0.671***
	[0.070]	[0.087]	[0.095]	[0.126]	[0.149]
Country & Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	29484	29484	29484	29484	29484
Number of Industries	273	273	273	273	273
Number of Countries	108	108	108	108	108
R-squared	0.69	0.69	0.69	0.69	0.69

Note: The regressions are estimates of (IV.16) and (IV.17). The dependent variable is the natural log of U.S. imports of intermediate inputs sourced from industry *i* of country *c*. Standardized beta coefficients are reported, with robust standard errors clustered around countries in brackets. *, **, *** indicate significance at the 10%, 5%, and 1% levels.

Table E.5: Sensitivity Results

	I	II	III	IV	V	VI	VII
(Contr. Dep.) * (Contr. Quality)	0.168***	0.366***	0.118***	0.178***	0.160***	0.148***	0.201***
	[0.042]	[0.052]	[0.036]	[0.035]	[0.026]	[0.023]	[0.027]
(Contr. Dep.) * (ln Lab. Supply)	0.062***	0.222***	0.083***	0.083***	0.056***	0.043**	0.081***
	[0.019]	[0.031]	[0.025]	[0.023]	[0.020]	[0.019]	[0.020]
(Skill Dep.) * (ln Skill Endow.)	-0.044	0.320***	0.003	0.195***	0.110***	0.110***	0.101***
	[0.029]	[0.057]	[0.026]	[0.038]	[0.024]	[0.024]	[0.023]
(Cap. Dep.) * (ln Cap. Endow.)	0.102*	0.206*	0.122**	0.240***	0.176***	0.176***	0.170***
	[0.057]	[0.108]	[0.053]	[0.074]	[0.042]	[0.043]	[0.042]
(Contr. Dep.) * (ln Skill Endow.)	0.010						
	[0.035]						
(Contr. Dep.) * (ln Cap. Endow.)	-0.070						
	[0.051]						
(Skill Dep.) * (Contr. Quality)	0.240***						
	[0.040]						
(Cap. Dep.) * (Contr. Quality)	0.119**						
	[0.058]						
Constant	-0.483***	-2.362***	1.337***	-1.420***	0.501***	1.008***	0.787***
	[0.131]	[0.493]	[0.144]	[0.221]	[0.100]	[0.105]	[0.108]
Country & Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Restrictions	None	Non-Zero	South	No Africa	No China	No S.E. Asia	Outlier Ind.
Observations	29484	11984	24024	20748	29211	27846	27324
Number of Industries	273	273	273	273	273	273	253
Number of Countries	108	108	88	76	107	102	108
R-squared	0.69	0.65	0.59	0.68	0.68	0.70	0.69

Note: The regressions are estimates of (IV.16). The dependent variable is the natural log of U.S. imports of intermediate inputs sourced from industry *i* of country *c*. Standardized beta coefficients are reported, with robust standard errors clustered around countries in brackets. *, **, *** indicate significance at the 10%, 5%, and 1% levels.

Table E.6: Comparison of Import Patterns

	Dependent Variable			
	Intermediates	Non-Intermediates	Total	Total
	I	II	III	IV
(Contr. Dep.) * (Contr. Quality)	0.163***	0.206***	0.161***	0.256***
	[0.026]	[0.017]	[0.018]	[0.025]
(Contr. Dep.) * (ln Lab. Supp.)	0.060***	0.02	-0.005	0.044**
	[0.019]	[0.014]	[0.013]	[0.020]
(Skill Dep.) * (ln Skill Endow.)	0.108***	0.094***	0.096***	0.093***
	[0.023]	[0.024]	[0.023]	[0.023]
(Cap. Dep.) * (ln Cap. Endow.)	0.172***	0.204***	0.187***	0.260***
	[0.041]	[0.044]	[0.041]	[0.044]
Constant	1.098***	1.835***	1.056***	0.600***
	[0.095]	[0.098]	[0.086]	[0.115]
Country & Industry Fixed Effects	Yes	Yes	Yes	Yes
Restrictions	No	No	No	No
Observations	29484	32724	34020	34020
Number of Industries	273	303	315	315
Number of Countries	108	108	108	108
R-squared	0.69	0.70	0.69	0.69

Note: The regressions are estimates of (16). The dependent variables in Columns I and II are U.S. imports of intermediate goods and non-intermediate goods, respectively. Columns III and IV are total U.S. imports. The *Contract Dependence* variable is constructed differently in each column, as described in the text. All dependent variable are expressed as the natural log of imports sourced from industry *i* of country *c*. Standardized beta coefficients are reported, with robust standard errors clustered around countries in brackets. *, **, *** indicate significance at the 10%, 5%, and 1% levels.

Table E.7: Comparison of Import Patterns By Utilization Rates

	All		25%≤		50%≤		75%≤	
	I	II	III	IV	V	VI	VII	VIII
(Contr. Dep.) * (Contr. Quality)	0.102***	0.237***	0.142***	0.103***	0.152***	0.134***	0.167***	0.182***
	[0.019]	[0.029]	[0.027]	[0.032]	[0.026]	[0.028]	[0.028]	[0.031]
X Materials Dummy	-0.024***	-0.029***	0.048***	0.052**	0.059***	0.071***	0.095***	0.113***
	[0.009]	[0.010]	[0.017]	[0.020]	[0.020]	[0.024]	[0.024]	[0.029]
(Contr. Dep.) * (ln Lab. Supply)	0.008	0.063**	0.043*	0.048	0.055***	0.088***	0.084***	0.145***
	[0.022]	[0.025]	[0.022]	[0.032]	[0.020]	[0.029]	[0.020]	[0.032]
X Materials Dummy	-0.022**	-0.030**	-0.039**	-0.050**	-0.042***	-0.054**	-0.050**	-0.060**
	[0.010]	[0.012]	[0.015]	[0.020]	[0.016]	[0.023]	[0.020]	[0.028]
(Skill Dep.) * (ln Skill Endow.)	0.050***	0.104***	0.129***	0.153***	0.143***	0.180***	0.150***	0.202***
	[0.018]	[0.025]	[0.025]	[0.026]	[0.025]	[0.027]	[0.026]	[0.029]
X Materials Dummy	-0.014*	-0.029***	-0.072***	-0.098***	-0.138***	-0.179***	-0.158***	-0.198***
	[0.008]	[0.009]	[0.015]	[0.018]	[0.021]	[0.025]	[0.024]	[0.029]
(Cap. Dep.) * (ln Cap. Endow.)	0.051***	0.220***	0.114***	0.064	0.107***	0.095*	0.119***	0.120**
	[0.019]	[0.044]	[0.043]	[0.051]	[0.040]	[0.048]	[0.041]	[0.049]
X Materials Dummy	-0.021***	-0.027***	-0.119***	-0.151***	-0.112***	-0.151***	-0.157***	-0.198***
	[0.006]	[0.008]	[0.017]	[0.021]	[0.018]	[0.024]	[0.023]	[0.029]
Constant	-0.597***	-0.233***	-0.740***	-0.158*	-0.618***	-0.394***	-1.115***	0.017
	[0.064]	[0.083]	[0.121]	[0.092]	[0.115]	[0.120]	[0.076]	[0.088]
Country & Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Restricted	No	Yes	No	Yes	No	Yes	No	Yes
Observations	62208	56376	53292	38915	49541	31672	46568	29607
R-squared	0.65	0.69	0.59	0.58	0.53	0.48	0.53	0.48

Note: The regressions are estimates of (IV.16). The dependent variables are drawn from pooled samples of U.S. imports of intermediates and non-intermediates, expressed as the natural log of imports sourced from industry *i* of country *c*. The samples in Columns I and II include all imports, while the samples in Columns III-IV, V-VI, and VII-VIII contain only those imports that have at least 25%, 50%, 75% utilization rate as intermediate or non-intermediate goods. The samples in Columns II, IV, VI, and VII are restricted to include only those industries which source both intermediate and non-intermediate goods. Standardized beta coefficients are reported, with robust standard errors clustered around countries in brackets. *, **, *** indicate significance at the 10%, 5%, and 1% levels.

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