Imports of Intermediate Parts in the Auto Industry – A Case Study

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Thomas H. Klier
Federal Reserve Bank of Chicago
tklier@frbchi.org

James M. Rubenstein
Miami University (Ohio)
rubensjm@muohio.edu

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Abstract

Intermediate parts contribute roughly 70 percent of the value added in production of motor vehicles. Carmakers like Ford and General Motors once made many of these parts in-house, but now procure most of them from independent producers. Outsourcing of parts extends globally, with more than one-fourth of the parts in vehicles assembled in the United States imported from other countries. This paper describes the growing role of motor vehicle parts imports for U.S.-based light vehicle assembly. Imports of motor vehicle parts have increased to both substitute for U.S.-based parts production as well as to complement U.S.-based vehicle production of foreign producers. The paper assesses the effect of imports on production costs by distinguishing high- and low-cost source countries. This analysis is supplemented with anecdotal evidence on two key measurement issues: the globalization of supply chains as well as the relocation of production from a developed to a less developed country and attendant changes in the structure of production costs.

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1. Motivation

The production of an automobile is complex, involving thousands of parts and hundreds of different companies. [1] As many of the intermediate parts cross international borders (some multiple times, especially between Michigan and Ontario along the U.S. Canadian border) automobile production is of interest from the vantage point of properly measuring the extent of off-shoring as well as the price of attendant imported intermediate goods.

Intermediate parts contribute roughly 70 percent of the value added in production of motor vehicles. Carmakers like Ford and General Motors once made many of these parts in-house, but now procure most of them from independent producers. Outsourcing of parts has also been globalized, with more than one-fourth of the parts in vehicles assembled in the United States imported from other countries. In the same vein, foreign-headquartered motor vehicle parts producers have established significant production operations in the U.S.

This paper describes the growing role of motor vehicle parts imports for U.S.-based light vehicle assembly. Imports of motor vehicle parts have increased to both substitute for U.S.-based parts production as well as to complement U.S.-based vehicle production of foreign producers. The paper serves as a case study in the context of this conference by focusing on two key measurement issues: the globalization of supply chains as well as the relocation of production from a developed to a less developed country and attendant changes in the structure of production costs. Both examples will be discussed in the context of Mexico as a production location for motor vehicle parts.

The paper is structured as follows. Section 2 summarizes the relevant literature. We then discuss the source for our data on the auto supplier industry. Section 4 presents the trends in imports of motor vehicle parts to the U.S. Section 5 focuses on Mexico as a source for U.S. motor vehicle parts imports. We present two examples illustrating in some detail the challenges for proper measurement of the imports of intermediate inputs in the auto industry: the shift of production for a specific product, aluminum wheels, from the U.S. to Mexico, and the globalization of the supply chain for an intermediate part, the seat.

2. Literature

The auto industry is often highlighted as an example of a global manufacturing industry (see for example work at the International Motor Vehicle Program as well as Sturgeon et al, 2007). In North America, automobile and parts production has long been integrated across the U.S. and Canadian border (see Weintraub and Sands, 1998). Mexico became an important location for

[1] In this paper the term automobile is used synonymously with “light vehicle”, which is a term frequently used to summarize vehicles consumers tend to buy. Light vehicles comprise cars and light trucks, such as pick-ups, SUV’s, and minivans.

parts production starting in the late 70s. Montout et al (2007) suggest that the degree of intra-industry trade in the North American automobile industry increased at the beginning of the 90s.

Most of the literature on the North-American auto industry describes the evolution of especially Mexico as an important source of intermediate good production (see for example Gilmer and Canas, 2008, Carillo and Contreras, 2007, and earlier Herzenberg, 1991, and U.S. Congress, 1992). In the last few years there have been a number of papers estimating the share of vertical and horizontal intra-industry trade in the auto industry (see Montout et al 2007, Ito and Umemoto, 2004). Regarding the focus of this conference, there is very little information on the relative production costs of auto parts, including comparisons between production in the U.S. and Mexico. The few published examples tend to be dated and apply to large and complex components, such as engines (see U.S. Congress, 1992).[2] Klier and Rubenstein (2008) provide a recent and comprehensive analysis of the trade flows in auto parts to and from the U.S.

3. Data

Detailed Harmonized Tariff System (HTS) code data are available from the U.S. International Trade Commission. That coding system was enabled by the 1988 Trade Act. It created the HTS system which authorized eight-digit and 10-digit codes for imports. This very detailed data source forms the basis for our analysis of changes in the nature and source of motor vehicle part imports to the U.S. Many parts for motor vehicles are included in HTS code chapter 87, yet they are scattered throughout a number of other chapters as well.

To generate a comprehensive list of motor vehicle parts based on HTS codes we painstakingly combed through all relevant HTS chapters. Our goal was to identify parts intended for use in the assembly of new light vehicles (so-called light-vehicle OEM parts). Therefore we excluded parts for use in motorcycles, buses, or commercial trucks whenever possible. Despite the incredible detail available in the 10-digit HTS-code system, there is one major drawback to the data classification: trade data, just like Census-based data on U.S. production, cannot identify where the parts will be used. Ideally we would like to focus in our analysis exclusively on parts that are intended for the assembly of new vehicles as opposed to “aftermarket” parts, which are parts that end up in the retail or wholesale channel (for example for installation at a car repair shop). For large and complex parts, such as engines and transmissions, the HTS codes distinguish new from “remanufactured” parts. While that distinction does not substitute as an identification of OEM and aftermarket parts – e.g. a new engine can be purchased through a parts dealer – we excluded all “remanufactured” parts, as those are not intended for use in the assembly of a new vehicle.

[2] The only exception we came across is a comparison of production costs of wiring harnesses for a U.S. and Mexico location (US Congress 1992, p. 147). Assembly costs of wiring harnesses, a very labor intensive product, in the U.S. around 1990 ranged from $12 to $23. Assembly cost in Mexico varied between $1-2; shipping and inventory added $7.50. All costs are expressed in U.S. Dollars.

Our list of motor vehicle parts consists of just over 200 individual eight- and 10-digit HTS codes, representing 10 different 2-digit chapters.

We supplemented the trade data with a plant-level database that describes the geography of motor vehicle parts production by part in North America. The plant-level database covers 3,179 parts plants in the U.S., 416 in Canada, and 673 in Mexico. It represents information from late 2006/early 2007 and is the basis for our book on the North American auto supplier industry.[3]

4. Trends in motor vehicle parts imports

Figure 1 shows that the value of imports of motor vehicle parts imports (as defined above) more than doubled between 1996 and 2008. Yet the volume of U.S. light vehicle production fluctuated in a rather narrow band, between 10 and 12 million units, between 1996 and 2006, before steadily declining to below 8 million units by the end of 2008. As a share of the material costs of light vehicle assembly (data available from the Census of manufactures), imports have increased noticeably from 29% in 1997 to 36% in 2002.

Figure 2 breaks out data on U.S. imports of motor vehicle parts by countries of origin. It identifies the five largest countries in year 2008. The remainder is aggregated into the "rest of the world" category. There has been a fair amount of movement among the largest source countries during the last decade and a half. Canada and Mexico, the two NAFTA partners, have traditionally represented the origin for more than half of all U.S. imports of motor vehicle parts. In 1996 the two counties represented nearly 60% of all U.S. parts imports, with Canada firmly holding the lead. By 2008 Canada was essentially tied with Japan for rank three among import source countries, having lost more than ten percentage points in almost a decade and a half. Mexico's share of U.S. motor vehicle parts imports held steady at just below 30%; by 2004 it had taken over as largest source of imports from Canada. China represents the fastest-growing origin of motor vehicle parts imports. It had eclipsed Germany for rank 4 by 2006 and represented 10% of U.S. imports in 2008.

Figure 3 breaks out all motor vehicle parts imports by high- and low-wage countries.[4] It demonstrates the steady growth of imports in motor vehicle parts from low-wage countries during the last decade and a half. Low-wage countries added about 25 percentage points of import share during that time. By 2007 the majority of all parts imports originated in low-wage countries. Stated differently, 69% of the growth in motor vehicle parts imports between 1996 and 2008 had originated in low-wage countries. Figure 4 identifies the three largest source countries for both high- and low-wage countries. Among high-wage countries, Canada's role has been shrinking, whereas China has been growing among low-wage countries.

[3] See Klier and Rubenstein, "*Who really made your car? Restructuring and geographic change in the auto industry,*" 2008, pages 10-13 for a detailed description of the construction of the plant-level data.
[4] High-wage countries consist of Canada, Japan, and all of Western Europe.

5. Focus: Mexico

We now look toward Mexico, the largest source of low-wage country imports of motor vehicle parts to the U.S. After a brief recap of the history of the Mexican motor vehicle parts industry, we illustrate with two specific examples the growth in imports of motor vehicle parts: the shift of production from the U.S. to low-wage countries, and the complexity of the supply chain for intermediate parts.

5.1. Maquiladora plants

The leading suppliers of motor vehicle parts from Mexico have been foreign-owned maquiladora plants.[5] Mexico's Border Industrialization Program, established in 1965, permitted foreign companies to import materials from the United States, assemble them in so-called maquiladora plants, and export them back to the United States without having to pay duty on the raw materials brought into Mexico, the equipment in the maquiladora plants, or the subassemblies shipped back to the United States.

U.S. auto parts makers started taking advantage of the maquiladora laws in the late 1970s. GM's Packard Electric Division, now part of Delphi, established Conductores y Componentes Electricos to make wire harnesses, a very labor-intensive part, in Ciudad Juarez in 1978. Electrical components dominated Mexican early maquiladora production, accounting for twice as many imports as all other systems combined into the 1990s.

GM's Inland Division, now also part of Delphi, arrived in Ciudad Juarez in 1978 to make seat covers and interior trim. Production of seat components expanded rapidly into the twenty-first century as the three large assemblers of complete seats, Lear, JCI, and Magna, relocated production of some individual components to Mexico and purchased more individual seat parts from Mexico-based lower-tier suppliers.

In terms of geography, maquiladora plants are strung out in Mexican cities along the U.S. border, especially (from east to west) in Matamoros (across the border from Brownsville, Texas), Reynosa (across from McAllen), Nuevo Laredo (across from Laredo), Ciudad Juarez (across from El Paso), and Tijuana (across from San Diego). The more easterly cities have attracted most of the auto parts maquiladoras because of their relative proximity to auto alley. Auto-related maquiladora production is also clustered in larger northern Mexican cities 100 miles or so south of the border, such as Nuevo Leon, Monterrey, Chihuahua, and Hermosillo.

According to the Mexico Maquila Information Center, 24 of the 100 largest maquiladoras in 2006 were motor vehicle parts suppliers. The three largest maquiladoras on the list were Delphi, Lear, and Yazaki, all motor vehicle parts producers. The 24 auto-related maquiladoras together

[5] This section draws heavily on Klier and Rubenstein (2008), pp 318-320

employed 216,696 workers in Mexico in 2006, including 66,000 at Delphi, 34,000 at Lear, and 33,400 at Yazaki.

Figure 5 demonstrates the changing composition of motor vehicle parts imports from Mexico during the last decade and a half. The figure is based on HTS-code import data. We aggregated the individual parts into seven distinct subsystems, such as electrical and drivetrain (engine and transmission). The data illustrate the large share of electrical parts, even in 2008. To this day Mexico continues to be by far the largest source of automobile wiring harnesses imported into the U.S. (47% of all imported wiring harnesses came from Mexico in 2008, down slightly from 54% in 1996). Yet there is evidence that the composition of the types of auto parts produced in Mexico for U.S. consumption is changing. See for example Carillo and Contreras (2007), who point out that companies such as Delphi have upgraded their production operations in Mexico "from simple assembly to centralized coordination of functions including sophisticated product design, development, and research (p.2). As part of that transformation Delphi transferred a technical center and its research, design, and product development functions from Anderson, Indiana, to Ciudad Juarez, Mexico, in 1995 (p. 4).

5.2. Shift of production from the U.S. to Mexico: aluminum wheels

We chose the aluminum wheel as an example of a component for which most production has relocated during the past decade from the United States to low-wage countries. The wheel represents a rather well-defined stand-alone part. Its production is quite simple. About 70% of production costs are represented by alumina, the raw material, and the processing of it, such as casting, heat-treating, machining and painting.[6] The aluminum wheel has its own 10-digit HTS code, although as noted already we are not able to distinguish between OEM and aftermarket imports. We were also able to obtain some detailed information about the cost structure of aluminum wheel production in the United States and Mexico from Richard M. Lilley of Lilley Associates, Inc., which publishes a biannual *NAFTA Light Vehicle Road Wheel Survey*.

Aluminum is the main material for the construction of wheels, representing roughly two-thirds of the OEM market for wheels in the world and in North America. Although more expensive than steel, aluminum has replaced steel during the past quarter-century as the metal of choice for casting wheels, because it is much lighter and can be more easily shaped into designs that carmakers prefer.

The mass-produced aluminum wheel is a commodity that is sourced by carmakers on the basis of price. Carmakers know to the fraction of a penny the cost of each component in the price of a wheel, especially standard wheels produced in high volumes. Profit margins on high-volume wheels are extremely small, according to Lilley Associates. Wheel suppliers make a profit primarily by producing low-volume niche and specialty wheels.

[6] Once melted, the aluminum is fed to the wheel casting machines. After the aluminum has solidified, the blank casting is sent to trimming machines and to the heat treatment station. Each wheel is "baked" for several hours to give it the proper metallurgical structure and strength. Subsequently the wheel is sent to the machining stations for drilling. Afterwards wheels are cleaned and painted.

The two leading U.S.-based suppliers of wheels are Hayes-Lemmerz and Superior Industries. Hayes, a venerable supplier founded in 1908, filed for Chapter 11 in May 2009. Hayes has been shedding other parts units to focus on wheels. Once the dominant supplier of steel wheels, the company was slow getting into aluminum. Superior Industries, the other leading U.S.-headquartered producer, is the "upstart," having been founded in 1973 in California. Superior specializes in the production of aluminum wheels. The company has about 1/3 of the U.S. market for aluminum wheels. Like Hayes, Superior has addressed the difficult economic climate by giving up production of parts other than wheels.

Superior produces aluminum wheels at two factories in the United States, both in Arkansas, and three in Mexico, all in Chihuahua. Between 2007 and 2009, the company closed three of its aluminum wheel plants in the United States, one each in California, Kansas, and Tennessee. As a result, two-thirds of Superior's North American OEM wheel production is in Mexico and one-third in the United States, according to its 2008 Annual Report.

All of Hayes' North American aluminum wheels are produced in Mexico. Hayes closed its only U.S. aluminum wheel factory in Gainesville, Georgia, in 2008. The company started wheel production in Mexico as the minority partner in a joint venture. It has since taken over full control over that operation.

Other North American producers of aluminum wheels include Alcoa Wheel Products, a division of Alcoa, which invented the forged aluminum wheel in 1948. It produces aluminum wheels in Cleveland, Ohio, and Lebanon, Virginia, but most of these wheels are destined for commercial vehicles and the aftermarket. The company closed an aluminum wheel plant in Beloit, Wisconsin, in 2008. Several Japanese-owned aluminum wheel suppliers have U.S. operations. Central Motor Wheels of America and Canadian Autoparts Toyota, both Toyota captives, produce aluminum wheels in Paris, Kentucky, and, Delta, British Columbia, respectively. These two companies are the principal supplier of aluminum wheels to Toyota's North American assembly operations.[7] AAP St. Mary's, a subsidiary of Hitachi, produces aluminum wheels in St. Mary's, Ohio, and primarily supplies Ford. Enkei America, located in Columbus, Indiana, mainly supplies Honda with aluminum wheels.

Figure 1 compares the costs of producing aluminum wheels in the United States and in Mexico. It is based on estimates provided by Lilley Associates for total production costs, as well as the share accounted for by various costs for a typical high-volume 17-inch wheel sold to the Detroit 3 carmakers.

The largest single cost of producing the wheels is the aluminum. According to *American Metal Market*, a 17" aluminum wheel contains roughly 20 lbs of aluminum. Lilley Associates suggests that aluminum accounts for around one-fourth of wheel production costs. According to

[7] Canadian Autoparts Toyota only produces cast aluminum wheels, Central Motor Wheels makes both cast and steel wheels.

DataMonitor, the principal supplier of alumina for the aluminum wheels is Alcoa, with 58.6 percent of the U.S. primary aluminum market in 2008.

Table 1: Comparing aluminum wheel production costs between Mexico and the U.S.

	MEXICO		UNITED STATES	
	Percent	$	Percent	$
Materials	30%	$13	24%	$13
Processing	41%	$18	52%	$28
Casting*	16%	$7	20%	$11
Heat treatment*	3%	$1	4%	$1
Machining*	11%	$5	14%	$8
Painting*	11%	$5	14%	$8
SG&A	4%	$2	4%	$2
Profit	9%	$4	7%	$4
Other	16%	$7	13%	$7
Total	100%	$44	100%	$54

Note: * All processing functions are assumed to be equally labor intensive, SG&A stands for selling as well as general and administrative expenses.
Source: Lilley and Associates

Alumina (also known as aluminum oxide) is sourced primarily within the United States for production of wheels in Mexico as well as in the United States. Alcoa's long-standing North American alumina facility is at Massena, New York. A plant at Rockdale, Texas, may also be a source of primary metal for the Chihuahua plants. Thus, a "Mexican" wheel is likely to include some U.S. content.

In our example, the $10 (or 22%) cost advantage to Mexico originates with the processing of the alumina, especially casting, machining, and painting as the processing operations are the most labor-intensive elements of the wheel production process. Yet Mexico no longer represents the largest source of aluminum wheel imports to the U.S.[8]

China accounts for an increasing share of global wheel production (as well as U.S. consumption), according to the trade data. According to Research in China, total production of aluminum wheels in China has increased from 3.5 million in 2001 to 35 million in 2008. The 35 million figure included an estimated 15-20 million for motorcycles, 1.5 million for the aftermarket, and 1.5 million in inventory, leaving 12-17 million for light and heavy motor vehicles. Per Richard Lilley, about half of the 12 million aluminum wheels imported by the U.S. from China in 2008 represent OEM wheels. In the same year, Mexico exported just under 4 million aluminum wheels to the U.S. Presumably most of these are OEM wheels.

[8] See Watkins (2006) on the challenges China represents to manufacturing in Mexico.

We do not have authoritative information on production costs in China. While manufacturing wage rates in China are substantially lower than in Mexico, we don't have a basis for comparing productivity which would allow us to estimate processing costs in China. We assume them to be lower in China than in Mexico, because of China's lower labor costs. China's aluminum wheels producers obtain materials from Chinese alumina sources.[9]

To reach the U.S. market Chinese wheels incur additional shipping costs compared to production in Mexico. A standard 40-foot shipping container can hold around 1,000 17-inch wheels and costs around $1,100 to ship from China to the United States.[10] Therefore the shipping cost from China amounts to just over $1 per wheel. While the additional shipping expense per wheel is likely much less than the labor cost savings on processing, production in China also triggers incremental inventory costs to make up for the greater distance to the customer.

5.2 Role of imports in assembly of intermediate part: seat assembly

This section demonstrates the complexity of supply chains in the motor vehicle industry and what this means for identifying the extent to which the import of intermediate goods is hidden. The seat provides a good example of the challenges in distinguishing between domestic and foreign sources for motor vehicle parts.

Seats are produced at two types of plants:

- Plants that specialize in individual parts such as frames, cloth, and foam.
- Seat assembly plants that assemble seat parts into finished seats ready for installation in vehicles.

Seat assembly plants are located extremely close to the carmakers' final assembly plants, normally within one hour. Seats are delivered to carmakers' final assembly plants on a just-in-time and in-sequence basis, minutes before they are actually installed in the vehicles. Suppliers assemble seats in response to specific orders from the carmakers; the seats are placed in delivery trucks in such a manner as to facilitate unloading in the sequence needed on the final assembly line.

A carmaker's final assembly plant typically obtains all of its seats from a single seat assembly plant, and a seat supplier in turn typically dedicates a single facility to producing seats for only one final assembly plant. Because carmakers have clustered their final assembly plants in auto alley, so have seat assemblers. Therefore, one might conclude that a seat is a good example of a domestically produced intermediate part.

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[9] General Motors struck a deal to obtain Chinese alumina a few years ago at a favorable price, but assigning a market price to Chinese alumina is not easy.

[10] Huber et al. (2009)

However, a closer look at the supply chain reveals that many of the parts that go into making a seat are actually produced in other countries. A seat consists of several distinct pieces, including foam padding, leather or fabric, a metal frame, and controls for seat position and temperature. Most of the parts that go into seats involve straightforward labor-intensive tasks such as cutting and sewing. Plants producing seat parts do not have to be near seat assembly plants, and instead can locate in low-wage countries.

Trade data illustrate the challenge in identifying the extent of intermediate goods imports (Figure 6). The import of assembled seats is minimal, and is accounted for primarily by a Lear Corp. seat assembly plant in Windsor, Ontario, that delivers finished seats to a GM final assembly plant only 10 miles away, but on the other side of the Canada-U.S. border, in Hamtramck, Michigan. Other than Hamtramck, carmakers' final assembly plants in the United States receive finished seats from seat assembly plants also in the United States – and therefore the finished seat is considered a U.S.-made component.[11]

Meanwhile, between 1989 and 2007, import of seat parts increased from $621 million to nearly $5 billion. As U.S. motor vehicle production started to decline sharply towards the end of 2008, imports of seat parts fell to $4.1 billion in 2008. Imports of seat parts are destined for seat assembly plants. According to trade data, Mexico accounted for around $2.8 billion of the $4.1 billion imports of seat parts in 2008, and Canada nearly $667 million (Figure 7).[12] Thus, we can conclude that Mexico is a large producer of intermediate goods for U.S. seat assembly.

The example of seat assembly demonstrates that an intermediate good itself consists of intermediate goods, many of which can be imported. Such supply chain relations may not be currently reflected in the way import price indices are calculated.

6. Summary

This paper tries to shed some light on the measurement issues related to growing globalization by illustrating the complexities of the supply chain of the automobile industry. The production of automobiles is a large and complex undertaking that involves nearly every manufacturing industry. Assembly of motor vehicles and production of parts represented 6.5 % of all U.S. manufacturing jobs in 2008.

Imports of motor vehicle parts to the U.S. have been rising as supply chains increasingly extend across borders. Rising imports of vehicle parts both substitute for U.S.-based parts production and complement U.S.-based vehicle production of foreign producers. During the last 15 years the mix of source countries has changed considerably. In particular the share of imports of intermediate parts from low wage countries has increased. This paper provides some

[11] Two companies dominate production of finished seats in the United States – Lear Corp. and Johnson Controls, Inc. (JCI). Each has roughly 40 percent of the North American market. Faurecia, Magna, and Trim Masters hold much of the remaining share.

[12] Mexico's share of seat part imports has averaged 70% since 2000.

background on these trends. The shift of production of aluminum wheels to Mexico as well as the sourcing of seat parts represent two specific examples discussed in more detail.

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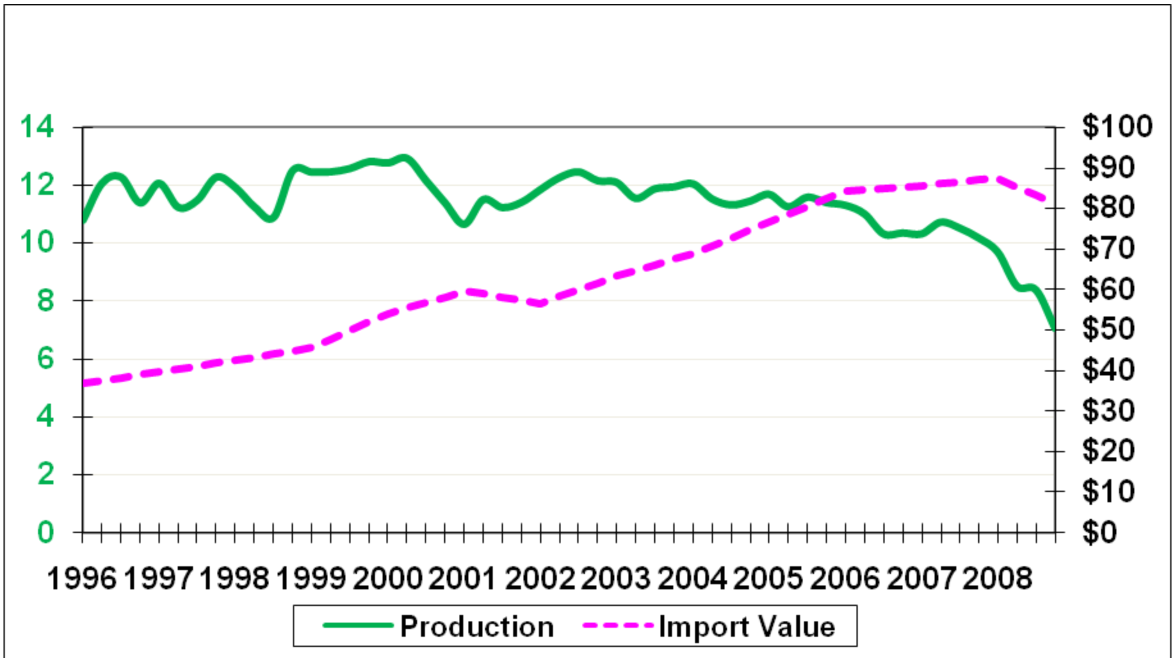
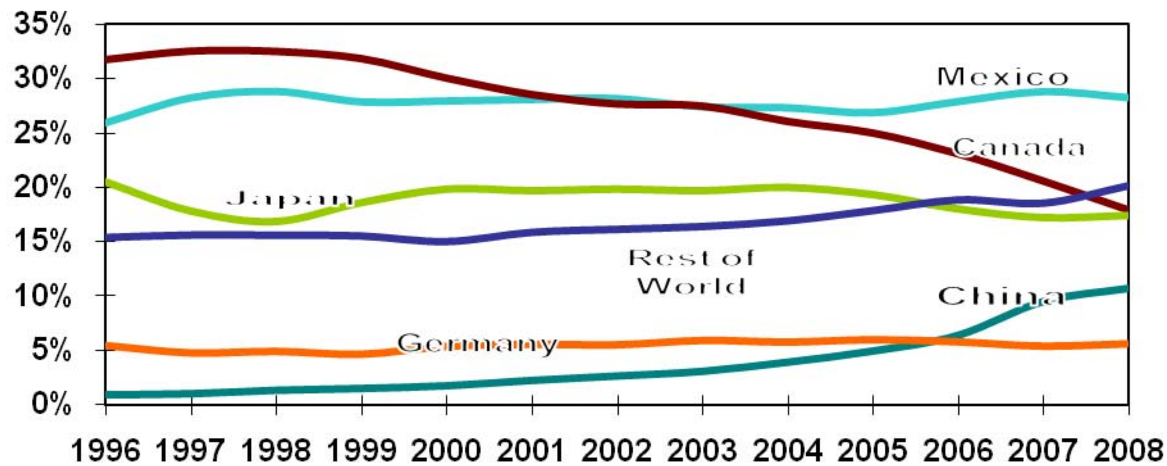
Figure 1: U.S. Light vehicle production (million units) and motor vehicle parts imports ($ bn)



Source: USITC Dataweb, Federal Reserve Board via Haver Analytics

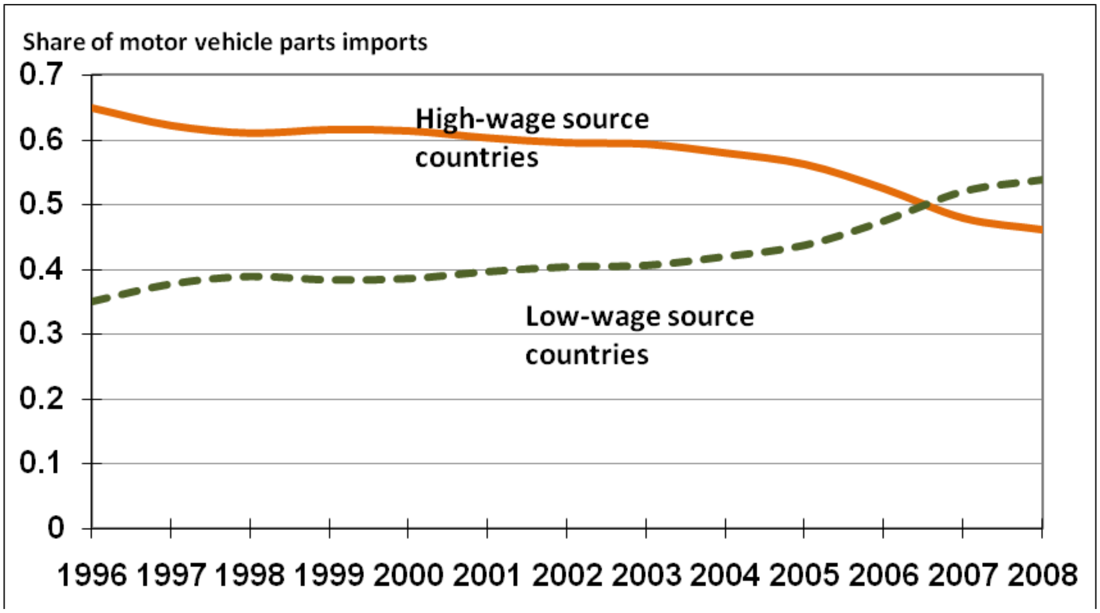
Note: trade data are of annual, light vehicle production data are of quarterly frequency.

Figure 2: U.S. motor vehicle parts imports by major source countries



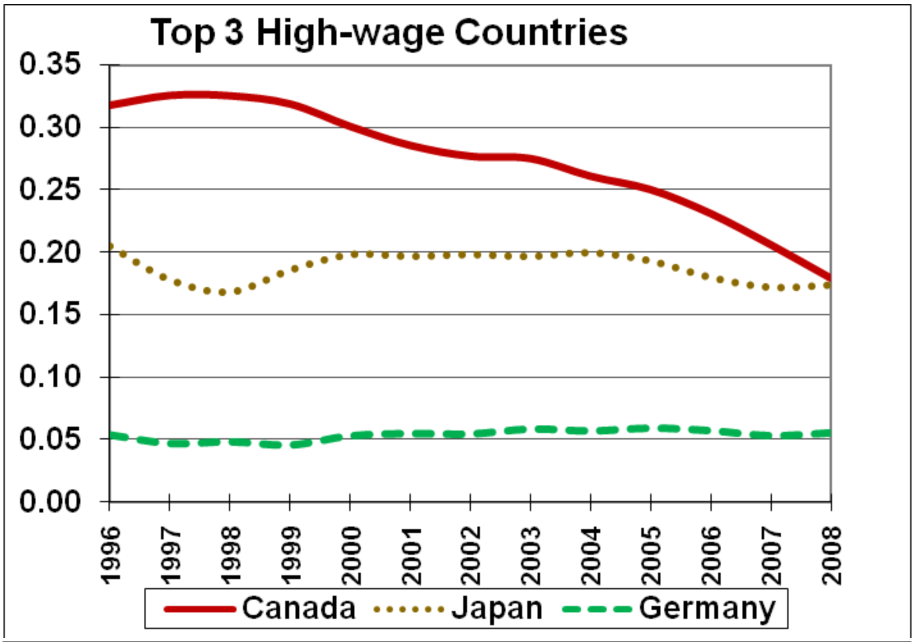
Source: USITC dataweb, author's calculations

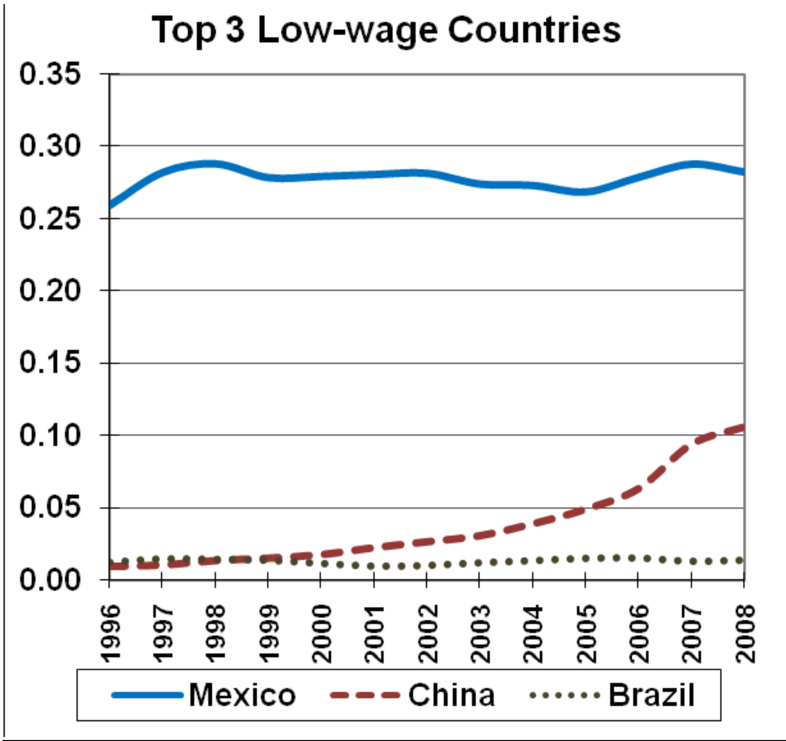
Figure 3: U.S. motor vehicle parts imports by high-wage and low-wage countries



Source: USITC dataweb, authors' calculations

<u>Figure 4: Largest high-wage and low-wage source countries for US auto parts imports</u>

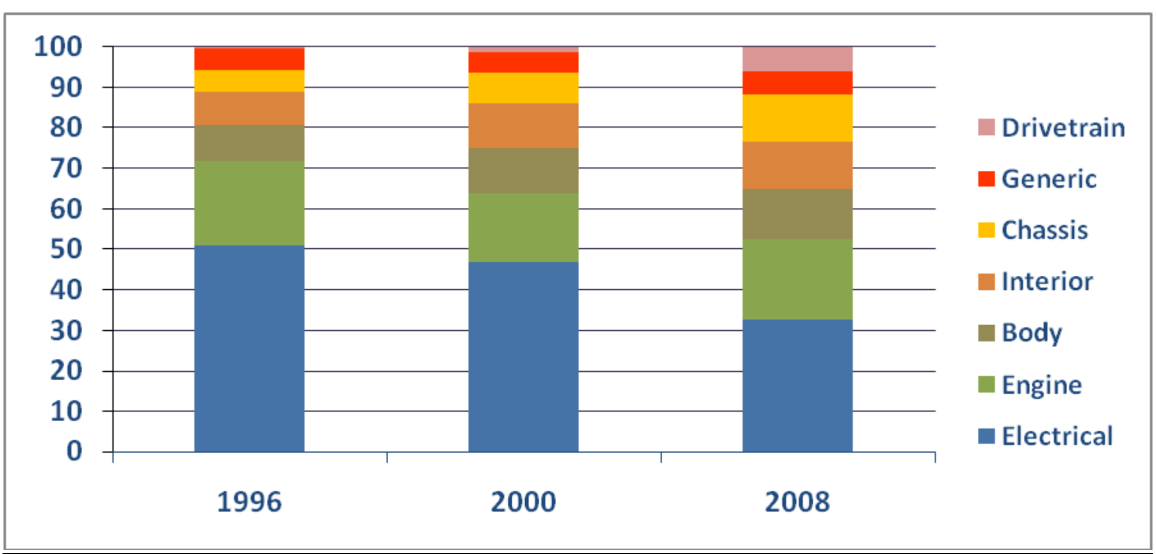




Source: USITC Dataweb and authors' calculations

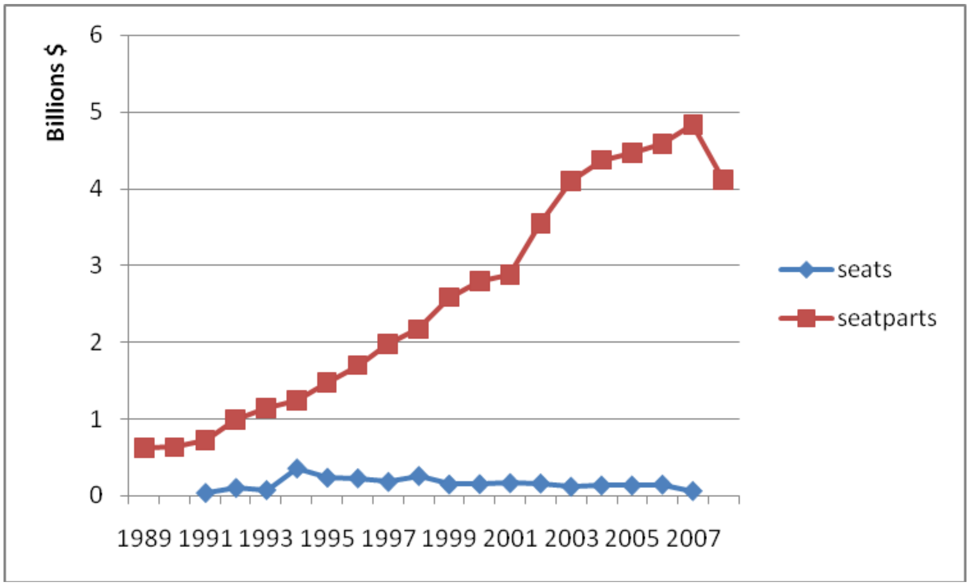
Note: Shares are out of all imports

<u>Figure 5: Motor vehicle part imports from Mexico by major subsystems</u>



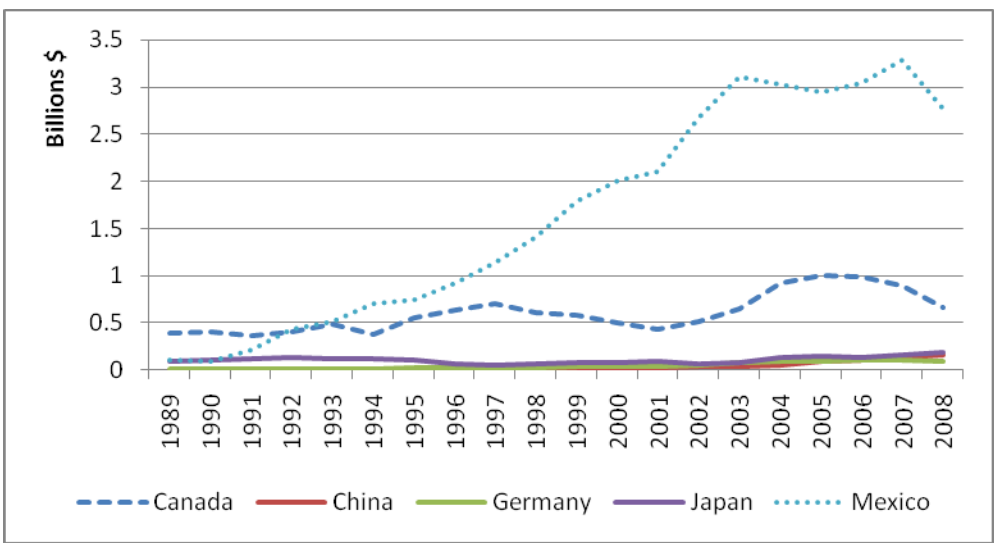
Source: USITC Dataweb and authors' calculations

Figure 6: U.S. Imports of automotive seats and seat parts



Source: USITC Dataweb, and authors' calculations

Figure 7: U.S. Imports of seatparts by largest source country



Source: USITC Dataweb and authors' calculations