Trade Data Archeology:

Reconstructing the Industrialization of Taiwan and South Korea

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Trade-Data Archeology

Introduction

While in the middle of doing research for a book comparing and contrasting business groups in two emergent Asian economies, South Korea and Taiwan, we faced a problem of evidence. The problem was as follows: Using databases showing the internal transactions during the early 1990s among member firms in South Korean and Taiwanese business groups, we were able conclusively to show that the two sets of business groups, as well as the economies in which they were embedded, differed greatly from each other. Whereas the largest business groups in South Korea were vertically integrated manufacturers of final products, the largest Taiwanese business groups either made upstream intermediate goods for other firms, assembled products whose components were made by non-member firms, or supplied services for any buyer, such as shipping or insurance. The differences between the two economies were clear from the model of economic organization that we developed and tested using the business group data that we had collected. But, as we asked ourselves, did these organizational differences make a difference in the overall performance of these two economies. To us, it seemed self-evident that these differences did make a difference, namely, that the Korean economy, organized around the very large and vertically integrated *chaebol*, should perform very differently than the Taiwanese economy, which was structured around the manufacturing output of independently owned small, medium-sized, and modestly large firms organized in production networks. But what evidence could we use to examine the economic effects of large scale economic organization. That was our problem: We needed comparable empirical evidence and a convincing methodology to link causally the organization of economies with the performance of economies.

Many analysts had examined the industrialization process in South Korea and Taiwan before us, but very few of them had looked carefully at these causal links between the way these economies are organized and what they produce. And those who did look at this linkage drew on observational accounts and anecdotal evidence. To make matters worse, in order to test our hypothesis of the emergence and simultaneous divergence of these two economies, we needed evidence covering the entire period of industrialization, roughly from 1970 to the present day.

For the export-oriented economies of East Asia, the obvious data to use is trade data. Many writers had used trade data before, but never at the level of disaggregation that we needed. They had used such data only as aggregate measures of rapid growth or as loose indications of outcomes produced by state planners. It was apparent that a large part of the difficulty in systematically using trade data for any but the most general purposes was the inability to connect trade either to specific manufacturing processes or to actual merchandising and retailing activities. In most studies, such as those espousing gravity or comparative advantage models, trade data represented supply and demand conceptualized at the most general level possible. We should not be surprised at this level of analysis, because these studies built on the best export data available at the time, usually trade statistics supplied by exporting countries, statistics that are aggregated into major product categories, such as textiles and garments. These aggregated classifications allowed few, if any, distinctions within categories or between countries producing the same range of products.

To work around these difficulties, we decided to use a database Robert Feenstra had compiled for the International Trade and Investment Program at the National Bureau of

Economic Research. As Program Director, Feenstra had put together a comprehensive database of all US imports from 1972-2001.[1] This database contains the most disaggregated trade data available anywhere. Collected by the U.S. Custom Service, the data report the country of origin for U.S. imports at a seven-digit level known as the Tariff Schedule of the U.S. Annotated (TSUSA) from 1972-1988, and at the ten-digit Harmonized System (HS) level from 1989 on. Both of these are fine enough to distinguish between four-wheeled and three-wheeled baby carriages, or between bicycles having wheel sizes between 55 and 63.5 centimeters and those having wheel sizes 63.5 centimeters and larger, or between parts of almost any export product and the whole product itself. For instance, in 1985, listed among Taiwan's 6,257 categories of export products sold to the United States were 1,691 distinct types of garments and 127 distinct types of footwear. Although these data are only for imports into one country, albeit by far the most important trading partner for both South Korea and Taiwan, we found them to be an invaluable source of data for making inferences about the organization of Asian economies, as well as the connections between Asian manufacturers and American buyers.

As we began to work with these data, we realized that they are, in fact, so disaggregated that they serves as historical records of East Asian economic development. They are the footprints left behind on the path to industrialization. They indicate the real record of growth, the best remaining record of the items that firms actually made and sold overseas and whose sales provided revenues that could be reinvested, pocketed, or otherwise used. Because trade data record the products exported, these data permit us to track the changes in the products being produced for export. The more disaggregated the data are, the more the data reflect actual items being produced. The closer we get to the actual products, the better we can make inferences about the main drivers pushing these products, as well as the firms and the economies producing those items. Of course, as for any historical study, different types of documents and records need to be triangulated in order to interpret and to be confident in the findings, and accordingly we did not rely on trade data alone. Nonetheless, the careful use of trade data provided us with one of the best ways available to examine the path of development and, by inference, the organization of economies proceeding along this path.

There are, of course, limitations to our use of these data. Systematically reported trade data are a fairly recent development (Morgenstern 1963, pp. 167-168). Standardized import/export data were only developed after the United Nations established standardized national economic statistics in the 1950s, and most developing nations only established an adequate customs accounting system in the 1960s. (For political reasons, the UN still does not report the trade statistics for Taiwan.) Therefore, we did not have access to highly disaggregated trade data for Taiwan and South Korea before 1972.[2] For the 1960s, we relied on aggregated trade data based on different classificatory systems reported in the statistics given by each country. Although the comparison are not as exact or as fine grained as we would wish, they still give us sufficient information to infer that the products manufactured for export from the late 1960s were similar to those in 1972 when standardized reporting begins.

Facing the mountainous quantity of disaggregated data, we needed a methodology that was product specific, transparent, easily understood, easily visualized, and exhaustive. It needed to be product specific, because if our hypotheses were correct the organizational differences between economies should show up in subtle differences in the products being manufactured. The methodology needed to be transparent because we needed to be able to follow production of the same products over time and to aid causal attributions. The methodology needed to be easily understood and visualized to communicate a very complex thesis to a very diverse academic audience. Finally, because our thesis is about the organization of the entire economy, rather than just a segment of it, the methodology needed to be exhaustive, that is, it needed to include all products being exported.

Therefore, we ended up using this trade data in two focused ways. First, we developed a series of representational graphs that allowed us to present a large amount of detailed data visually. Second, we developed statistical techniques to confirm comprehensively what we could visualize graphically. We divided our presentation of the data to two periods, the first corresponding to the TSUSA classification and the second to the HS classification. As we will describe, these two periods also have substantive significance, as the precedes and the second follows the decisive break that occurred with the Plaza Accord.

Visualizing Industrialization before the Plaza Accords, 1965-1985

Just concentrating on the US imports from South Korea and Taiwan, we can infer from the initial period of industrialization, from 1965 to 1985, that the primary goods produced were mostly the result of contract manufacturing. Before summarizing these findings, it is well to keep two facts in mind: First, in the initial decade of rapid economic growth, roughly from 1965 to 1975, most of the growth in both countries is accounted for by growth in the export sector of these economies. This is particularly true for Taiwan, whose population and total economy was roughly half the size of South Korea's, but whose export totals to the United States exceeded Korea's every year from 1965 to 2000. Second, in the late 1960s, exports to the United States suddenly leaped forward, making the United States by far the largest single market for exports from South Korea and Taiwan. Moreover, unlike their exports to other countries such as Japan, which included many agricultural products, the exports to the United States overwhelmingly consisted of manufactured, differentiated goods (i.e., goods that have no set prices and no established market in which prices are set [Rauch 1999]). In fact, in the twenty years from 1965 to 1985, nearly 50% of the value for all manufactured goods exported from Taiwan and 40% from Korea went to the United States. In a nutshell, then, the initial period of growth of South Korean and Taiwanese economies primarily resulted from manufactured exports to the United States.

A detailed analysis of these exports into the United States from 1972 until 1985 shows two sets of trends. One set of trends shows basic similarities between South Korea and Taiwan in their pattern of exports to the United States, and the second set reveals that underlying these similarities are basic and increasingly apparent differences between the two economies. The similarities between the two countries reflect similarities in the demand from intermediaries, and the differences grow out of the divergence in economic organization between the two countries that was present at the outset of industrialization and that increased as time went on.

Similarities in Trade Patterns

To give a sense of the similar patterns in export growth, Figure 1 shows, especially in the early years, the tremendous increase in the value of exports to the United States, and Figure 2 shows the ratio of exports to the US in relation to the total exports. Clearly, the exports to the United States account for most of the increase in total exports until the 1980s. Figure 3 gives some depth to this pattern. In the early years of industrialization, until 1985, there was in both countries a rapid proliferation of the categories of goods (at a seven digit level) exported to the US, and a less spectacular but still substantial growth in the number of categories of garments and footwear in that total. Nothing so far is surprising, but in Figure 4 we see that, despite the fact that both South Korea and Taiwan exported thousands of different categories of products to the United States, the total value of the exports is highly concentrated in only a few product categories. The highest concentration for both countries occurs in the earliest period, with nearly 50% of the value of Korea's exports to the United States and 25% of the value of Taiwan's exports contained in only 10 seven-digit categories. The concentration lessens in the early 1980s, but then increases again in the late l980s and throughout 1990s, so that by 2000, the top 10 ten-digit items in both economies accounted for over 30% of the total value of exports to the United States, while the top 100 categories account for over 60% of all exports. We should note a difference here as well: throughout the entire period, Korea's exports are consistently more concentrated in only a few product categories than are Taiwan's exports.

Export Landscapes

Exactly what were the top categories of exports and what were the patterns of change over time? Aggregating the TSUSA categories at the three-digit level for the period from 1972 to 1988, which is the entire period this classification system was used, we can see, in Figures 5 and 6, that during this fifteen year-period most imports from South Korea and Taiwan occurred in only a few general product categories and that, at the three-digit level, the export landscapes of both countries look very similar. Going from the left to right, the peak categories above two billion US dollars in one or both export landscapes are plywood (TSUSA 240), garments (381-384), steel (610), machinery and component parts of machinery (646) (653), (661), (676), electrical appliances (684), electronic products (television and radio (685), (687) transportation vehicles and parts (692), footwear (700), luggage and related products (706), furniture (727), bicycles (734), (737) rubber and plastic products (772), and leather products (791).

All these figures in this section show similarities in patterns of export trade between South Korea and Taiwan. As we will spell out more fully below, these similarities primarily reflect export pull, that is, the demand from big buyers choosing what categories of goods to buy from South Korean and Taiwanese manufacturers. Within these categories, there is a huge range of very different sorts of products, and it is in the manufacture of these products that systematic differences between South Korea and Taiwan emerge.

Differences in the Patterns of Goods Produced for Export

If we examine inside the main three-digit categories that are so prominent in the export landscape, we find that the similarities mostly disappear and that the differences emerge and become increasingly obvious over time. Several trends are apparent in this regard. The first trend is that, in the earliest period of import data from 1972 to 1976, the export profile of both countries contained very similar and often identical products, and that most of the value of each broad category was highly concentrated in only a few products within that category. Remember this is the period before specialized buying strategies and specialized manufacturing strategies had emerged, a period when buyers were making their first big orders and when local manufacturers were engaged in intense competition to obtain these orders. In these years, for example, garments exports were among the highest categories of exports from both countries, with garments providing about a third of the total value of Korea's exports to the United States and a quarter of Taiwan's. Among the 263 and 345 types of garments that South Korea and Taiwan, respectively, exported to the United States in 1972, the top five items provided 42% of the total value of garments from Korea and 39% from Taiwan. Three of the top five garment items are the same for both countries, namely specific types of sweaters, knit shirts, and trousers, all for women and girls.

The second trend emerged, between 1975 and 1985, when intermediary demand for Asian goods dramatically increased and when buyers and manufacturers began to figure out their respective strategies to fill that demand. In this period, as orders began to pour in, the composition of products in each category begins to change, and the product mix of exports from each country in each category increases dramatically. This trend is true for both countries, but especially so for Taiwan**.** This second trend merges with a third trend: Very quickly a division of labor emerged between South Korea and Taiwan, with each country beginning to specialize in particular products within each category. In some cases, such as footwear, specialization appeared very early in the process, as is clear from Figure 7.[3] This figure shows that, even from the very first period of our data in 1972, Taiwanese and South Korean footwear exports were producing somewhat different types of footwear, even though they shared some of same products (a type of soft sole vinyl shoes for women). However, as new categories emerged by the middle 1970s, a clear division of labor between Taiwan and South Korea footwear manufactures was established and continued to grow throughout the entire period, with Taiwan specializing in rubber and plastic shoes and South Korea in leather shoes.

Rubber and plastic products, which are an important export items for both countries throughout the period, shows another variation of these two trends. Before 1975, both countries predominately exported rubber and plastic wearing apparel to the United States, but as Figure 8 shows, after 1975, Korea increasingly specialized in exporting various kinds of tires—tires for cars, trucks, buses, and bicycles—while during the same interval, Taiwan's exports in this category expanded to include an array of products in addition to plastic wearing apparel: religious articles, household furnishings, curtains, Christmas tree ornaments, as well as some bicycle tires.

Fourth, during this fifteen year period leading up to 1987, products within categories gradually begin to segment, with South Korean exports in most categories increasingly consisting of products that could be mass-produced (e.g., in garments: men's shirts, as opposed to women's fashion), and often, but not always, were final products ready for consumer use, such as microwave ovens, video machines (VCR's), tires, and automobiles. In contrast, within the same three-digit product categories, Taiwanese exports tended to be component parts, goods having short product cycles (e.g., in garments: women's clothes), and some fairly complex final products that can be assembled from standardized components (e.g., computers, TVs, and bicycles), this in addition to a considerable range of relatively inexpensive simply made consumer products (e.g. luggage, household products made of plastic). Figures 9 and 10 depict the clearest examples of this trend, household appliances and transportation parts and equipment, including bicycles and bicycle parts.

In summary, this analysis of trade data reveals a sudden and accelerating expansion of exports from South Korea and Taiwan that began in the late 1960s and that does not level off until the mid to late 1980s, twenty years of extraordinary growth. The rapid emergence of these exports was highly concentrated in only a few product categories. As Figure 11 and Figure 12 show, demand in these categories grew rapidly, so that many goods continued to be produced in common, but within these categories during this twenty-year period export products began clearly to diverge, as each economy began to specialize in particular types of production capabilities and the products compatible with those capabilities.

Our analysis reveals one more characteristic of the exports from both countries that we have not yet discussed. Examining the trends over this twenty-year period, we have been struck by the sudden oscillations in products in nearly every major category of exports to the United States. Many product lines, particularly those with less total value, expand rapidly for a few years and then go into an equally rapid decline, seemingly being replaced by a score of nearly equivalent goods. Some of these shifts are due to changes in classification between years, but the oscillations also come from changes in the demand, or more precisely abrupt changes in the orders for goods as buyers seek out new product styles and the lowest-cost suppliers. It is difficult, if not impossible, to explain these oscillations only from the producer side. These are clearly demand-driven changes.

Linking Exports to Intermediary Demand

The principal exports from both South Korea and Taiwan are exactly those products that fueled the retail revolution in the United States: garments, footwear, bicycles, toys, televisions, microwaves, computers, thousands of plastic household and office items, and a large array of semiconductors that have in turn become the core components in a vast and growing number of other products, such as cell phones and digital cameras. This retail revolution is described more fully in our book (Feenstra and Hamilton 2006), but what is important here is that this period of time marks the rapid rise of consumer goods imports into the U.S., goods that were increasing sold by discount retailers and brand name merchandisers. This import penetration is shown in Figure 13.

Using the trade data on imports collected by the US Customs Service, we can be precise about these imports. For instance, we know for sure that in 1985, South Korea and Taiwan were two of the three largest importers into United States of all garments with nearly 28% of the total value (along with Hong Kong which itself exported an additional 24% of the total). Within that total, the two countries sent 26% of the value of all imported women’s garments and 60% of the value of all imported men’s shirts. Also in 1985, Taiwan imported into the United States 57% of total value of all imported bicycles, and Korea 28% of all imported microwaves. In the same year, the two countries imported into the United States 54% of all handbags and luggage, 40% of all toys and games, 36% of all television sets, 24% of a huge category of miscellaneous rubber and plastic products, and a whopping 50% of imported footwear of all types. If we go to the seven-digit level, then in 1985, Taiwan supplied 100% of 55 different categories, and South Korea 100% in 24 different categories of products, most of which for both countries were categories of textiles and clothing.

If we survey the main items of exports throughout the period from 1972 to 1985, it becomes clear that products secured through contract manufacturing forms an extremely high percentage of the total exports. For instance, according to a report on the Korean garment industry (cited by Lee and Song, 1994, p. 148), "Until 1988, approximately 95 percent of garment exports were produced under contract to foreign firms, rather than under Korean-owned labels." According to Levy's analysis of the footwear industry in South Korea and Taiwan (1988, p. 46), "(I)n the initial phases of export expansion," Levy notes, "export business in both nations was based overwhelmingly on the fulfillment of orders placed by Japanese trading companies, and designed for the US market." Japanese trading companies were soon supplanted as Western firms began to place their orders directly. In both countries, Western brand name merchandisers, such as Nike and Reebok, controlled export footwear industry (Levy 1988, 1990). Also in his case study of the manufacture of personal computers in the two countries, Levy (1988) cites figures from the trade associations for electronic appliances that 84% of Korean-made personal computers and 72% of Taiwan-made computers were sold under non-local brand names. The world's largest exporter of bicycles during the 1980s and early 1990s, Taiwan's export industry until the late 1980s was largely OEM manufacturing (Cheng and Sato 1998). At one point in the late 1970s, Schwinn placed an order of 100 million bicycles with Giant, "which was then only a small factory" (Cheng and Sato 1998, p. 7).

Examining the lists of exported finished manufactured products in those early years of economic growth, it is difficult to find any major product category that was not dominated by contract manufacturing or any major retailers that were not involved in contract manufacturing in East Asia. Garments, household appliances, electronic products, toys, bicycles—the majority of all of these finished exports were sold under foreign-owned brand names and product labels. Many manufactured exports from both countries, but especially from Taiwan, were component parts, and other types of intermediate goods, such as textiles. A sizeable amount of other manufactured exports were inexpensive unbranded products, such as kitchen items and tools of various kinds, which were sold in a range of retail outlets, often in discount stores, such as K-Mart and Wal-Mart. As long as they were purchased from South Korean and Taiwanese firms in contracted batches for assembly or sale elsewhere, however, even the simplest and least expensive items were driven by intermediary demand.

From the perspective of America's total imports in the late 1960s and 1970s, those imports from East Asia represented only a modest but steadily increasing percentage, especially in comparison with imports of oil from the Middle East and manufactured and agricultural products from Europe. But from the perspective of Asia's industrial expansion, these US bound exports accounted for a huge percentage of the total output of these Asian economies and drove these economies forward into capitalism. Ironically, the very success of these Asian connections also helped to transform the retail and manufacturing structure of the United States.

What made East Asian countries, and specially Taiwan and South Korea, such good places to arrange buyer-driven manufacturing? Gary Gereffi (1994) whose work has consistently informed our own, argues that the greatest advantage of doing business in South Korea and Taiwan is the capability of firms there to act as "full-package providers," able to execute every step in the manufacturing, packaging, and delivery processes, and, remarkably, they were able be full-package providers from the very first. In other words, the reason these economies became so crucial to American retailers and mass-market merchandisers is that they adapted to and were instrumental in the construction of intermediary demand. Their advantage was their demand-responsiveness.

Visualizing Industrialization after the Plaza Accord, 1985-2001

On September 22, 1985, at the Plaza Hotel in New York City, after years of running trade deficits with South Korea, Japan, and Taiwan, the United States completed negotiations on a currency reform measure that all parties signed. The Plaza Accord, as this currency reform became known, removed the pegged trading range of East Asian currencies with the U.S. dollar and allowed the Asian currencies to appreciate. Within two years, Taiwan's currency moved from 40 to 30 New Taiwan dollars to one US dollar, while Korea’s currency appreciated more moderately. In the span of just a few years, the Japanese, Taiwan, and, to a lesser degree, South Korean economies went through a momentary period of jubilation, a period when everyone felt much richer and many began to make extravagant purchases at home and abroad. The period of jubilation ended quickly, however, when domestic manufacturers realized that they could not longer meet the price points that the U.S. retailers and merchandisers required.

Based on interviews made in Taiwan at the time (Kao and Hamilton 2000), leading manufacturers lowered their own profit margins to the point of breaking even, and had to relentlessly squeeze other firms in their production networks. They complained of working harder for longer hours and for less pay than they did in the early 1980s, when it seemed like everyone was getting rich. By 1990, in both Taiwan and Japan, the property and stock market bubble collapsed. Japan entered a long, deflationary recession, from which, in the year 2005, it has yet fully to emerge.

The currency revaluation stopped the Japanese economy in its tracks, but not its main exporting firms. By the late 1980s, Japanese industries were major OEM suppliers in only just a few products (e.g., microwaves, computers). Instead, many of the largest Japanese business group had gone to considerable effort to build their own globally recognized brand names (e.g., Sony, Panasonic, Toyota) or to use their technology to develop upstream products, such as Toshiba's LCD panels and Shimano's bicycle gears, that they then could sell to all makers of the respective products. In order to remain competitive in terms of price and quality, the major Japanese companies transferred their final assembly sites, along with some production, to other countries. The automobile makers went to the U.S. to achieve cheaper costs and avoid tariff barriers (Kenney and Florida 1993), and also invested heavily in Southeast Asia, especially in Thailand (Doner 1991). The huge consumer electronic conglomerate, Matsushita, transferred much of its manufacturing and assembly to Malaysia, where it contributed about 5% of Malaysia's GDP. The effect of these foreign direct investments on the domestic economy was widely reported as the "hollowing out" of the Japanese economy.

Unlike Japan, South Korea and Taiwan were able to escape severe recessions, and they even were able to increase their exports, but they did so in characteristically different ways. By 1985, the four largest South Korean chaebol (i.e., Hyundai, Samsung, Lucky Goldstar, and Daewoo) dwarfed all the other business groups in South Korea in size and sales, and virtually monopolized exports from South Korea. After the currency evaluations, these behemoths began to follow the precedent set by the largest Japanese business groups, establishing global brand names and developing higher quality, up-market products. They extended the scope and scale of their enterprise groups in Korea, and they began to systematically globalize their business. They built manufacturing plants in cheap labor areas, such as Indonesia and Central America for shoe and garments, as well as in locations near their target markets, such as in Eastern Europe. They established an array of differentiated products--Samsung and LG in consumer electronics, Hyundai and Daewoo in automobiles--that undercut the prices of their Japanese competitors. This strategy led these business groups to disengage from U.S. branded products, but still allowed them to market their products with American retailers, in competition with all other brands (Lew and Park 2000).

In the wake of the Plaza Accords, many of Taiwan's export manufacturers faced a serious dilemma (Kao and Hamilton 2000; Hsing 1998). They had OEM contracts for goods that they needed to deliver to U.S. retailers, but they could not produce those goods profitably. If they failed to honor their contracts, the retailers and brand name merchandisers would easily find other manufacturers to make the products. If they stayed in Taiwan and honored their contracts, they would likely go bankrupt, and lose the contract anyway. After several years of hesitation, those small and medium sized firms making garments, bicycles, footwear, and other types of similar consumer goods moved their manufacturing operations to China. The move occurred suddenly, like a stampede, in a matter of just a couple of years. The abrupt departure of so many exporters shows up clearly in the trade statistics. In some industries, such as bicycles, most of the production networks moved to China when the lead firm moved, but in other industries, such as footwear, toys, furniture, and garments, only the lead firm moved, and once in China, they vertically integrated their production, producing most component parts of their products in-house. Many firms producing for export, however, split their operations, with low-end mass production going to China and the high-end batch production staying in Taiwan.

In the late 1980s and early 1990s, at the same time when Taiwan's most successful export manufacturers were contemplating moves to China, or perhaps to Southeast Asia, the high technology boom occurred in Silicon Valley. Taiwan's high technology industry was closely linked to Silicon Valley through multiple connections (Saxenian 1999). Early on, Taiwanese manufacturers were leading producers of PC peripherals and component parts, but as the boom in the U.S. continued, Taiwanese manufacturers, in their own Silicon Valley outside of Hsin Chu in north central Taiwan, began to make more and more of the standardized PC components and founded a number of leading PC firms, most notably Acer Computers. Along with several other firms, Acer became one of the world's leading OEM producers of inexpensive PCs. The high technology in Taiwan was also fed by the establishment of semiconductors foundries, which are upstream firms that made semiconductors chips to order for any downstream firm that designs and wants to use those chips in dedicated products. The first and most important of these foundries was the government-sponsored Taiwan Semiconductor Manufacturing Association (TSMC).

Major retailers and brand name merchandisers, such as Dell Computers, Hewlett Packard, and Gateway, were primary drivers of Taiwan's high technology industry. As the demand for these American branded products rose, so too did the productive capacity of Taiwan's high technology manufacturers. The success of these firms was not based on, and did not lead to, the efforts to develop their own brand names; rather they continued to upgrade their capabilities as high level contract manufacturers deeply integrated in industries led by U.S. retailers and merchandisers.

It is against this background that we examine the overall pattern of exports from South Korea and Taiwan to the U.S. after 1989, and then discuss the trends in particular industries.

The Plaza Accord immediately made the export goods from both economies more expensive abroad, and accelerated the shift out of labor-intensive products towards more high-skilled and capital-intensive exports in both Taiwan and South Korea. This shift corresponds in time with a change in our U.S. import data in 1989, from the Tariff Schedule of the USA (TSUSA) to the Harmonized System (HS).

Export Landscapes

The broadest pictures of exports from the two countries can be obtained by aggregating the HS system to 3-digit categories of goods and summing exports over 1989-2000. The resulting “export landscapes” are plotted in Figures 14 and 15, and we have labeled those 3-digit categories with cumulative exports exceeding $5 billion. The dominant export industries in both countries are those within the HS 800 category, which includes various types of machinery and mechanical appliances, electrical equipment, and parts thereof. The largest exports from Korea are from two categories of high-technology equipment: semiconductors and integrated circuits (854), with cumulative exports exceeding $50 billion over 1989-2000, and office machines and parts (847) with cumulative exports of about $40 billion. The relative ranking of these industries is reversed for Taiwan, where cumulative exports within office machines and parts (847) exceeds $80 billion, which is more than twice as much as that exported within semiconductors and integrated circuits (854). This reversal reflects a rather profound difference in the export orientations of the two countries, whereby Korea has focused on DRAMs within semiconductors, which is a large-volume but highly competitive product, whose price fluctuates a great deal with changes in global capacity and demand. Taiwan, by contrast, has focused on the assembly of personal computers and their components, and within the semiconductor category, has specialized in smaller-volume chips that are customized to the needs of buyers. These products are less prone to price fluctuations.

The next largest cumulative exports from Korea are close to $25 billion for both video, radio and TV equipment (852) and motor vehicles and parts (870). Taiwan exports about half as much within the former industry, though it also has cumulative exports exceeding $10 billion in the related industries of electric motors, generators and appliances (850) and electronic devices for cars, lighting and communication (851). It exports almost no motor vehicles at all, though it does have substantial exports of their parts. The other industries that show up in the export landscape for Taiwan include certain plastic products (392), outer garments (611 and 620), footwear (640), wires, nails and screws (731), motorcycles, bicycles and parts (871), household furniture (940) and toys (950). Korea has cumulative exports exceeding $5 billion in many of the same industries, and in addition, trunks and bags (420).

Of these items with the highest cumulative exports over 1989-200, some are declining in importance over time. In particular, the less technologically sophisticated products (plastic products, trunks and bags, and footwear) are no longer among the top exports from either country in 2000. Rather, the exports for both countries become concentrated in a fairly narrow range of knowledge and capital-intensive products, and this concentration is greater in Korea and than in Taiwan. There are eighteen 3-digit HS categories where the exports from Taiwan to the U.S. exceed $500 million in 2000, and only nine such categories for Korea. The single 3-digit industry with the greatest exports from both countries is office machines and parts. For the “top nine” industries for Korea,[4] average exports to the U.S. in 2000 are $3.3 billion, or $2.7 billion if we exclude office machines and parts. In comparison, average exports from Taiwan in its “top nine” exporting industries is $2.9 billion, or $1.9 billion with office machines and parts excluded.[5] Thus, with the exception of office machines and parts, Korean exports are more concentrated in a narrower range of industries than are Taiwanese exports to the U.S.

There is an important difference in exports over time among these major industries, as shown in Table 1. In part A of Table 1 we report the 3-digit HS categories whose recent annual exports from Korea or Taiwan exceed $2 billion; in part B we include the “top eighteen” industries whose exports exceed $500 million in 2000; and in part C we include all exports to the U.S. The “top eighteen” industries are also graphed in Figures 16 and 17.

Korean exports of semiconductors to the U.S. reached a peak of about $7 billion in 1995, but declined in the years immediately thereafter due to falling prices (Table 1 and Figure 16). Exports in 1998, for example, were nearly $2 billion below their 1995 peak. Much smaller declines in Korean exports also occurred within office machines, and video, radio and TV equipment. Taiwanese exports within these industries, by contrast, declined slightly or not at all over the year 1995-2000 (Table 14 and Figure 17). This reflects differences in the composition of exports within these broad industries, as we will examine in detail later in the chapter.

Notice that over 2000-2001, however, high-technology exports from both countries to the U.S. experienced a marked decline, which was due to the U.S. recession and reduction in business investment. But Korean exports of motor vehicles remained high, held up by strong consumer demand for durables in the U.S. So while reduced exports of high-technology equipment from Korea was partially offset by growing export of motor vehicles, this did not occur for Taiwan, where the U.S. recession hit squarely its dominant high-tech exports with little or no offset in other industries. These trends are also evident if we look at the eighteen industries exporting more than $500 million from either country to the U.S. in 2000 (part B of Table 1), or more broadly at total exports (part C). The total Korean exports from the “top eighteen” industries experienced a pronounced fall in the years 1995-1998, then rise to 2000, and fall by about 14% from 2000 to 2001. In contrast, the Taiwanese exports in the "top eighteen" industries rise continuously from 1995 to 2000, and then fall by 20% to 2001. Taiwan managed to escape the softening in export demand that hit Korea prior to the 1997-98 financial crisis, but was impacted more strongly by the 2000-2001 U.S. recession.

These differences in the time-path of exports from the two countries feeds back on their economies, and offers an explanation for why Korea suffered most during the financial crisis, whereas Taiwan has experienced a slowdown more recently. The reason for the differential response is intimately tied, we believe, to the different structure of the high-tech industries across the two countries. We begin by examining the somewhat simpler case of the transportation industry, which includes both motor vehicles and parts (HS 870) and motorcycles, bicycles and part (871). This industry will be used to motivate our measurement of product variety and "mix"

Transportation Industry Exports

Korean exports of automobiles, from Hyundai, Daewoo and Kia, are well known to consumers in America and worldwide. In 1997, on the eve of its financial crisis, Korea was the world's fourth largest producer of automobiles and the sixth largest exporter of automobiles (Kim, 2000, p. 60, note 1). What is most exceptional about the automobile industry in Korea is that, unlike other developing and newly industrialized countries, Korean groups have been able to build and export the entire car, while establishing brand-name recognition and dealerships on a global scale. In contrast, Taiwan produces finished automobiles primarily for its domestic market, while exporting a plethora of automobile parts as well as being a leading global producer and exporter of bicycles. Thus, Korea has intentionally transformed its automobile industry into a "producer driven" commodity chain, whereas Taiwan has continued to export as part of "buyer driven" commodity chains.

The distinction between these two types of commodity chains is described by Gereffi and Korzeniewicz (1994, p. 7):

> The difference between the two types of commodity chains resides in the location of their key barriers to entry. Producer-driven commodity chains are those in which large, usually transnational, corporations play the central roles in coordinating production network (including backwards and forwards linkages). This is most characteristic of capital-and technology-intensive commodities such as automobiles, aircraft, semiconductors, and electrical machinery. Buyer-driven commodity chains, on the other hand, are those in which large retailers, brand-named merchandisers, and trading companies play the central role in shaping decentralized production networks in a variety of exporting countries, frequently located in the periphery. This pattern of industrialization is typical in relatively labor-intensive consumer goods such as garments, footwear, toys, and housewares.

In producer-driven chains, the producers themselves decide what models to push onto the market; but in buyer-driven chains, the retailers and merchandisers perform the design and marketing functions, and have these orders filled through their network of suppliers. The characterization of the automobile industry as a "producer-driven" chain applies mainly to the production of finished vehicles in industrialized countries, as well as in Korea. Outside of the industrialized countries, assembly may occur simply through "knock-down" sets or the production of labor-intensive component parts. Taiwan has focused on the production of high-quality aftermarket components such as brakes, mufflers, and other auto supplies, which are retailed through Grand Auto, Wal-Mart, Sears and other distributors in the U.S. (Biggart and Guillén, 1999, p. 735).

Both South Korea and Taiwan started at about the same place in the automobile industry: in 1972. Taiwan manufactured twice as many vehicles as South Korea – 22,000 as compared to 9,500.[6] In the years that followed, however, these industries followed quite different paths. By 1987, Korea had reached the production of nearly a million vehicles, over four times as many as Taiwan.[7] While most cars were still for the domestic market, it then turned towards the huge international market. Hyundai exported its first car to the United States in 1986, and by 1995, slightly more than half of production was for export (Kim, 2000a, p. 64). Notice that Hyundai's success occurred despite the appreciation of the Korean won following the Plaza Accord. In contrast, the larger appreciation of the New Taiwan dollar after 1986 effectively foreclosed Taiwan's entry into the export market for finished vehicles: the government had attempted to attract foreign producers to Taiwan, but a deal with Toyota fell through in 1984, and after 1986 the Japanese producers looked towards the lower wages found elsewhere in Southeast Asia.[8]

Interestingly, the very policies that encouraged the Korean *chaebol* to become major exporters of motor vehicles appear to have hindered Korean firms from producing automobile components. Initially, programs such as the Automobile Industry Protection Law (1962) and Automobile Industry Basic Promotion Plan (1969) prohibited imports of assembled cars but allowed for tariff-free imports of components.[9] Later, the Korean government tried to encourage more local production of components by raising local content requirements in the late 1970s, but this only created a protected local market for component producers, and they never achieved the quality levels required for mass export. Of one recent poll conducted with Korean parts producers, two-thirds reported that they did not export at all, and of those that do export, the share of exports in often quite small.[10] On the import side, some of the most technologically advanced components of the automobiles – such as the power transmission – continue to be imported into Korea from Japanese producers (Kim, 2000a, p. 68).

While the impact of exchange rate changes as well as government policies are no doubt important in shaping the industry across the two countries, Biggart and Guillén (1999) argue that the key difference is the organizational capacity of the *chaebol* to harness the resources needed to design, produce and market finished vehicles. Acting through a combination of low-interest funds from the state, vertical links to suppliers, and fierce competition between each other, the largest *chaebol* were able to overcome the barriers to entry inherent in auto manufacturing, and produce cars that were second in quality but among the lowest in price. In contrast, the economic organization of Taiwan, with the business groups located upstream and many small and medium-sized firms downstream, never would have supported global production and exports from this capital-intensive industry: "The economy of densely networked family firms is ill suited to a capital-intensive enterprise such as auto assembly. It is ideal, however, for producing capital-light but knowledge-intensive products."[11]

The differences in the exports from this industry to the United States are illustrated in Figures 18 and 19, which use the principal products from the HS categories 870 and 871. Korean exports are focused predominantly on the passenger car (Figure 18). While these exports experienced a significant decline from 1989 to 1993, they began to grow again in 1994 and nearly recovered to their former values by 1997, just prior to the Asian crisis. There was fall in exports to 1998 due to the crisis, and then a rapid rise again through 2001, by which time exports of automobiles and parts to the U.S. exceeded $6 billion. Taiwanese exports, by contrast, remained much more stable over the 1989-2000 period and are spread across a much wider range of products (Figure 19): in addition to a very small number of cars, there are substantial exports of automobiles parts, bicycles, parts for bicycles, trailers and parts, and even wheelchairs and baby carriages! There is an increase in exports of some $300 million over 2000-2001, but the magnitude of exports remains small in comparison to Korea.

Hypothesis Testing with Trade Data

With this example from the transportation industry, we need to formulate a specific hypothesis that would allow us to distinguish these exports from Korea and Taiwan and that can be applied across other industries. We are not attempting here to capture the rich dynamics of specific industries, nor the details of their institutional differences. Rather, we are looking for a key difference between the exports of these countries that would show up in any year, and would allow us to evaluate the role that economic organization plays in their export patterns.

In our book (Feenstra and Hamilton 2006), we described an important hypothesis arising from the model of business groups: an economy dominated by strongly vertically-integrated groups (V-groups), as we have argued characterizes Korea, will have *less product variety* of final goods than a like-sized economy where the business groups are primary located in the upstream or downstream sectors, as characterizes Taiwan (with its U-groups and some D-groups). This holds even though the *individual* V-groups are actually diversified across a very wide range of final goods, as applies to the large *chaebol* in Korea, especially. Thus, despite the diversification across products and markets of the *chaebol*, we predict less product variety for the entire economy than obtained from the smaller and more dispersed groups in Taiwan.

This seemingly paradoxical conclusion comes from the overall resource constraints for the economy, i.e. the limits on what can be produced given the labor, capital and natural resources. The V-groups in our model, like the largest *chaebol* in Korea, benefit from access to a wide range of differentiated intermediate inputs from the group firms, sold at marginal cost. The production costs of final goods are therefore low, and so the V-groups find it most profitable to produce a higher quantity of *each* final good than would other types of groups, or unaffiliated firms. This fits, for example, the often reported desire of the top *chaebol* to become "world leaders" in specific commodities, such as cars, microwave ovens, or semiconductors. But with the V-groups produce a high quantity of each final good, it is impossible for the economy to also produce *more product varieties*, given its resources. On the contrary, an economy with groups primarily in the upstream sectors (U-groups), like Taiwan, actively selling goods downstream to unaffiliated firms, will have higher product variety than would the like-sized economy that is organized with V-groups.

This theoretical conclusion is illustrated in Figure 20, where we plot the total number of final goods produced, or product variety, in each of the equilibria. On the horizontal axis we measure the elasticity of demand for differentiated inputs, which takes on a single value in each equilibrium. For each value of the elasticity, we solve for one or more equilibria, and then compute the economy-wide level of product variety. In the book, we distinguish several types of equilibria: those without any unaffiliated firms, but just strongly vertically-integrated group (V-groups); those with downstream firms, receiving inputs from the less vertically-integrated business groups upstream (U-groups); and those with upstream firms, selling inputs to the business groups located downstream (D-groups). Each of these are labeled as such.

From Figure 20, we see that the extent of product variety in the V-group equilibria are *always less* than the product variety in either the D-group or the U-group equilibria. Product variety in the D-group and U-group equilibria themselves are roughly comparable. Thus, when the business groups sell to downstream unaffiliated firms, as in the U-group configuration, the economy will achieve a greater variety of the final product than in an equilibrium consisting of vertically-integrated groups. The U-group configuration is how we have characterized many of the business groups in Taiwan, while the V-groups describe the largest *chaebol* in Korea. Given that the size of these economies is similar,[12] this leads to our first testable hypothesis: that Taiwan will exhibit *greater product variety of final goods* than South Korea. Because the final goods are also exported in our model (whereas the intermediate inputs are not),[13] we restate this hypothesis as: there is *greater product variety* ***of exports*** *from Taiwan than Korea, reflecting its less integrated group structure.*

A second, related hypothesis is that the *most diversified* groups in either country will have greater incentive to develop a reputation in *high-quality*, which would lead to an increase in demand for all its products. That is, any action that shifts out the demand curves for all its products, such as building reputation, will more valuable to a large multi-product group than to a smaller group or to a single-product firm. Thus, the second hypothesis is that in *market dominated by large, diversified business groups, we expect higher product quality than if the market is served by smaller groups or single-product firms.* This result is obtained theoretically by Rodrik (1993), who supposes that the level of product quality perceived by buyers equals the *averag*e product quality within an industry. In that case, groups that have a high share of sales within the industry have a greater incentive to improve product quality. The hypothesis does not directly follow from the model we described in the book, because of a simplifying assumption we used there: that all groups were "symmetric" in equilibrium, producing the same quantity and charging the same price for each good (this rules out any differences in product quality). We introduce this second hypothesis, however, because it is a natural extension of our model and it turns out to be easy to test empirically using the same data used to measure product variety.

Product Variety and Quality Indexes

Product Variety

Returning now to the example of the transportation industry, we shall use this to explain our measure of product variety and product quality. In addition to using the disaggregate HS data, it will be useful to classify the products in this industry according to the Standard Industrial Classification (SIC). The transportation equipment industry is labeled 37 in the SIC, and contains roughly twenty 4-digit industries, ranging from bicycles to guided missiles. Those industries with the highest value of exports from Korea and Taiwan to the U.S. are shown in Table 15: motor vehicles and passenger car bodies (SIC 3711); motor vehicle parts and accessories (SIC 3714); and motorcycles, bicycles, and parts (SIC 3751). For each of the years 1992-1994, we show the *value of exports* from Korea and Taiwan to the United States (in millions of dollars), and the *number of HS products* that each country is exporting.

For example, during this period Korea sold between $750 and $1,262 million of motor vehicles and car bodies to the U.S., in up to twenty HS products; most of these sales were in finished autos. In contrast, Taiwan sold only between $4.3 and $5.0 million in up to four product categories. Most of these detailed products overlapped with categories in which Korea also sold, as shown by the column labeled "common" in Table 2.[14] At the same time, there are numerous HS categories that were *unique to Korea*, i.e. products that Korea exported to the United States but Taiwan did not. Furthermore, these unique products accounted for the vast majority of Korean sales: $1,255 million out of the total $1,262 in sales in 1994. A similar pattern is shown in the 1992 and 1993, with Korea having most of its sales in product categories which Taiwan does not export to the U.S. at all.

It is quite clear within this SIC industry of "motor vehicles and passenger car bodies," that Korea has much greater product variety than Taiwan in its sales to the U.S., which is *contrary* to our first hypothesis. But as we look more closely, the reasons for this become clear. Nearly all of Korean sales in this industry are accounted for by finished autos, or more precisely, HS categories that are further subdivisions of "passenger motor vehicles with a spark ignition engine capacity of over 1000CC" – in other words, the family car, all of which were produced by four of the top ten *chaebol*. By contrast, Taiwan's exports are nearly all in just one single category – a "passenger motor vehicle with a spark ignition engine capacity of *under* 1000CC." Just what is this product? It turns out to be *all terrain vehicles (ATV)*, which are used recreationally and in some construction sights, and which both countries sell to the U.S. So while the huge productive capacity of the Korean *chaebol* are harnessed around worldwide exports by massive groups like Hyundai, Daewoo and Kia, the Taiwanese are mainly exporting dune buggies!

The fact that Korea sells many more "unique" products in this industry – not sold by Taiwan at all – is an appropriate way to establish that Korea has higher product variety. To make this more precise, we would like to have a measure of product variety that reflects not only the number of HS categories, but also the sales in each, and especially the sales in the unique products that one country sells but the other does not. This can be developed as follows.

The total sales of motor vehicles and bodies from Korea to the U.S. in 1994 was $1,262 million, and from Taiwan was $4.7 million, so the ratio of these is 4.7/1,262 = 0.0037. In comparison, for the common product categories imported from both countries (which are the ATV and their bodies), Korea sold $7.2 million and Taiwan sold $4.7 million, giving the ratio 4.7/7.2 = 0.65. Taiwan is selling about one-third less of these *common* products, but we would associate this with their *volume* of trade rather than product *variety*. To correct for this, we deflate the first ratio by the second, and take the natural logarithm, obtain a measure of product variety, ln(0.0037/0.65) = -5.16. This is reported in the final column of Table 2 for 1994, and for the other years we obtain similarly large negative values. Computing the mean and standard deviation of the product variety indexes for motor vehicles and bodies over the three years, we easily conclude that the mean is significantly less than zero,[15] so that Korea has *greater product variety* than Taiwan in this industry.

To summarize, our method for computing product variety of Taiwan relative to Korea is to construct the index,

$$\text{(1)} \qquad \text{Product Variety Index} = \ln\left[\frac{\text{(Taiwan Sales / Korean Sales) of all products}}{\text{(Taiwan Sales / Korean Sales) of common products}}\right].$$

Clearly, this index will be higher when Taiwan is selling more unique products, and smaller when Korea is selling more unique products. If both countries are selling in exactly the same disaggregate HS categories, then product variety (measured as a logarithm) is zero, indicating that there is no difference at all between the countries. In this case, there still might still be a difference in the *distribution* of sales across the common product categories, but this is not what the product variety index measures. Rather, the product variety index depends on having *some but not complete* overlap in the product categories of the two countries, so there are both common and unique products. This index is given a more formal economic justification in Appendix C of our book (Feenstra and Hamilton 2006).

Looking at the other industries in Table 2, the results for “motor vehicle parts and accessories” (SIC 3714) are in marked contrast to those for finished vehicles. In this case Korea and Taiwan both sell in a large number of product categories, and many of these (over 50) are common to the two countries. Taiwan sells about twice as much as Korea in total, but we view this as an indication of the volume of trade rather than product variety. Notice that the value of sales from each country in unique product categories is very small – less than $1 million in most years. Accordingly, when we calculate the product variety index, we obtain values that are small in magnitude and that vary in sign over the years (see the last column of Table 2). Taking the sample mean and standard deviation of the variety index for motor vehicle parts over 1992-1994, we cannot reject the hypothesis that the mean value is zero: in this industry, there is no systematic difference in product variety across the countries.

Finally, turning the motorcycles, bicycles and parts (SIC 3714), the results are quite different again. Now it is Taiwan that sells a great deal to the U.S., some $500 million, in a large number of product categories. Notice that in every product category where Korea sells, Taiwan also does, and considerably more. The difference in sales values for these *common* products is very dramatic, but again, this represents a difference in the volume of trade rather than product variety. When the variety index is calculated, we consistently obtain positive values, indicating that Taiwan has greater product variety than Korea (see the last column). This is reverse of what we found for finished automobiles. Furthermore, computing the sample mean and standard deviation of product variety index for motorcycles and bicycles over the three years, we conclude that the mean is significantly greater than zero at nearly the 90% level of significance,[16] so that Taiwan has greater product variety.

In these three industries within transportation equipment, we have therefore found a rich array of outcomes. In finished motor vehicles, which require highly capital-intensive and large-scale production, Korea has much greater sales values and product variety than Taiwan. This is also an industry in which the largest *chaebol* dominate. In automobile parts, the two countries cannot be ranked in their product variety of automobile parts, though Taiwan sells about twice as much. Motorcycles, bicycles and their parts can be produced at a much smaller scale than autos, and in this industry Taiwan has both higher export value and product variety than Korea. Taiwanese production in this industry is dispersed over many small firms, woven into a tight and highly efficient network. The contrast between automobiles and bicycles perfectly captures the difference in the economic organization of the two countries, and in their trade patterns.

Product Quality or "Mix"

Next, we turn to a measure of product quality. We cannot hope to assess the underlying quality for each and every product. Instead, we can measure the extent to which one economy or the other is focused on more "high end" products, in each industry. In other words, what is the "mix" of products sold from each economy: are they mostly inexpensive, easily manufactured products; or complex products that sell for a higher price? We will essentially rely on the price of each disaggregate category to measure the technological sophistication of that product, at least as compared to other products within a narrowly-defined industry. Accordingly, we will call this a measure of "product mix", and it will still give us additional insight into the different production and trade patterns of the two countries.

Beginning with motor vehicles and passenger car bodies, we first calculate the unit-value (or average price) of these products from each country. For Korean exports which are mostly finished autos, the unit-values are about $6,000, but for the Taiwanese ATV (i.e. the dune buggies), the unit-values are closer to $1,000. These are shown is the third and fourth columns of Table 3, and their ratio is shown in the fifth column. The fact that the unit-value is so much higher in Korea reflects the type of product that each country is exporting, and we interpret the higher Korean unit-values as an indication of higher "product mix" or "quality." However, the comparison of unit-value is also affected by pure price differences between the countries *for the same product.* In particular, the ATV exported from Taiwan sell for about two-thirds the price of the ATV exported from Korea, as is shown in the sixth column labeled "price index." Price differences across countries for the same product reflect a host of factors such as exchange rates, wages, cost of materials, market competition, etc. In our measure of product mix, we would like to control for these price differences for common products, so we *divide* the ratio of unit-values by the price index, and take the natural logarithm. The index of product mix in 1994 is therefore obtained as ln(0.17/0.65) = -1.33. In the other years we also obtain negative values, and we can easily accept the hypothesis that the mean is significantly less than zero. This indicates that Korea has *higher product mix* than Taiwan, i.e. Korea is exporting relatively more higher-price items.

To summarize, our method for computing product mix of Korea relative to Taiwan is to construct the index,

(2) $$\text{Product Mix Index} = \ln\left[\frac{\text{(Taiwan / Korean) Unit Values}}{\text{(Taiwan / Korean) Price Index}}\right]$$

The unit-values that appear in the numerator are straightforward to compute: they are total sales value divided by total quantity sold within each product category. In added up the quantity sold, we obviously want to have goods that are similar, i.e. we do not want to add apples and oranges. This means that the industries chosen to assess product mix should be as narrow as possible. In Table 3 we have been using each 4-digit SIC category as an industry, but even this may be too broad (within industry 3711, for example, we are adding up units of finished vehicles and their bodies). When looking across other years, we will be able to use the 5-digit SIC as the industry level for 1978-1988, but only have the 4-digit SIC available in 1989-1994. A more formal economic interpretation of this product mix index is provided in Appendix C of the book (Feenstra and Hamilton 2006).[17]

Turning to the other industries in Table 3, the average price of motor vehicle parts and accessories from Korea is about $20 per unit, while those products from Taiwan have an average price of $7 or $8 per unit. It would appear to indicate that Korea has more sophisticated items in its product mix, but we need to correct for the price differences of common products. As we see from the price index reported in the middle of Table 3, Taiwanese products sell for 36-51% of the comparable Korean products exported to the U.S. Adjusting the ratio of unit-values for this price difference, we obtain the product mix index reported in the final column, which fluctuates between positive and negative. Thus, there is no consistent comparison of the countries in product mix, as we also found for product variety in this industry.

Finally, turning to motorcycles, bicycles and parts, there has been an interesting change over the three years shown. In 1992, Korea sold products with an average price of $39, but by 1994 this had fallen to $3. Over this period, Korea was actually exiting from the most expensive category of bicycles, i.e. "bicycles with both wheels exceed 65 cm diameter," or full-size adult bikes. This is where Taiwan has about half of its sales, exceeding $200 million per year, but Korea dropped from sales of $2 million in 1992 to just $30,000 in 1994. Korea's largest sales in 1994 actually occurred in *seats* for motorcycles and bicycles, which explains why its unit-value dropped to $3! Corresponding to this shift in product composition, the product mix index in Table 3 changes from negative in 1992 to positive and large in 1993-94, indicating that Taiwan is exporting substantially more expensive products than Korea, and has higher product mix in at least the later years.

This evidence from the product mix index reinforces what we have already found from product variety: these two very successful economies are organized so differently, and with such different productive capabilities, that it shows up very clearly in their trade with the U.S. The huge productive capacity of *chaebol* could not be harnessed around dune buggies or bicycles! Capital intensive, high-value products are the principal, if not the only kinds of products that can sustain the “one-set” production systems that the *chaebol* have perfected. By contrast, there is no way that Taiwan’s small and medium-sized firms could produce an automobile that could compete worldwide like those that Korea produces. The options that have been chosen by one would have been folly for the other.

Taiwan-Korea Comparison of Product Variety

We now turn to a more general evaluation of the product variety in exports for Korea and Taiwan, across a broader range of industries and years. For this purpose, we have constructed the product variety and mix indexes within *each* 4 or 5-digit SIC industry, over the years 1978-94.[18] These years were divided into three sub-periods, 1978-82, 1983-88, and 1989-94 to check for changes in product variety and mix that may have occurred. One difference from the detailed example we just gave for transportation equipment is that we include only those 4 or 5-digit industries that have at least *three common products* in both countries, over some sub-period. This would exclude, for instance, the “motor vehicles and passenger car bodies” industry given at the top of Table 2, where the countries have only *two* common products in some years. By excluding these cases, we are therefore focusing on industries where both countries have significant common presence in the U.S. market. To determine which country dominates in product variety or mix, we compute the *mean* of each index over the years within each period. We first report results at the 4 or 5-digit level, testing whether the means of the indexes are significantly positive or negative. We then test the joint hypothesis that all *5-digit industries within a 2-digit category* have greater product variety in one country or the other (see Appendix C in Feenstra and Hamilton 2006 for the formal derivation of this test).

Looking first at the disaggregate results in Table 4, the divergence of the two economies is clear. We find that about 40% of the categories of manufactured goods, Taiwan produces a greater variety of products than Korea, a trend that increased to 67% by the 1989-94 period (see the last line of Table 4). Thus, Taiwan has gone from having a greater product variety in less than half the disaggregate industry, to more than two-thirds. Taiwanese manufacturers had especially diverse products in final goods categories, but were also more diverse in most intermediate goods as well. In comparison, Korea shows greater diversity in only about 5% of categories in the early years, though rising to 20% by 1989-94. All of these industries were “high-end” final products. For the rest of the categories, mostly intermediate goods such as chemical products and primary metals, production is sufficiently similar across countries that there are no statistically significant results.

In Table 5, we report the results of the testing the joint hypothesis that all 4 or 5-digit industries *within* a two-digit class have higher product variety from one country or the other. If the hypothesis that *Korea has greater variety* in all industries is *rejected* at the 10% level, and that *Taiwan has greater variety* in all the industries is *not rejected* at the 25% level, then we conclude that Taiwan has higher product variety, which is denoted by T. If the opposite case holds, this is denoted by K. Borderline cases occur when first hypothesis is not rejected at the 10% level, but is rejected at the 25% level; or when the second hypothesis is not rejected at the 25% level, but is rejected at the 10% level; and these are denoted by U (for uncertain) followed by the letter of the country that has the higher index at the weaker significance level. Cases where both of these hypotheses are both rejected or both accepted are denoted by U, indicating that the conclusion is entirely uncertain.

Looking at the summary at the bottom of Table 5, Taiwan is found to have greater product variety in ten to twelve 2-digit industries across the three sub-periods, while Korea did not show greater diversity in any of the industries during all periods. A closer inspection of these results shows that the Taiwanese advantage in product variety holds more strongly in *final goods* than in *intermediate inputs.* This is consistent with our first hypothesis, since the business groups in Taiwan are mainly focused in the upstream sector, and the economies of scale within these groups can *offset* the tendency of the small and medium-sized enterprises to proliferate across varieties. Thus, in textile mill products and pulp and paper, Taiwan has a share of business groups that exceeds that for Korea, and in both these sectors the product variety ranking in Table 5 is uncertain. For chemical products and primary metal, the share of groups (including the state) in Taiwan and Korea is roughly comparable, and in these cases the product variety ranking in Table 5 is again uncertain (though in favor of Korea for 1983-88 in primary metals). In contrast, for all other intermediate sectors and final goods we find higher product variety in Taiwan, at least by the weak hypothesis test.

Summing up, in the upstream sectors where the groups in Taiwan are strong, their presence offsets the tendency to find higher product variety as compared to Korea. The only exception to this is stone, clay and glass, where Taiwan has higher product variety despite having about the same share of business groups as in Korea. But in those sectors where the presence of business groups are markedly less in Taiwan than in Korea, which includes all the final goods sectors, we still find markedly higher product variety from Taiwan. This provides robust support for our first hypothesis, that Taiwan has greater product variety in its exports than Korea, especially for final goods.

Taiwan-Korea Comparison of Product Mix

Turning next to a comparison of product mix indexes, these are also reported in Tables 4 and 5. We find that Korea specializes in higher-value *final products* (both consumption and capital goods), while Taiwan specializes in higher-value *intermediate goods*. In other words, Korea has higher product mix in final products, whereas Taiwan has higher product mix in intermediate products. This is consistent with the business groups in each country developing a reputation for high-quality products in their respective markets.

The detailed evidence for differences in the product mix can be found within the textile, wood, paper, and metal products industries. Looking first at textile mill products, Korea and Taiwan had their own specializations in different 5-digit industries, which made the 2-digit category “uncertain”; but Korea had a clear lead in the apparel category, which uses textiles as the intermediate input and creates the final products. The small and medium-sized firms creating apparel products in Taiwan, by contrast, would have no incentive to market higher-priced apparel products, but simply produce whatever is demanded by the large retailers in the U.S. and abroad. Turning next to the lumber and wood industry, Taiwan had higher product mix in lumber and wood products (intermediate inputs) for both periods, while Korea was specialized in higher-end furniture (a final product) during the second period. The third example is paper products. Korea and Taiwan had their own strength in particular types of paper products, Korea clearly had higher product mix relative to Taiwan in the printing and publishing industry, which is again a final product. The last example is from the metal products sector. Taiwan had higher product mix in fabricated metal for both periods, and in primary metal during the first, both of which are intermediate inputs, while Korea led in industrial machinery, which is a final capital good sold to firms.

By dividing the industries into intermediate and final products, and looking at the 2-digit level, the respective specializations of the two countries becomes even more evident. All of the 2-digit categories in which Taiwan had higher product mix are *intermediate inputs* (with the exception of a weak result in food products), for all three sub-periods. In contrast, Korea has higher product mix in nearly one-half of the 2-digit *final goods*, with the other final goods categories being uncertain. These results from the product mix index bear a close relation to the business groups shares in reported in Feenstra and Hamilton (2006, chapter 4). After adding up Taiwanese business group and state-owned shares, there are six industries whose shares are greater than 30% of the total sales: food, textile mill products, chemical materials, stone, clay & glass products, primary metal and transportation equipment. Except for food and transportation equipment,[19] these are all intermediate inputs and we have found that Taiwan has higher product mix than Korea. Taiwan's lead in some cases was overtaken by Korea in the second period, particularly in primary metals, where Korea had *chaebol* shares that exceed the Taiwanese business group shares. Similarly, Korea has *chaebol* share in nearly all final industries that exceed Taiwan, and also has higher product mix.

Summarizing, the sectors in which Taiwan maintains a lead in product mix are nearly all intermediate inputs, where it also has high business groups shares. In contrast, Korea has higher product mix in many final products, where it also has high *chaebol* shares. Thus, the presence of business groups in either case appears to be closely related to the production of high-value product varieties, consistent with our second hypothesis. Together with our finding on product variety, this again demonstrates the importance of economic organization in affecting the export patterns of the countries.

Conclusion: High Technology Exports: Differences that Make a Difference

We conclude this paper by looking in detail at the high technology industry – including office machines and semiconductors – where the differences in production and exports between Korea and Taiwan are especially important. As we found for automobiles, Korea was the fourth largest producer and sixth largest exporter of electronic components in 1996 (Lew and Park, 2000, p. 48). This is another case where Korea has successfully transformed its industry into a "producer driven" commodity chain, whereby some of the largest *chaebol* have achieved global scale in products such as dynamic random access memories. These products compete with those from Japan, Singapore, and the U.S., for the mass market available through sales of personal computers. Taiwan, by contrast, has specialized in "designer chips," and its upstream foundries such as Taiwan Semiconductor Manufacturing Company (TSMC) work cooperatively with small chip design firms to create special purpose chips that go into export products. These are purchased by firms worldwide as part of "buyer-driven" commodity chains, and need not be at the high-end of the market: they are used in simple toys, for example, and put the "bark" into electronic dogs. [20] We begin by reviewing how the differing structure of these industries came about.

Beginning from the production of radios in the 1960s, Korea moved up the ladder of products to cassette tape recorders and black and white televisions in the 1970s, color televisions and VCRs in the 1980s, and then to camcorders, CD/DVD players and digital televisions today.[21] In percentage terms, however, consumer electronics has declined in importance (falling from 33% of production in 1985 to 22% in 1996), while electronic parts and components has risen (from 46% in 1985 to 54% in 1996).[22] Chief among these components is semiconductors, which accounted for over 40 percent of total electronic exports in 1997 and 1998.[23] To produce these the Korean industry relies on imports of capital equipment, plants and core components, mainly from Japan.[24] In turn, it relies on exports of semiconductors and other final products to the United States and worldwide.

Production of semiconductors is concentrated among the largest *chaebol:* Samsung, Lucky-Goldstar, Hyundai, Daewoo and Korea Electronics. While these groups were supported by cheap government credit in the 1960s and 1970s, as well as by various five-year plans to develop the industry, their investment and business decisions sometimes diverged from government interests. As described by Lew and Park (2000, pp. 54-55):

> In the early 1980s, the Korean government conducted a promotion plan for the semiconductor industry. The plan's main strategy was import-substitution of semiconductors. But the *chaebol* did not follow this directive, and instead made large-scale investments for the international market. However, this conflict was resolved very quickly through an altered strategy in the mid-1980s, in which the government began to support local firms' R&D in semiconductors for the sake of exports.

This telling example shows that the *chaebol* were quite capable of moving in directions not suggested by the government, and which required enormous investments to achieve global scale. Similar to autos, semiconductors is again a case where the Korean industry has intentionally transformed itself into a "producer driven" commodity chain, marketing products such as dynamic-random access memories (DRAMs) under their own brand names, to become one the world's leading suppliers of this commodity.

The organization of the Taiwanese industry is completely different. As described by Kao and Hamilton (2000), the development of the high-technology industry in Taiwan dates from the early 1990s, and in particular, the Plaza Accord of 1985 and subsequent appreciation of the New Taiwan dollar. This revaluation had an immediate effect on the cross-market price structure within Taiwan's economy. Momentarily everyone was much richer as computed in U.S. dollars. The price of imports fell considerably, and local consumption and styles of life rose quickly. Real estate prices, which had been rising, now took off, and money poured into property construction. Stock market speculation also increased.

After a short lag time, however, the cost of labor in Taiwan grew prohibitively high and accordingly Taiwan exports became more expensive on world markets. By the late 1980s, the real estate bubble burst, the stock market collapsed from a high of about 14,000 to a little over 2,000, and rising exports began to taper off. Beginning in 1988, Taiwan's outward investment surged. In a two-year period, 1988-1990, some of Taiwan's most profitable manufacturers – those specializing in footwear, textiles, and garments – were out of business or moved the site of their assembly operations to China and Southeast Asia. Those entrepreneurs who stayed in Taiwan began to look for new products to manufacture, including high-tech products. These entrepreneurs were highly educated, many receiving their education in Taiwan, but an important few had gone to school in the United States, had worked in Western high technology firms, and then had moved back to Taiwan to start businesses or manage existing ones.

This new set of entrepreneurs built on a previous high technology industry that had arisen in Taiwan in the early 1980s, but that had remained small and relatively unsophisticated. According to interviews with these entrepreneurs conducted by Kao and Hamilton (2000), the personal computer (PC) industry in Taiwan developed accidentally and with no direct assistance from the government. The government indirectly helped, however, by banning the manufacture of gambling machines. With the government prohibition, those firms that had been making these machines needed to find something else for its production network to manufacture. Drawing on their expertise, they decided to make PC clones and copies of Apple II. When asked how he could make a computer from scratch, one entrepreneur replied with the Chinese saying, “We have no experience with horses, but we have ridden a donkey.” From this beginning, the PC factories in Taiwan grew to become the main OEM suppliers for such American PC computer companies as Compaq and Dell. By 1999, Taiwan was the third largest manufacturer of PC related products, behind the United States and Japan.

The new beginning for the high technology firms occurred in the early 1990s. Demand in the United States for computer components and peripherals was high, and many US firms were in hot competition with each other to offer the latest PCs to consumers who were just developing an appetite for fast computers with lots of memory. The area of deepest concentration of software and hardware producers was in Silicon Valley. Saxenian (1994, 1998) shows these producers were highly networked, and from the beginning Taiwanese and Chinese American entrepreneurs had an important presence among Silicon Valley firms. Many of the hardware firms were eager to locate high quality and low cost OEM producers for components that had very rapid product cycles. Drawing on their connections in both California and Taiwan, a number of Chinese high technology engineers started manufacturing firms in Taiwan, many adjacent to one another in the Hsinchu Science-Based Industrial Park.

At this time, in the late 1980s, Taiwan had no silicon wafer semiconductor factory. The Taiwan government decided Taiwan's economy needed to be competitive in high technology industries, but did not want to compete head on with firms in the US and Japan. Private entrepreneurs (Morris Chang, a former executive at Texas Instrument, being the most prominent one) persuaded government officials to follow the pattern of other large firms in Taiwan, namely to be upstream providers of intermediate inputs that SMEs could then use to manufacture exports. Joining with Philips Electronics, the government established Taiwan Semiconductor

Manufacturing Company (TSMC), the world's first dedicated independent semiconductor manufacturing foundry. A semiconductor foundry is simply an OEM manufacturer of semiconductor chips designed and merchandised by other firms, in much the same way that garments and footwear had been in Taiwan. In fact, TSMC's charter prevents the company "from designing or making our own brand-name IC products. TSMC therefore is a partner, not a competitor with other semiconductor companies." (TSMC Annual Report 1998, p. 7)

TSMC's success epitomizes Taiwan's new surge in what Kao and Hamilton (2000) call "reflexive manufacturing". From the beginning, TSMC began to work cooperatively with small chip design firms that would create special purpose chip sets that would go into export products. The design firms, in turn, worked with export manufacturing firms, some located in Taiwan and some elsewhere. The key feature of the semiconductor foundry business is its integration into a manufacturing system whose foremost characteristic is its quick response to external demand, the essence of reflexive manufacturing. The approach proved successful, and soon other entrepreneurs started foundries in competition with TSMC. The foundry business took off. Today, semiconductor foundries form an extremely important segment in the global high technology development, and Taiwanese foundries have a commanding lead, producing over 80% of the global demand in foundry-made chips. With foundries, every high technology firm can have their own "virtual fab." They can be designers and merchandisers of products that they do not produce. Increasingly the global high technology industries are becoming "buyer driven chains," and increasingly Taiwan's organizational capacity for reflexive manufacturing has pushed the global high technology in this direction.

With this description of the high technology industry in the two countries, we return to the question of how their organizational differences show up in the export patterns of South

Korea and Taiwan. We expand our earlier discussion of their exports to the United States to now also include their worldwide exports.

In Figures 21 and 22 we show the exports from Korea and Taiwan in office machines and parts (HS 847) and semiconductors and integrated circuits (HS 854) – both the U.S. and worldwide. It is evident that Korean exports in both categories of goods are more volatile than those from Taiwan. Thus, for office machines (847) Korean exports drop in 1998, during the financial crisis, but this drop is barely apparent for Taiwan worldwide exports, and does not occur at all for their exports to the U.S. In semiconductors (854), exports from Korea peak in 1995, and then display a sharp decline through 1998, which illustrates global glut in semiconductors. In contrast, worldwide exports from Taiwan experience a one-year drop in 1998, but once again, this decline does not occur for their sales to the United Sates.

What has protected Taiwan from the market fluctuations in these industries that are so apparent for Korea? We would argue that the much greater fall in exports from Korea than Taiwan was due to the different composition of export goods, and especially the heavy reliance of Korea on dynamic random access memory (DRAM) chips. To verify that semiconductors are an important part of the fall in export demand from Korea, we have examined these sales from each of Korea and Taiwan to the United States, and their prices. In Figures 23 and 24 we show the sales of the principal semiconductor chips sold by each country to the U.S., over the years 1994 – 2001. There are three categories of DRAMs, distinguished by their size, all of which are shown in the bottom of each graph. Sales of these DRAMs from Korea to the U.S. exceeded $4 billion in 1995, but plunged to less than $2 billion by 1998. These export sales were made in part by other types of semiconductors, but Korea remains heavily reliant on the DRAMs in its export sales. By contrast, a glance at Figure 24 shows that Taiwan spreads its export sales more evenly over multiple categories of semiconductors, and its sales of DRAMs to the U.S. did not reach even $0.5 billion until 2000. It is evident that overall sales of semiconductors from Taiwan did not suffer the fall over 1995 – 1998 that is so apparent for South Korea, though they did fall over 2000 – 01.

The same contrast between the countries shows up in the price indexes of semiconductor products sold from Korea and Taiwan to the U.S., as shown in Figure 25, where we graph the annual change in prices over the months September 1994 – September 1997 as compared to one year earlier.[25] It can be seen that semiconductor export prices from Korea declined by nearly 45% at the end of 1996, while those from Taiwan declined by less than 20%. We stress that the differences in the Korean and Taiwanese export prices shown in Figure 25 comes entirely from the *composition* of their respective exports. The price of 16 megabyte DRAM chips dropped from $54 at the end of 1995 to $13 by the middle of 1996, and $3 by the end of 1997 (World Bank, 2000, p. 49), and this applies to any country exporting that commodity. But Korea relied on semiconductors for much more of its exports, so the fall in prices for this commodity had a much greater impact on the economy. Indeed, semiconductors are important enough in Korean exports to the U.S. that the fall in their prices had a substantial impact the overall export price index, as shown in Figure 26. Thus, the focus of the largest *chaebol* on becoming "world leaders" in DRAMs led to a dramatic fall in overall export prices, whereas Taiwan was insulated from this by its differing export composition.

In Feenstra and Hamilton (2006, chapter 4) we argued that the fall in exports for Korea, as illustrated most aptly by its semiconductor exports, played a key role in the bankruptcies of the *chaebol,* which precipitated the financial crisis that occurred in that country in 1997-98. Taiwan was largely immune from that crisis due to its greater diversity of exports. But this diversity did serve to insulate Taiwan during the U.S. recession of 2000-01. The fortunes of Taiwanese exporters are sufficiently integrated with the fortunes of Silicon Valley that with the bursting of the “high tech bubble” in the U.S. had a pronounced impact of Taiwanese exports, as well as those from South Korea. The drop is evident in Figures 21 and 22, and hit Taiwan just as hard as Korea. Indeed, as we suggested earlier in the chapter, the Korean economy was somewhat better positioned to withstand this high-tech demand shock because of its exports of alternative products to the U.S. and world market, such as automobiles, which continued to grow in 2001. So in contrast to the 1997-98 crisis, which hit Korea especially hard, the 2000-01 U.S. recession has had the greatest impact on Taiwan.

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Table 1: Korean and Taiwan exports to the U.S.

in 3-digit HS categories ($ million)

	1995	1996	1997	1998	1999	2000	2001
A: With exports from Korea or Taiwan exceeding $2 billion in 2000							
HS 847 – Office Machines and Parts							
South Korea	3,879	3,921	4,238	3,474	5,548	7,885	4,711
Taiwan	7,426	8,289	9,914	9,625	9,697	10,667	8,849
HS 852 – Video, Radio and TV equipment							
South Korea	1,717	1,110	990	1,517	2,892	4,601	5,915
Taiwan	824	889	1,102	1,309	1,872	2,554	2,129
HS 854 – Semiconductors and Integrated Circuits							
South Korea	7,140	6,274	6,037	5,295	6,715	7,683	3,814
Taiwan	3,333	3,277	3,488	3,330	4,044	5,507	3,723
HS 870 – Motor Vehicles and Parts							
South Korea	1,795	2,009	2,080	1,891	3,223	5,175	6,760
Taiwan	383	422	461	495	598	632	647
B: With exports from Korea or Taiwan exceeding $500 million in 2000 [a]							
South Korea	18,204	16,807	16,937	16,251	23,232	30,921	26,422
Taiwan	19,597	20,812	23,352	23,541	25,207	29,829	23,871
C: Total exports from Korea or Taiwan to the U.S.							
South Korea	24,026	22,532	22,939	23,701	31,152	39,829	34,915
Taiwan	28,876	29,797	32,474	32,985	35,057	40,384	33,262

Notes:

a. This includes eighteen 3-digit HS categories (as detailed in notes 2 and 3).

Table 2 – Transportation Industry Exports from South Korea and Taiwan to the U.S. (Values, and number of HS categories)

Year	Variable	Korea, total	Taiwan, total	Korea, Taiwan Common		Korea, unique	Taiwan, unique	Variety Index[1]
SIC 3711 – Motor vehicles and passenger car bodies								
1992	Value ($mill)	1,205	4.3	5.1	4.2	1,200	0.06	-5.45
	Number HS	9	2	1		8	1	
1993	Value ($mill)	750	5.0	6.3	5.0	743	0	-4.78
	Number HS	15	2	2		13		
1994	Value ($mill)	1,262	4.7	7.2	4.7	1,255	0.03	-5.16
	Number HS	20	4	2		18	1	
SIC 3714 – Motor vehicle parts and accessories								
1992	Value ($mill)	150	309	149	306	0.7	3.2	0.006
	Number HS	52	59	46		6	13	
1993	Value ($mill)	154	325	154	325	0.6	0.5	-0.002
	Number HS	54	63	51		3	12	
1994	Value ($mill)	188	373	187	372	0.8	0.8	-0.002
	Number HS	71	78	66		5	12	
SIC 3751 – Motorcycles, bicycles, and parts								
1992	Value ($mill)	11	476	11	410	0	66	0.15
	Number HS	11	38	11			27	
1993	Value ($mill)	3.2	506	3.2	159	0	347	1.16
	Number HS	11	37	11			26	
1994	Value ($mill)	2.0	492	2.0	337	0	155	0.38
	Number HS	7	36	7			29	

Note:
1. This index measures the product variety of Taiwan relative to Korea, so a positive (negative) value indicates the Taiwan (Korea) has greater product quality. The formula used is shown in (8.1) and discussed in the main text.

Table 3 – Transportation Industry Exports from South Korea and Taiwan to the U.S. (Unit-values, and indexes)

Year	Variable	Korea	Taiwan	Taiwan/Korea Unit-Value Ratio	Taiwan/Korea Price Index	Mix Index[1]
SIC 3711 – Motor vehicles and passenger car bodies						
1992	Unit-Value ($/unit)	6,216	793	0.13	0.63	-1.60
1993	Unit-Value ($/unit)	5,920	1,048	0.18	0.63	-1.27
1994	Unit-Value ($/unit)	6,598	1,131	0.17	0.65	-1.33
SIC 3714 - Motor vehicle parts and accessories						
1992	Unit-Value ($/unit)	18	7	0.39	0.36	0.09
1993	Unit-Value ($/unit)	18	8	0.44	0.51	-0.07
1994	Unit-Value ($/unit)	22	7	0.32	0.46	-0.28
SIC 3751 – Motorcycles, bicycles, and parts						
1992	Unit-Value ($/unit)	39	21	0.53	1.39	-0.97
1993	Unit-Value ($/unit)	8	20	2.50	0.55	1.57
1994	Unit-Value ($/unit)	3	18	6.0	1.45	1.44

Note:
1. This index measures the product mix of Taiwan relative to Korea, so a positive (negative) value indicates the Taiwan (Korea) has greater product mix. The formula used is shown in (8.2) and discussed in the main text.

Table 4 Hypothesis tests for 4 or 5-digit SIC: Taiwan versus Korea

Industry (SIC)	Variety Index									Product Mix Index								
	1978-82			1983-88			1989-94			1978-82			1983-88			1989-94		
	T>K	K>T	U	T>K	K>T	U	T>K	K>T	U	T>K	K>T	U	T>K	K>T	U	T>K	K>T	U
Intermediate Products																		
Textile Mill Products (22)	2	0	4	5	3	3	3	5	2	2	2	2	3	3	5	4	4	2
Lumber & Wood Products (24)	2	0	0	2	0	1	1	0	0	2	0	0	1	0	2	1	0	0
Pulp & Paper Products (26)	0	0	2	1	0	3	4	0	1	1	1	0	1	1	2	2	3	0
Chemical Products (28)	0	0	2	2	0	3	7	2	1	1	0	1	2	0	3	6	2	2
Stone, Clay & Glass (32)	3	1	3	6	0	4	6	3	0	2	2	3	4	3	3	4	2	3
Primary Metal (33)	1	1	3	2	3	2	3	1	1	4	1	0	1	4	2	3	1	1
Fabricated Metal (34)	8	0	3	9	1	7	12	0	2	6	1	4	7	3	7	10	4	0
Subtotal	16	2	17	27	7	23	36	11	7	18	7	10	19	14	24	30	16	8
Final Products																		
Food Products (20)	4	1	1	6	1	0	6	3	1	2	1	3	2	3	2	6	4	0
Apparel & Textile Prod.(23)	8	0	8	9	1	13	11	9	1	4	9	3	4	13	6	5	14	2
Furniture (25)		----		0	0	1	1	0	0		----		0	1	0	0	1	0
Printing & Publishing (27)	2	0	2	1	0	3	2	0	1	1	3	0	1	3	0	0	3	0
Rubber & Plastic Prods.(30)	1	0	2	2	1	7	5	0	1	2	1	0	2	7	1	2	4	0
Leather Products (31)	3	1	4	4	0	5	5	3	1	2	3	3	2	3	4	0	9	0
Industrial Machinery (35)	1	0	3	5	1	5	21	2	5	0	2	2	3	5	3	11	11	6
Electrical Equipment (36)	4	1	9	11	1	12	20	4	3	3	8	3	7	10	7	8	16	3
Transportation Equip. (37)	1	0	0	1	0	1	1	0	1	0	1	0	0	2	0	0	1	1
Precision Instruments (38)	2	0	4	3	0	3	5	2	2	1	3	2	1	4	1	5	4	0
Misc. Manufacturing (39)	4	0	9	5	1	9	8	1	3	2	6	5	6	6	3	4	7	1
Subtotal	30	3	42	47	6	59	85	24	19	17	37	21	28	57	27	41	74	13
Total																		
Industries by Test	46	5	59	74	13	82	121	35	26	35	44	31	47	71	51	71	90	21
Number of industries	110			169			182			110			169			182		
Percentage	42	5	54	44	8	49	67	19	14	32	40	28	28	42	30	39	49	12

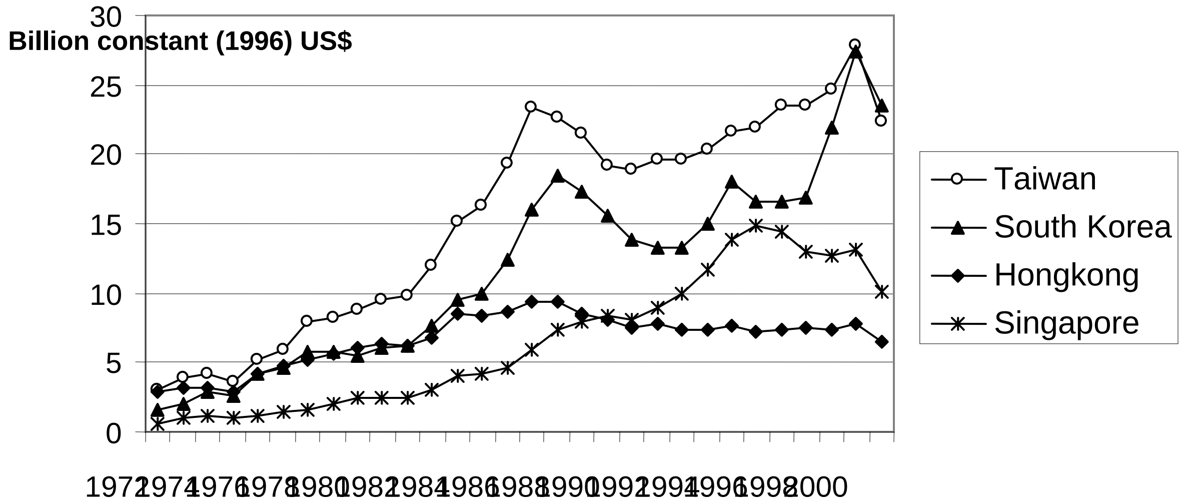
<u>Notes</u>:
T>K (K>T) means the hypothesis that the Taiwan index is less (greater) than the Korean index at the 5-digit level was rejected at the 10% level; U means that both these hypotheses could not be rejected. 5-digit SIC industries are used for the years 1978-88, while 4-digit SIC industries are used for 1989=94.

Table 5 Hypothesis tests for 2-digit SIC: Taiwan versus Korea

Industry (SIC)	Number of Common Goods			Variety Index			Product Mix Index		
	1980	1985	1992	78-82	83-88	89-94	78-82	83-88	89-94
Intermediate Products									
Textile Mill Products (22)	44	157	274	U(T)	U	T	U(K)	U	U
Lumber & Wood Products (24)	14	18	15	T	T	T	T	T	T
Pulp & Paper Products (26)	7	16	54	U	U	T	T	U(T)	U
Chemical Products (28)	9	39	108	U	U(T)	U(T)	U(T)	T	T
Stone, Clay & Glass Prod.(32)	51	72	104	T	T	T	U	U	U(T)
Primary Metal (33)	35	74	116	U	K	U	T	K	U
Fabricated Metal (34)	151	222	274	T	T	T	T	T	U
Subtotal	311	598	945	T--3 K--0 U--4	T--3 K--1 U--3	T- 5 K- 0 U- 2	T--4 K--0 U--3	T--3 K--1 U--3	T- 2 K- 0 U- 5
Final Products									
Food Products (20)	58	67	118	T	T	U	U(T)	U	U(T)
Apparel & Textile Prods. (23)	376	1170	649	T	T	U	U	U	U
Furniture (25)	--	15	29	--	U	T	--	K	U(K)
Printing & Publishing (27)	19	25	40	T	U(T)	U(T)	K	K	K
Rubber & Plastic Prods. (30)	29	76	192	U(T)	U(T)	T	U	U	U
Leather Products (31)	93	159	192	T	T	U	K	U	K
Industrial Machinery (35)	17	62	279	U(T)	T	T	K	U(K)	U
Electrical Equipment (36)	191	236	464	U(T)	T	T	U	U	U
Transportation Equipment (37)	10	22	44	T	T	U	K	K	K
Precision Instruments (38)	71	68	178	U(T)	T	T	U	K	U
Misc. Manufacturing (39)	94	132	165	T	T	T	K	U	U
Subtotal	958	2032	2350	T--6 K--0 U--4	T--8 K--0 U--3	T--6 K--0 U--5	T--0 K--5 U--5	T--0 K--4 U--7	T--0 K--3 U--8
Total	1269	2630	3295	T--10 K--0 U--7	T--12 K--0 U--6	T--11 K--0 U--7	T--4 K--5 U--10	T--3 K--5 U--10	T--2 K--3 U--13

Note:
T (K) means the hypothesis that the Taiwan index is less (greater) than the Korean index for all 4 or 5-digit industries within each 2-digit group was rejected at the 10% level; U means that these two hypotheses were both accepted or both rejected; U(T) and U(K) are borderline cases. 5-digit SIC industries are used for the years 1978-88, while 4-digit SIC industries are used for 1989=94.

Figure 1: U.S. Imports from the NICs, 1972-2001



Source: U.S. Import data, 1972-2001

Figure 2: The Share of Exports to the US in Total Exports from South Korea and Taiwan, 1960-1995

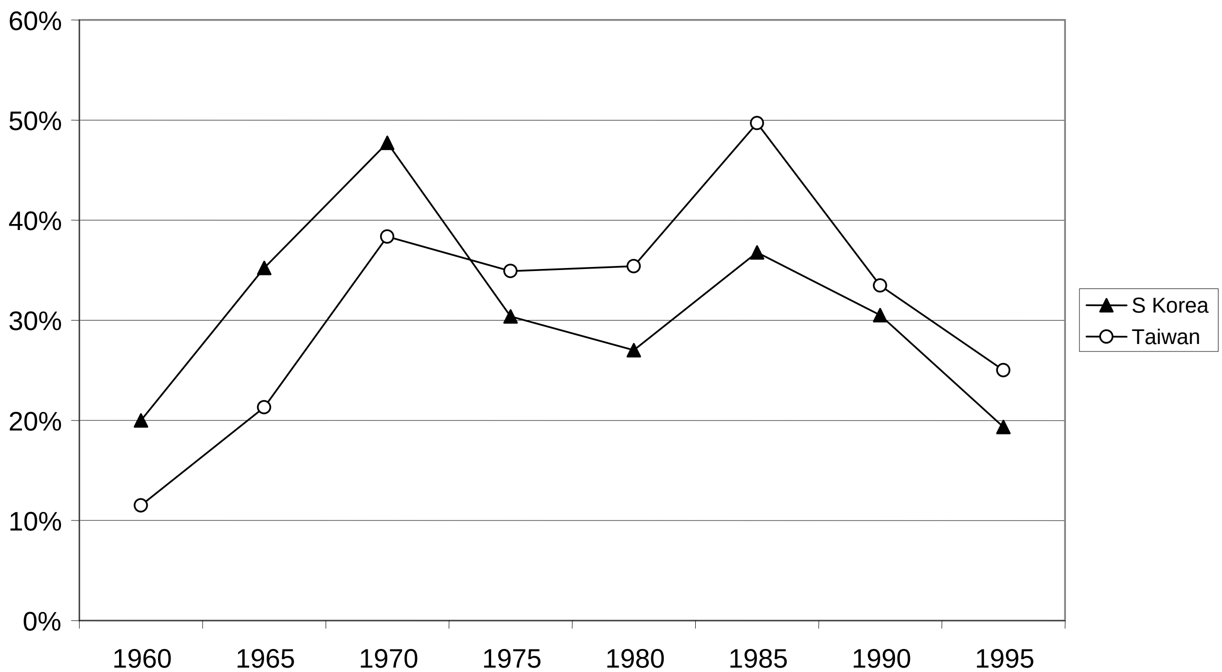
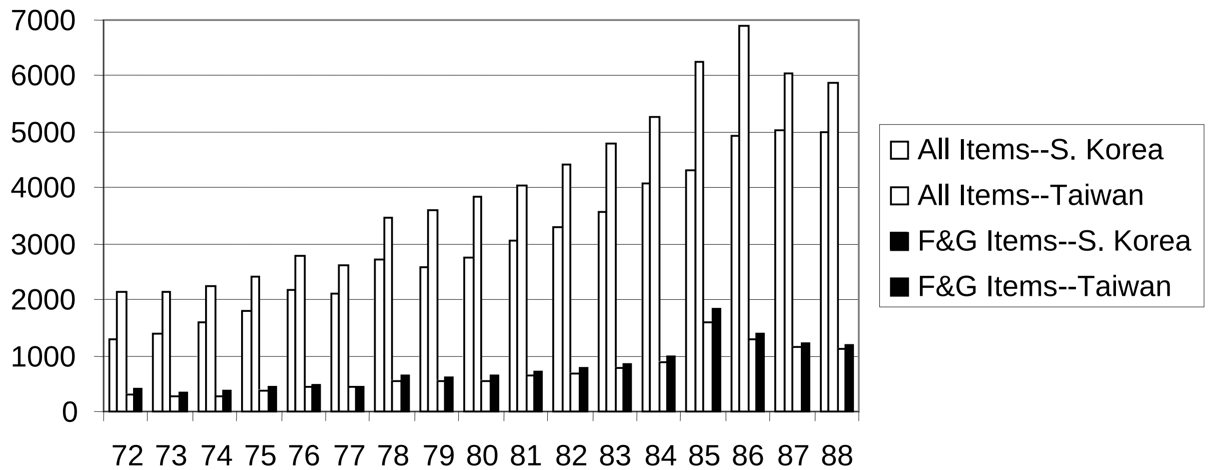
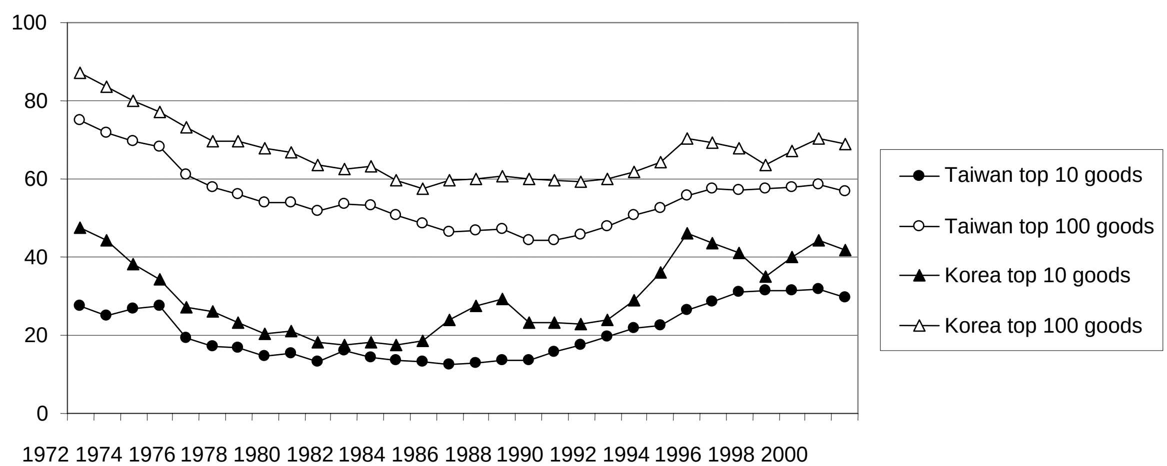


Figure 3: Number of 7-Digit TSUSA categories of Imports: Total and Footwear+Garment Combined, 1972-88



Source: NBER, TSUSA U.S. Import Data, 1972-1985

Figure 4: The share of top 10 and top 100 categories of goods in total export value, South Korea and Taiwan, 1972-2001



Note: 1972-88 based on the 7-digit TSUSA; 1989-2001 based on the 10-digit HS
Source: U.S Import Data, 1972-2001

Figure 5: South Korea Exports to the U.S., 1972-88 ($ mill)

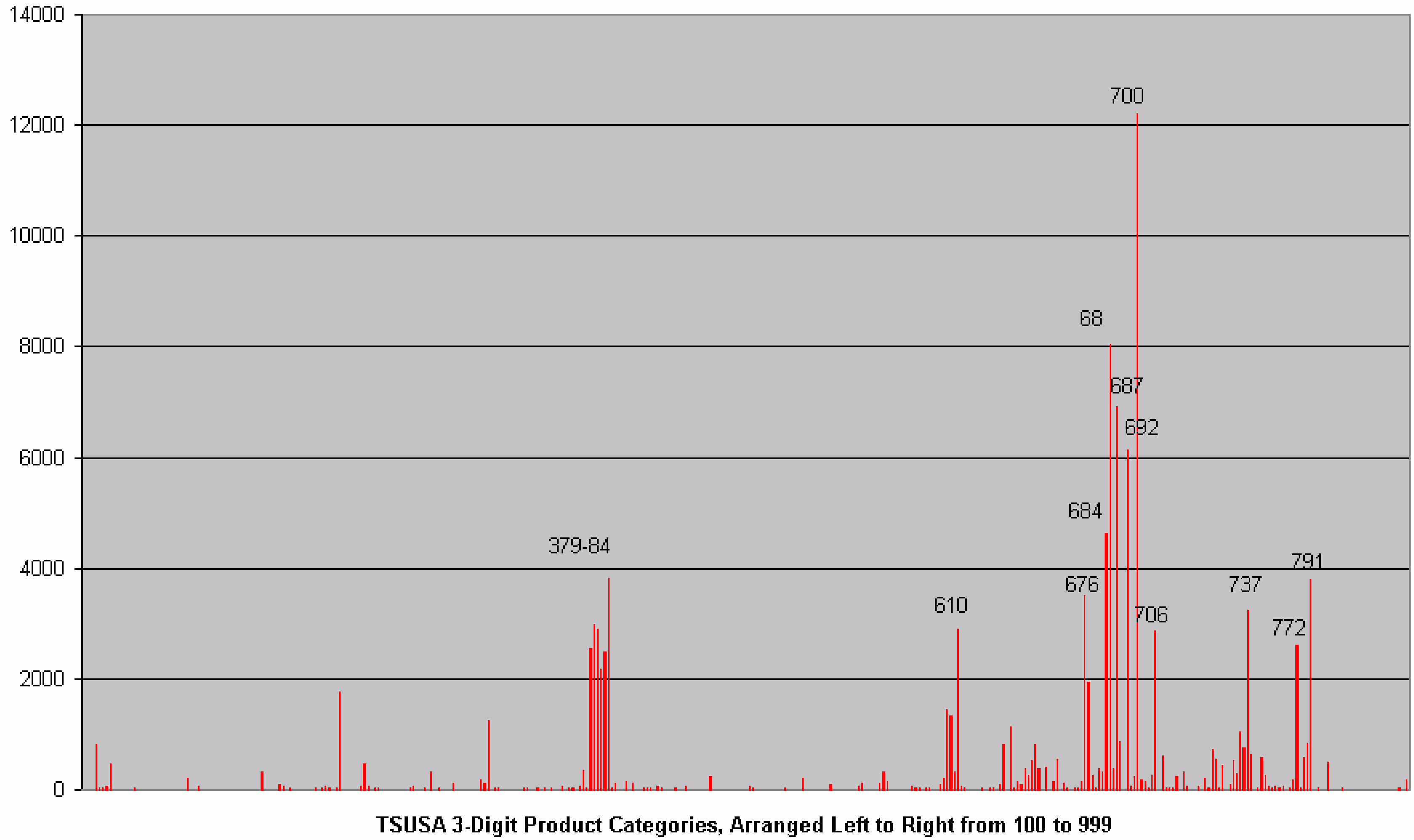
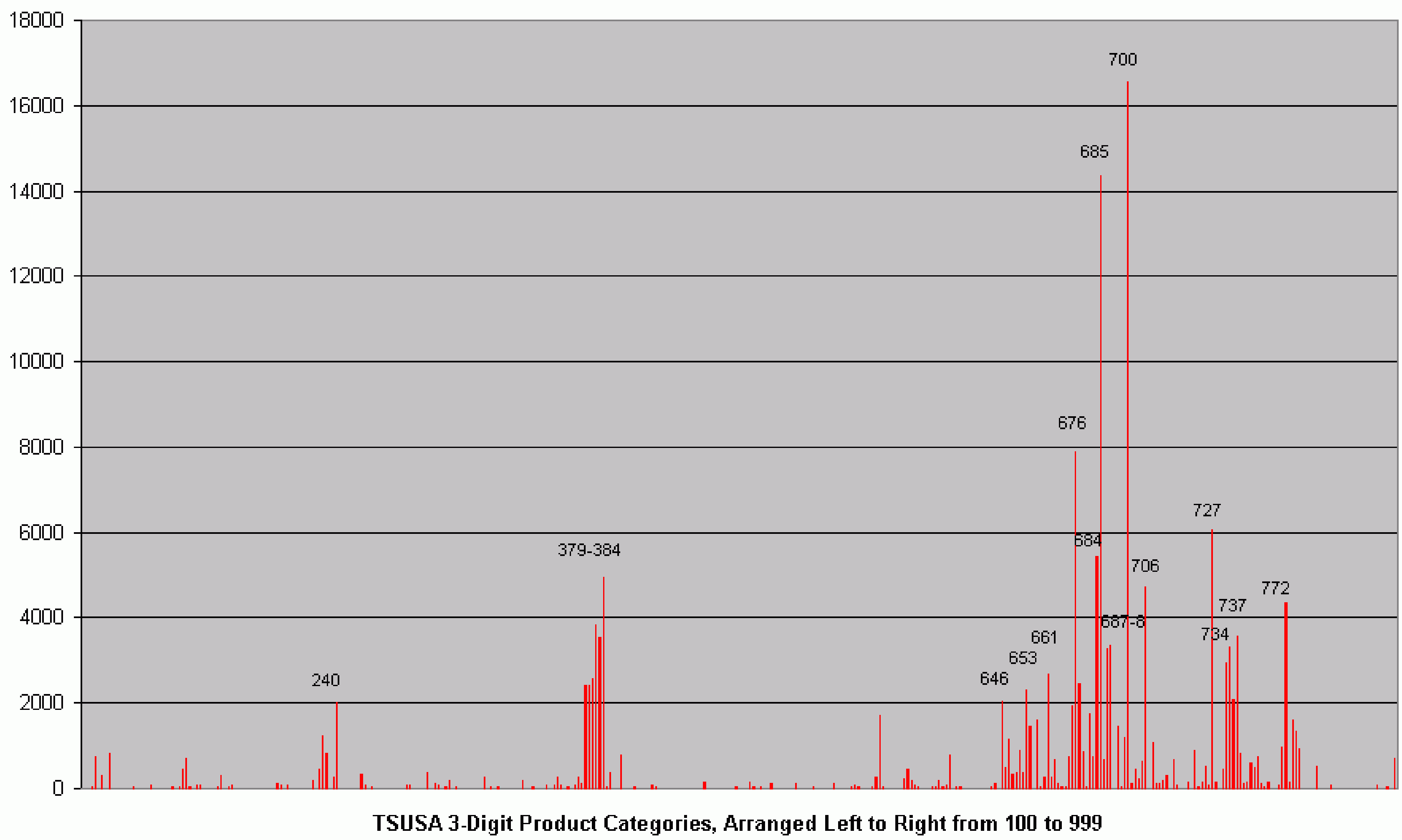


Figure 6: Taiwan Exports to the U.S., 1972-88 ($ mill)



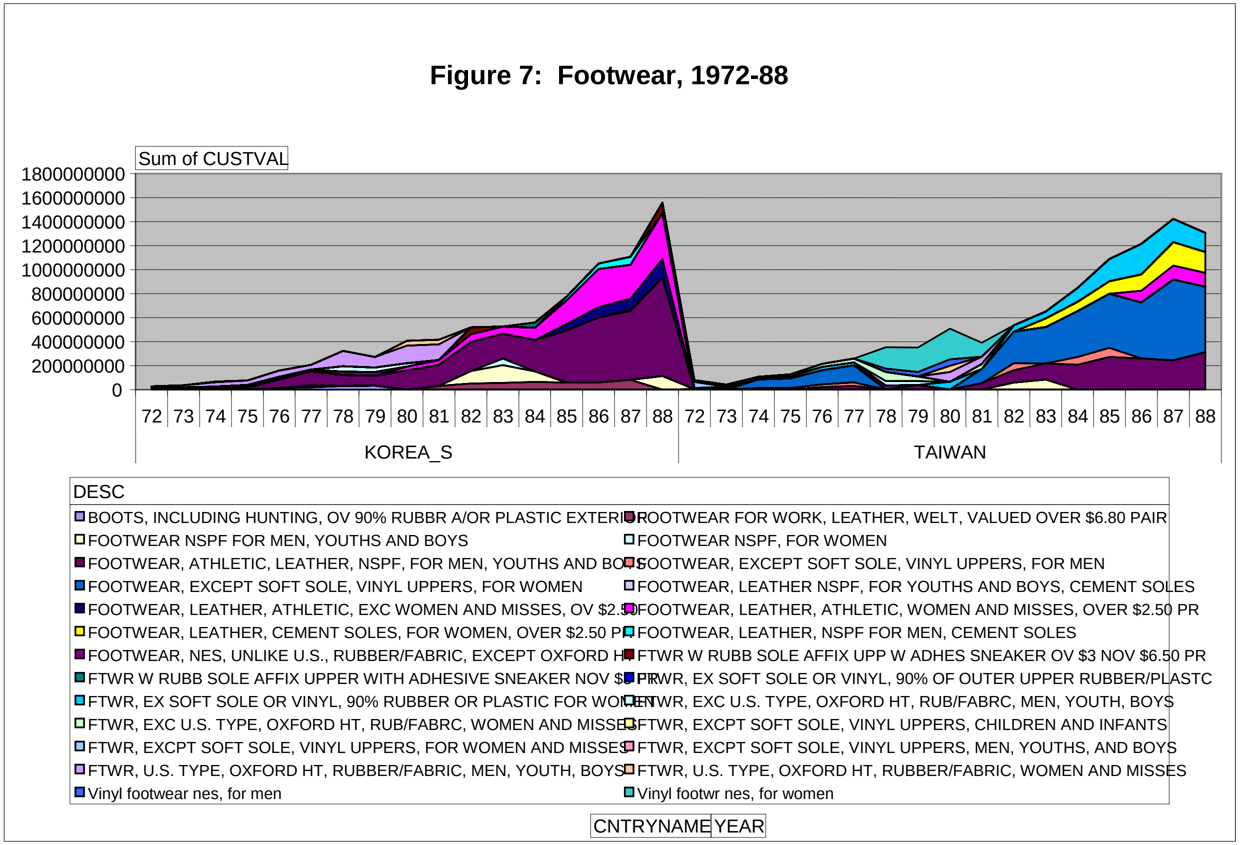


Figure 7: Footwear, 1972-88
Sum of CUSTVAL
1800000000
1600000000
1400000000
1200000000
1000000000
800000000
600000000
400000000
200000000
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88
KOREA_S
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88
TAIWAN
DESC
BOOTS, INCLUDING HUNTING, OV 90% RUBBR A/OR PLASTIC EXTERIOR
FOOTWEAR FOR WORK, LEATHER, WELT, VALUED OVER $6.80 PAIR
FOOTWEAR NSPF FOR MEN, YOUTHS AND BOYS
FOOTWEAR NSPF, FOR WOMEN
FOOTWEAR, ATHLETIC, LEATHER, NSPF, FOR MEN, YOUTHS AND BOYS
FOOTWEAR, EXCEPT SOFT SOLE, VINYL UPPERS, FOR MEN
FOOTWEAR, EXCEPT SOFT SOLE, VINYL UPPERS, FOR WOMEN
FOOTWEAR, LEATHER NSPF, FOR YOUTHS AND BOYS, CEMENT SOLES
FOOTWEAR, LEATHER, ATHLETIC, EXC WOMEN AND MISSES, OV $2.50
FOOTWEAR, LEATHER, ATHLETIC, WOMEN AND MISSES, OVER $2.50 PR
FOOTWEAR, LEATHER, CEMENT SOLES, FOR WOMEN, OVER $2.50 PR
FOOTWEAR, LEATHER, NSPF FOR MEN, CEMENT SOLES
FOOTWEAR, NES, UNLIKE U.S., RUBBER/FABRIC, EXCEPT OXFORD HT
FTWR W RUBB SOLE AFFIX UPP W ADHES SNEAKER OV $3 NOV $6.50 PR
FTWR W RUBB SOLE AFFIX UPPER WITH ADHESIVE SNEAKER NOV $3 PR
FTWR, EX SOFT SOLE OR VINYL, 90% OF OUTER UPPER RUBBER/PLASTC
FTWR, EX SOFT SOLE OR VINYL, 90% RUBBER OR PLASTIC FOR WOMEN
FTWR, EXC U.S. TYPE, OXFORD HT, RUB/FABRC, MEN, YOUTH, BOYS
FTWR, EXC U.S. TYPE, OXFORD HT, RUB/FABRC, WOMEN AND MISSES
FTWR, EXCPT SOFT SOLE, VINYL UPPERS, CHILDREN AND INFANTS
FTWR, EXCPT SOFT SOLE, VINYL UPPERS, FOR WOMEN AND MISSES
FTWR, EXCPT SOFT SOLE, VINYL UPPERS, MEN, YOUTHS, AND BOYS
FTWR, U.S. TYPE, OXFORD HT, RUBBER/FABRIC, MEN, YOUTH, BOYS
FTWR, U.S. TYPE, OXFORD HT, RUBBER/FABRIC, WOMEN AND MISSES
Vinyl footwear nes, for men
Vinyl footwr nes, for women
CNTRYNAME
YEAR

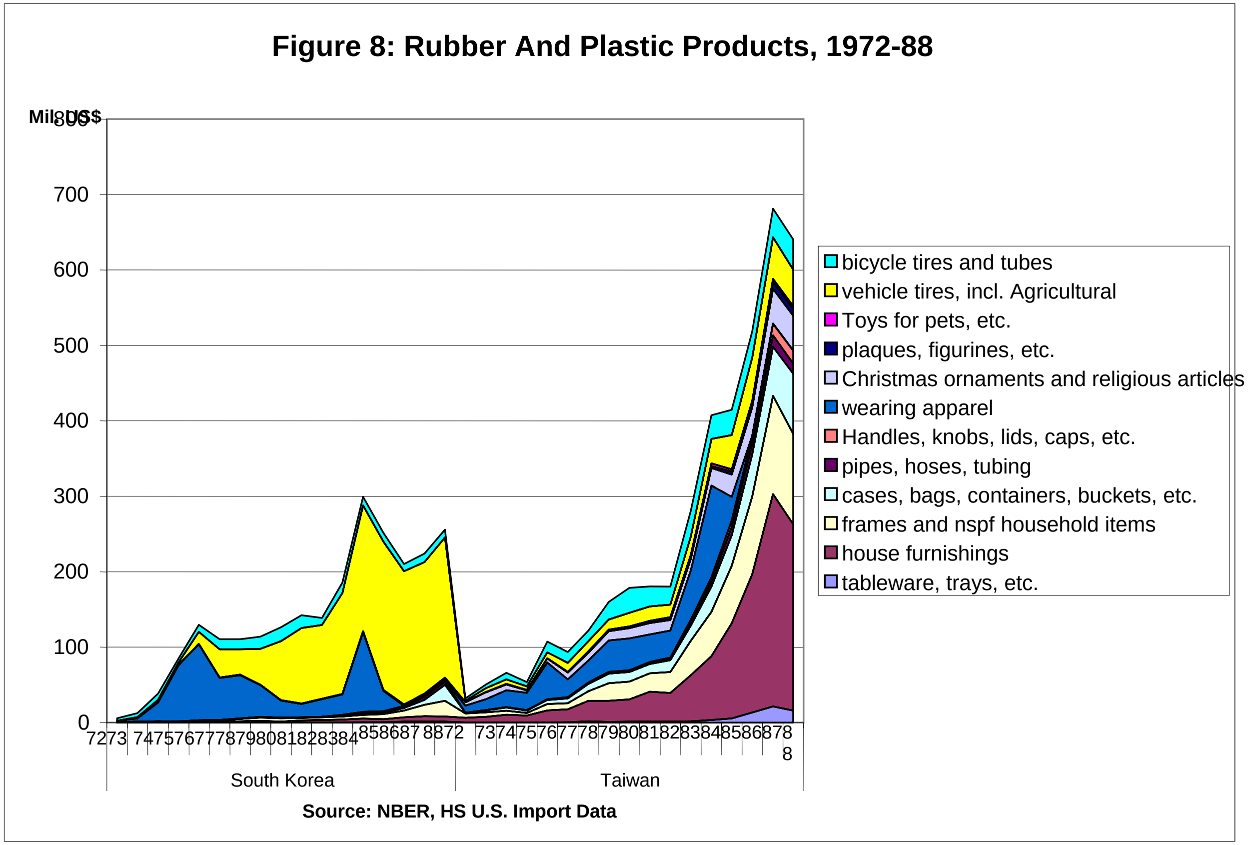
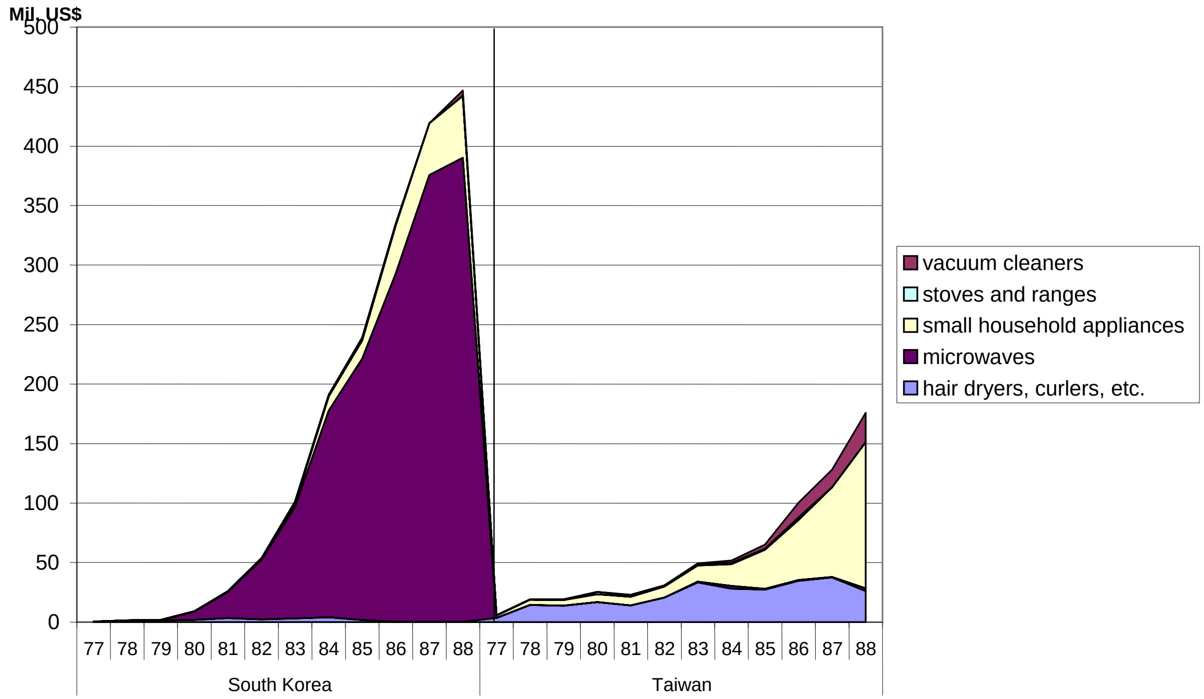


Figure 8: Rubber And Plastic Products, 1972-88
Mil US$
800
700
600
500
400
300
200
100
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88
South Korea
Taiwan
bicycle tires and tubes
vehicle tires, incl. Agricultural
Toys for pets, etc.
plaques, figurines, etc.
Christmas ornaments and religious articles
wearing apparel
Handles, knobs, lids, caps, etc.
pipes, hoses, tubing
cases, bags, containers, buckets, etc.
frames and nspf household items
house furnishings
tableware, trays, etc.
Source: NBER, HS U.S. Import Data

Figure 9: Household Appliances, 1972-1988



Source: NBER, HS U.S. Import data, 1972-2001

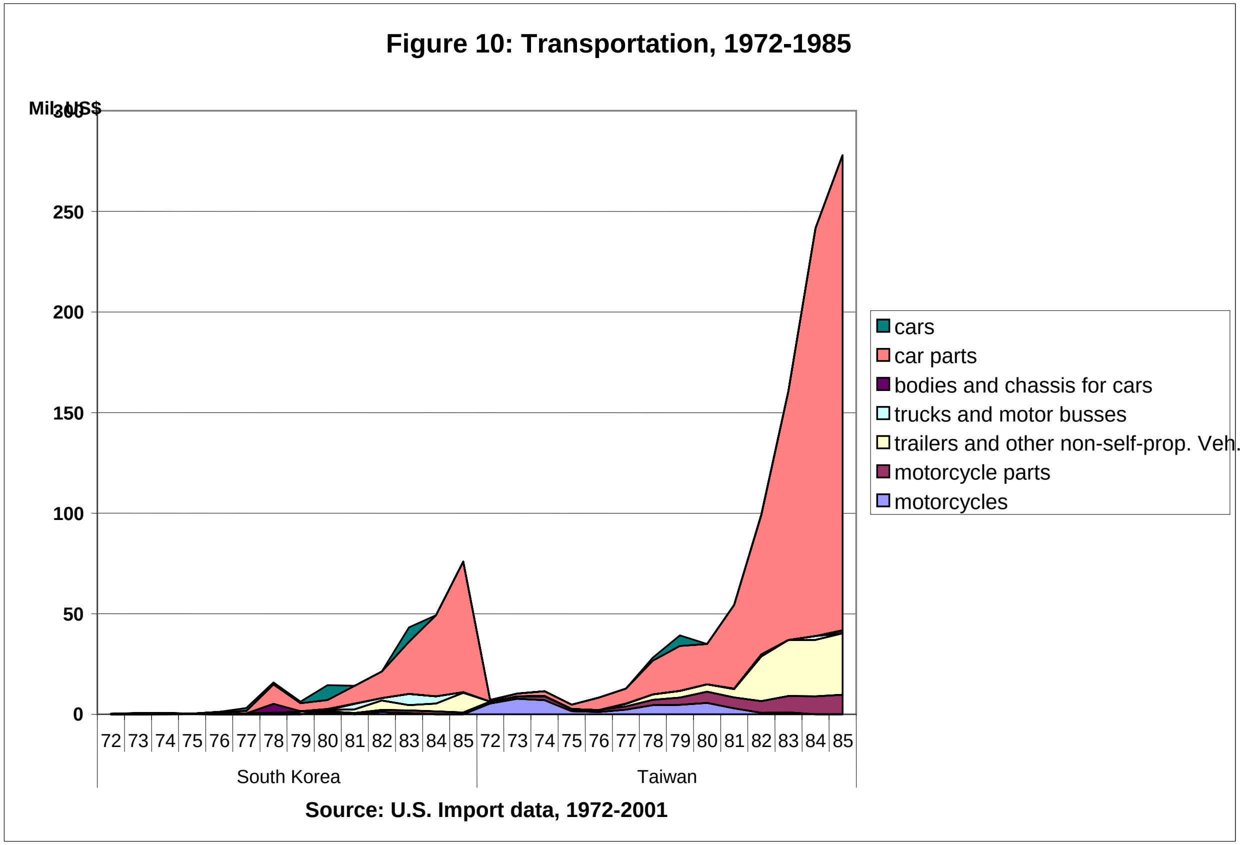
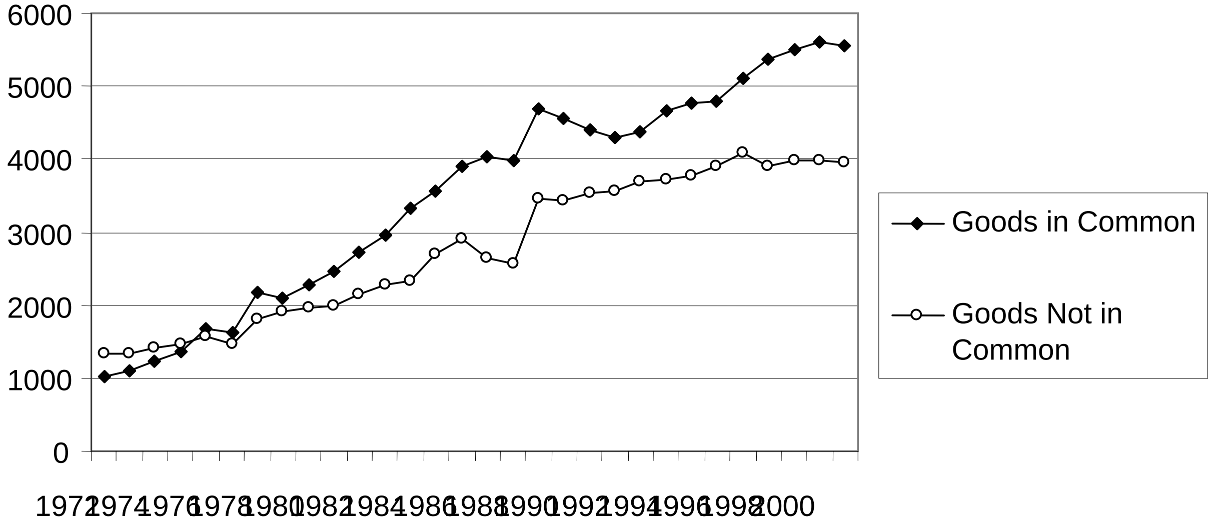


Figure 10: Transportation, 1972-1985
Mil. US$
300
250
200
150
100
50
0
72 73 74 75 76 77 78 79 80 81 82 83 84 85 72 73 74 75 76 77 78 79 80 81 82 83 84 85
South Korea
Taiwan
cars
car parts
bodies and chassis for cars
trucks and motor busses
trailers and other non-self-prop. Veh.
motorcycle parts
motorcycles
Source: U.S. Import data, 1972-2001

Figure 11: Similarity between South Korea and Taiwan's Export Landscapes



Source: U.S. Import data, 1972-2001

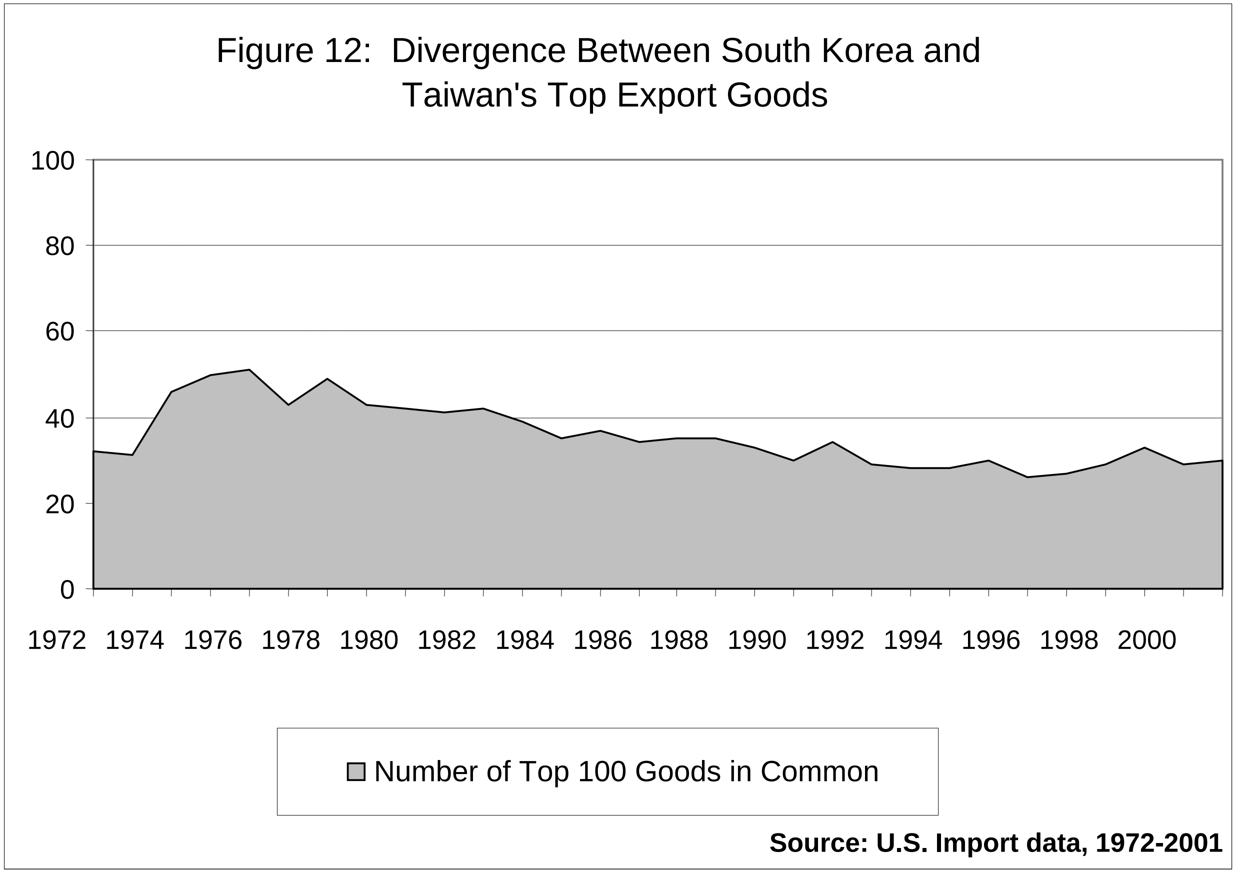


Figure 12: Divergence Between South Korea and Taiwan's Top Export Goods
100
80
60
40
20
0
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
Number of Top 100 Goods in Common
Source: U.S. Import data, 1972-2001

Figure 13: Import Penetration in Consumer Goods

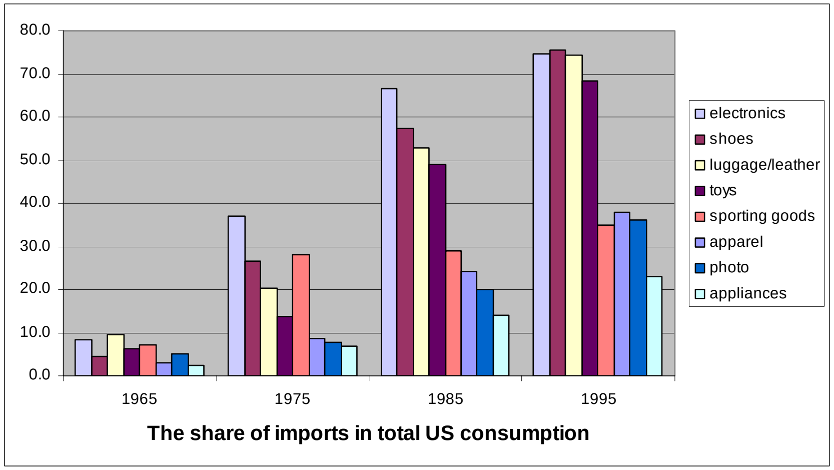
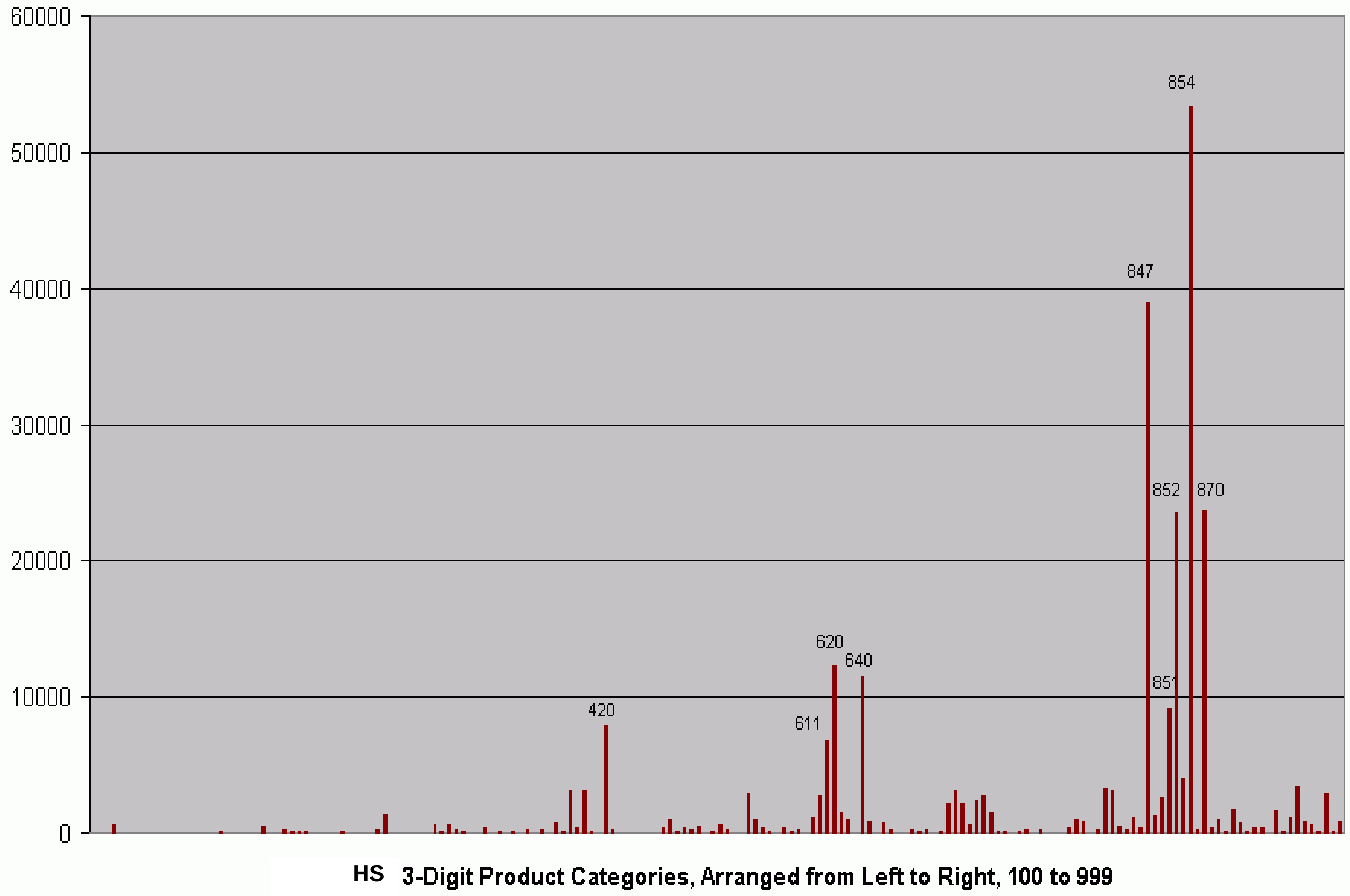


Figure 14: South Korea Exports to the U.S., 1989-2000 ($ mill)



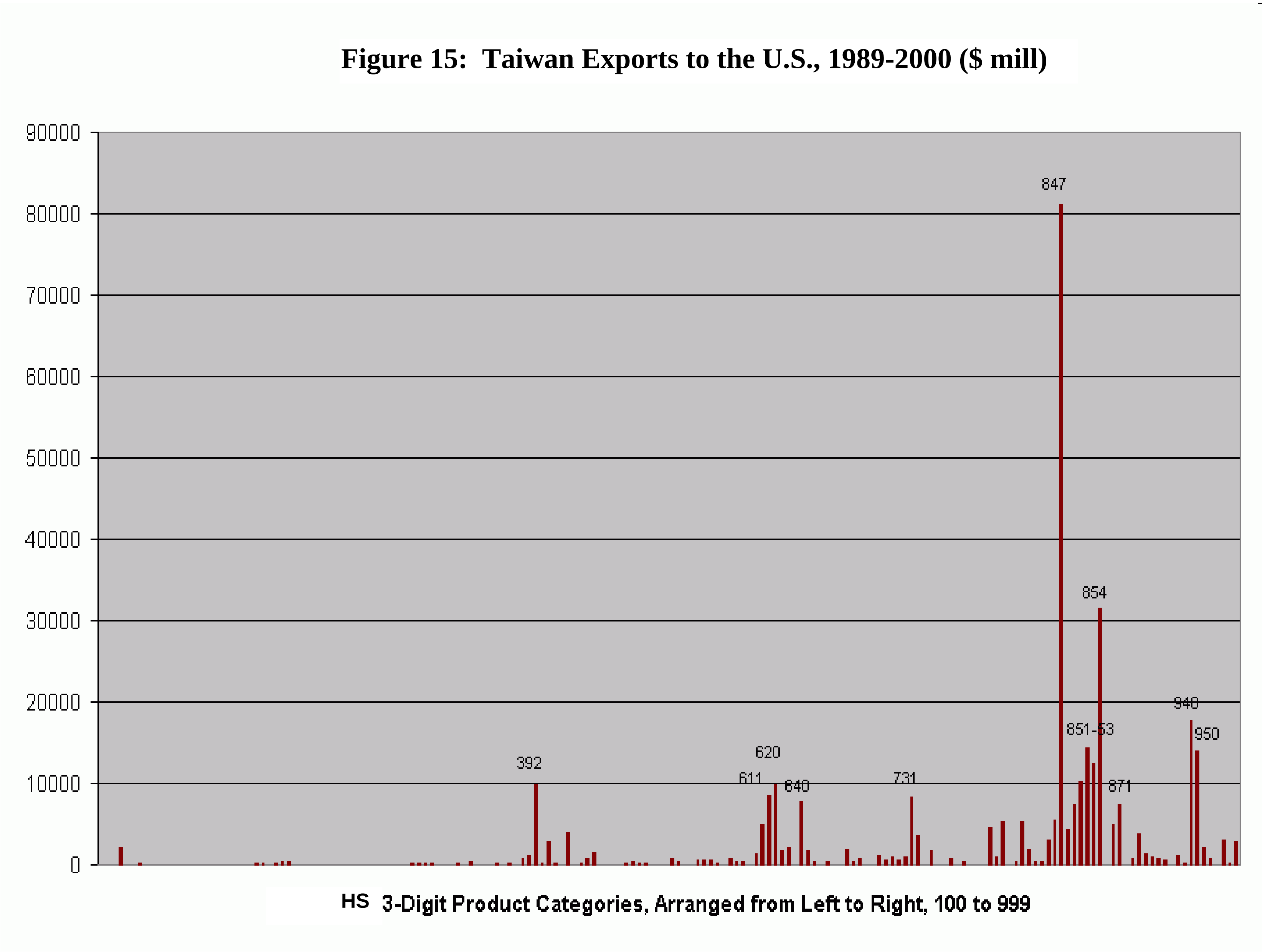


Figure 15: Taiwan Exports to the U.S., 1989-2000 ($ mill)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
847
854
940
851-53
950
620
392
611
640
731
871
HS 3-Digit Product Categories, Arranged from Left to Right, 100 to 999

Figure 16: South Korea Exports of "Top 18" Industries

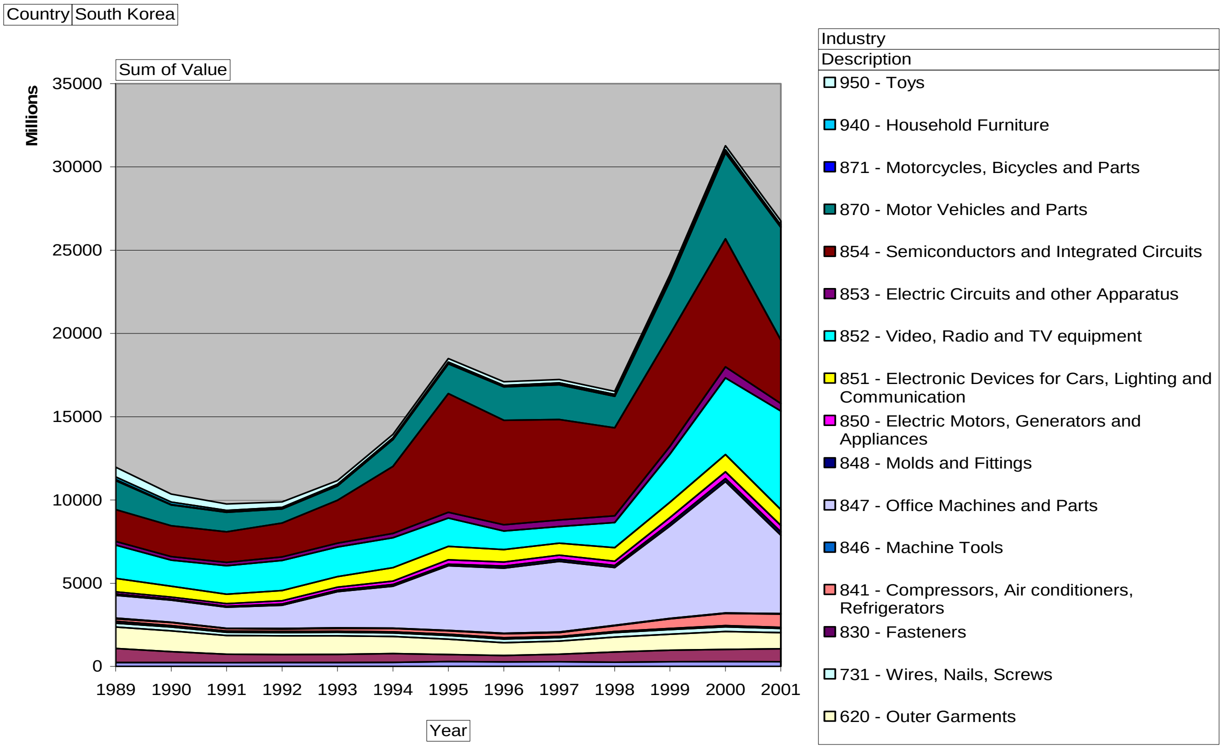


Figure 17: Taiwan Exports of "Top 18" Industries

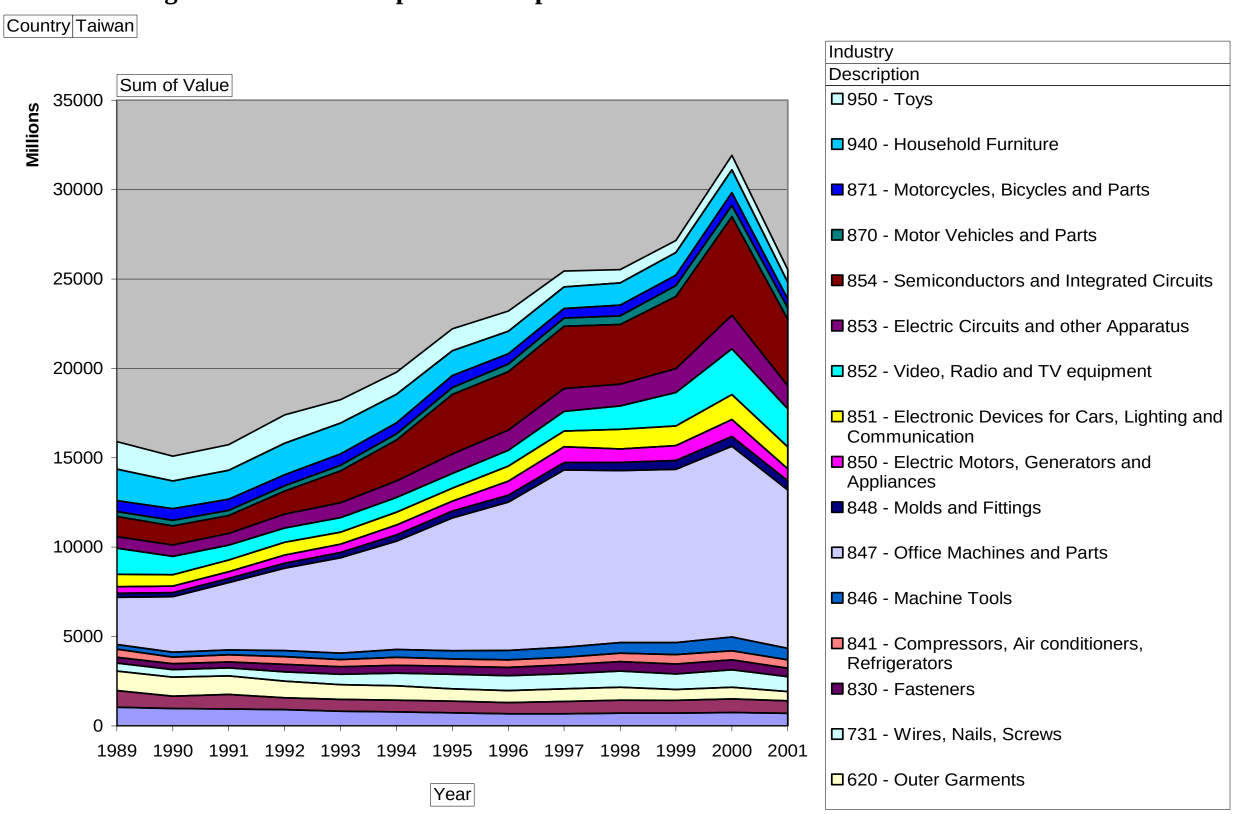


Figure 18: South Korea Exports of Transportation Products

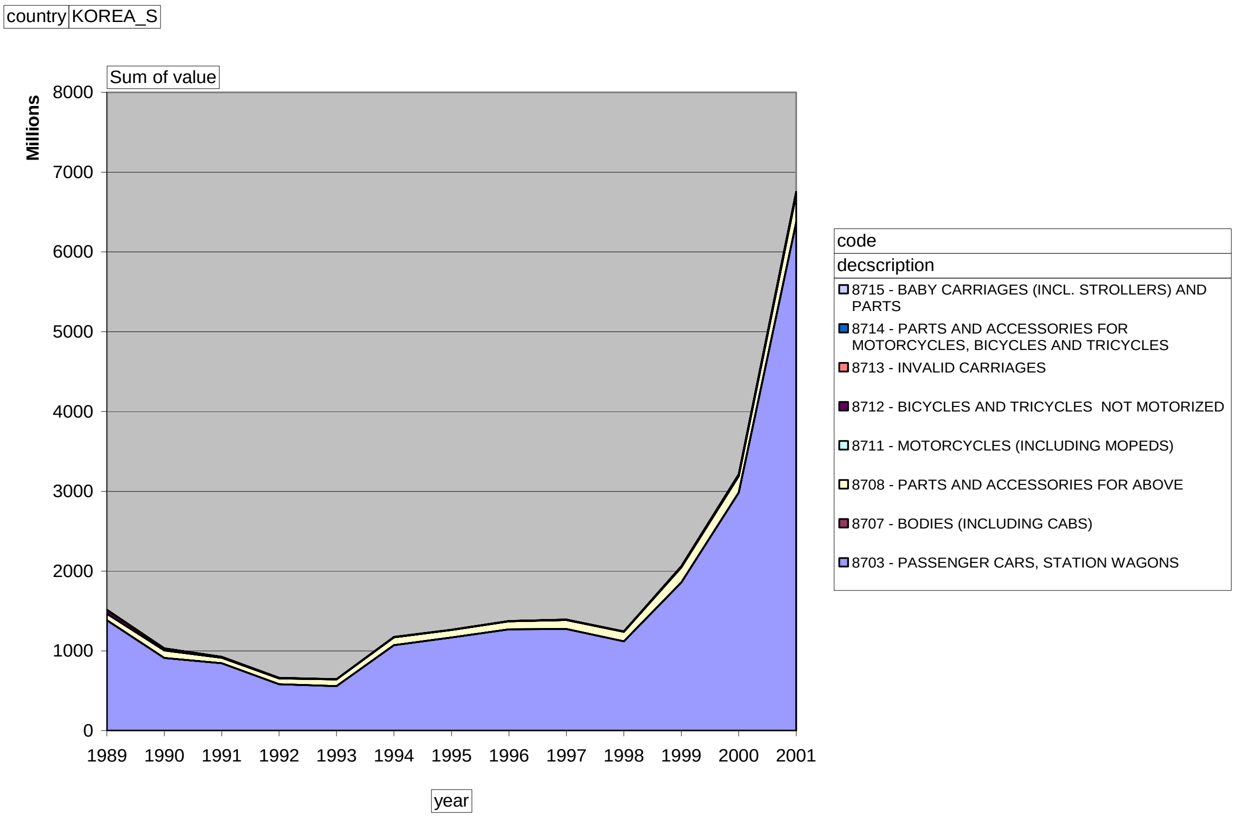


Figure 19: Taiwan Exports of Transportation Products

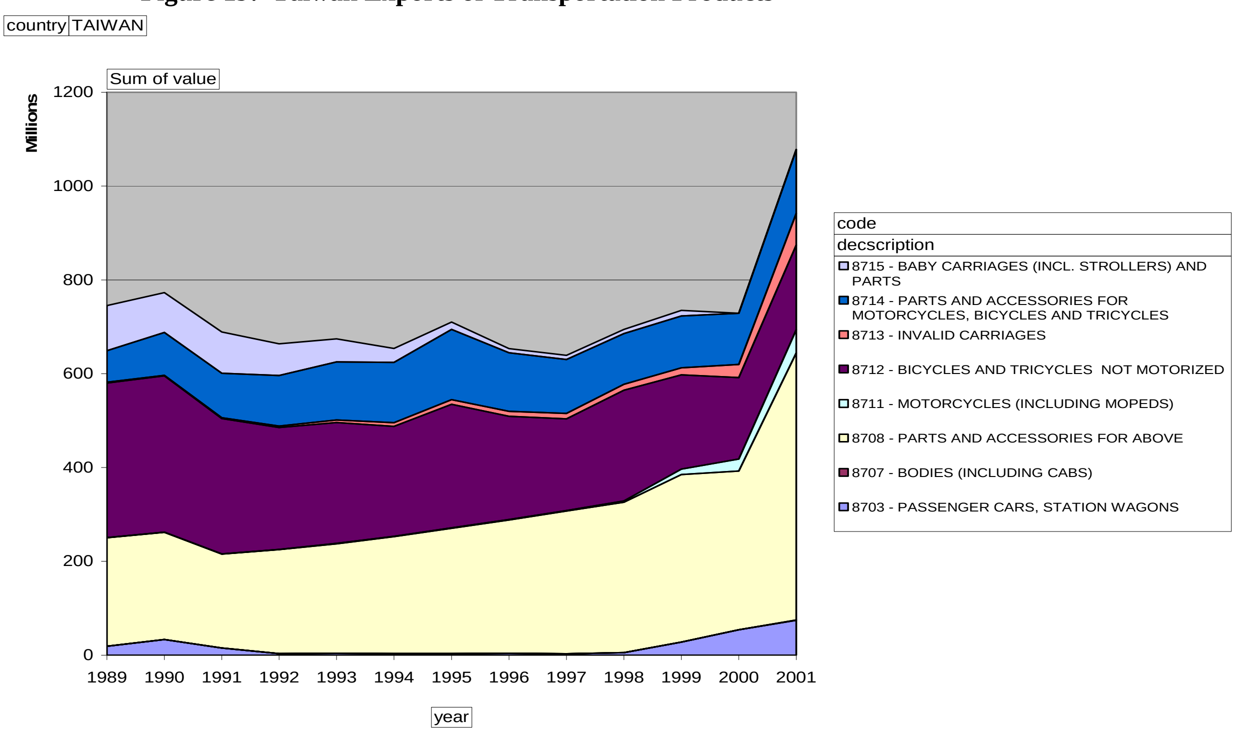


Figure 20: Economy-Wide Variety of Final Goods

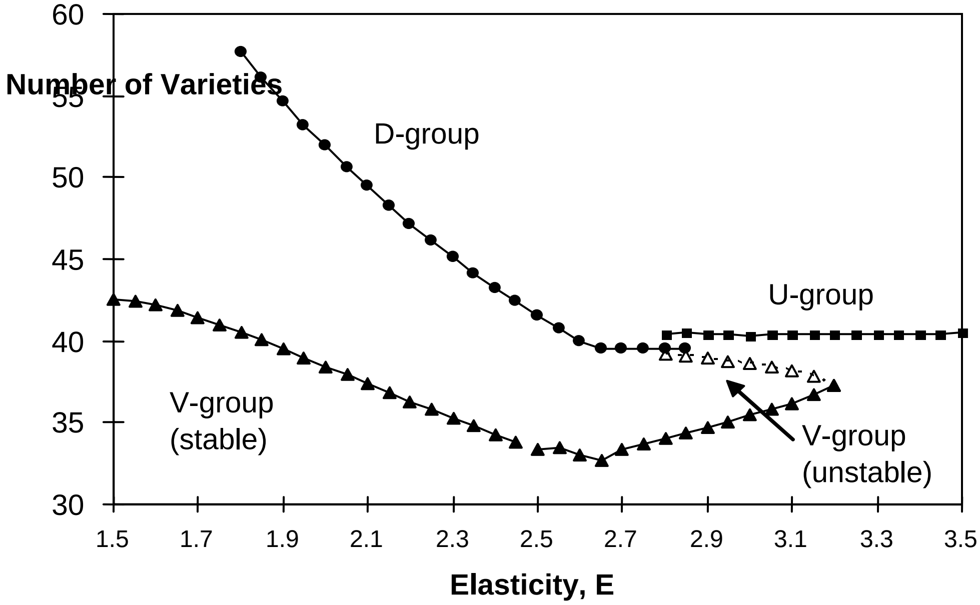


Figure 21: South Korea Exports of Office Equipment (847) and Semiconductors (854)

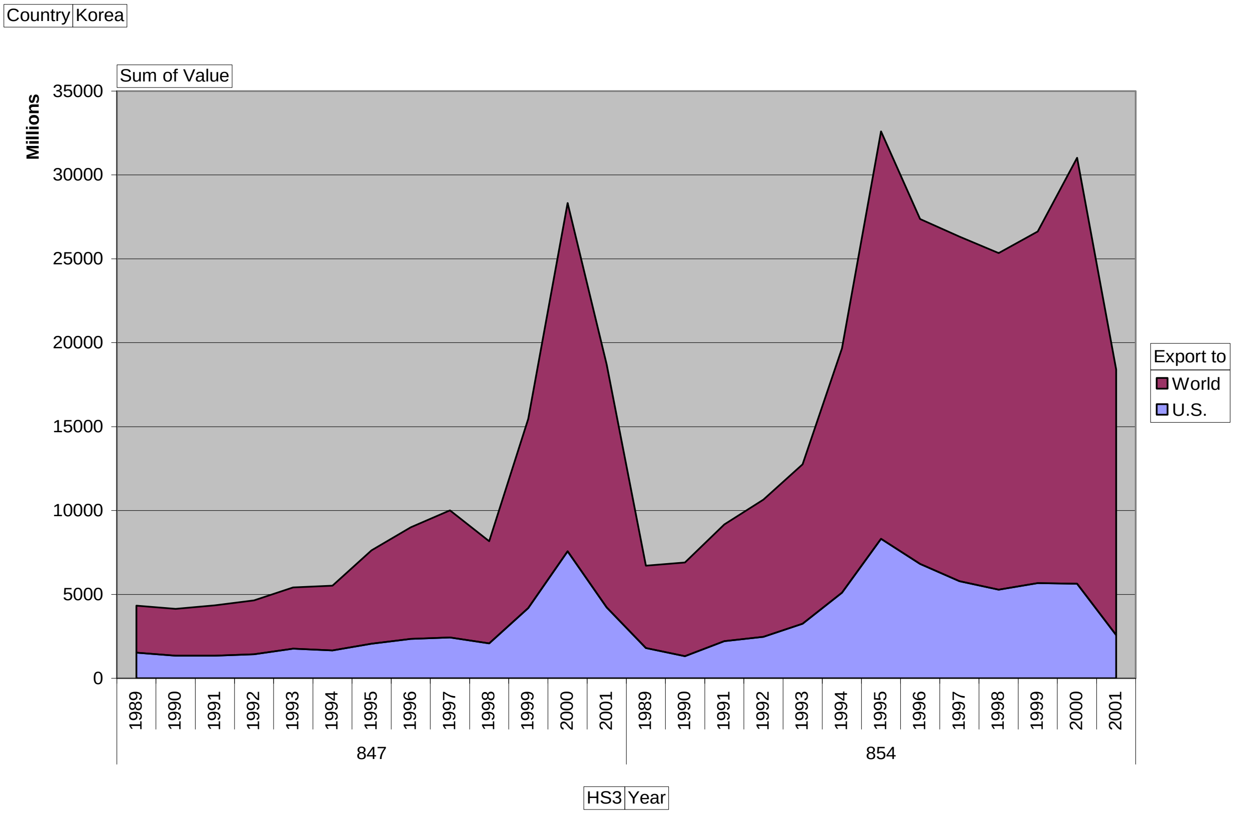


Figure 22: Taiwan Exports of Office Equipment (847) and Semiconductors (854)

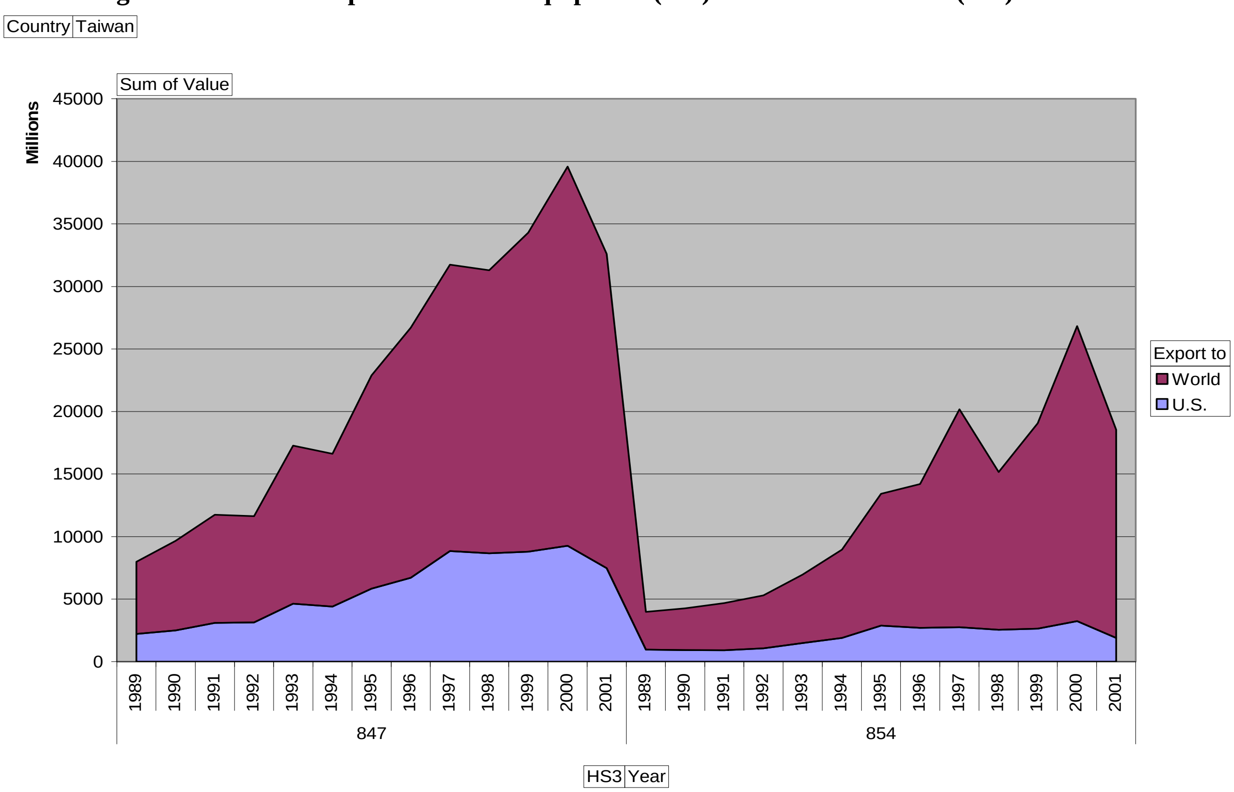


Figure 23: South Korean Exports of Semiconductor Products

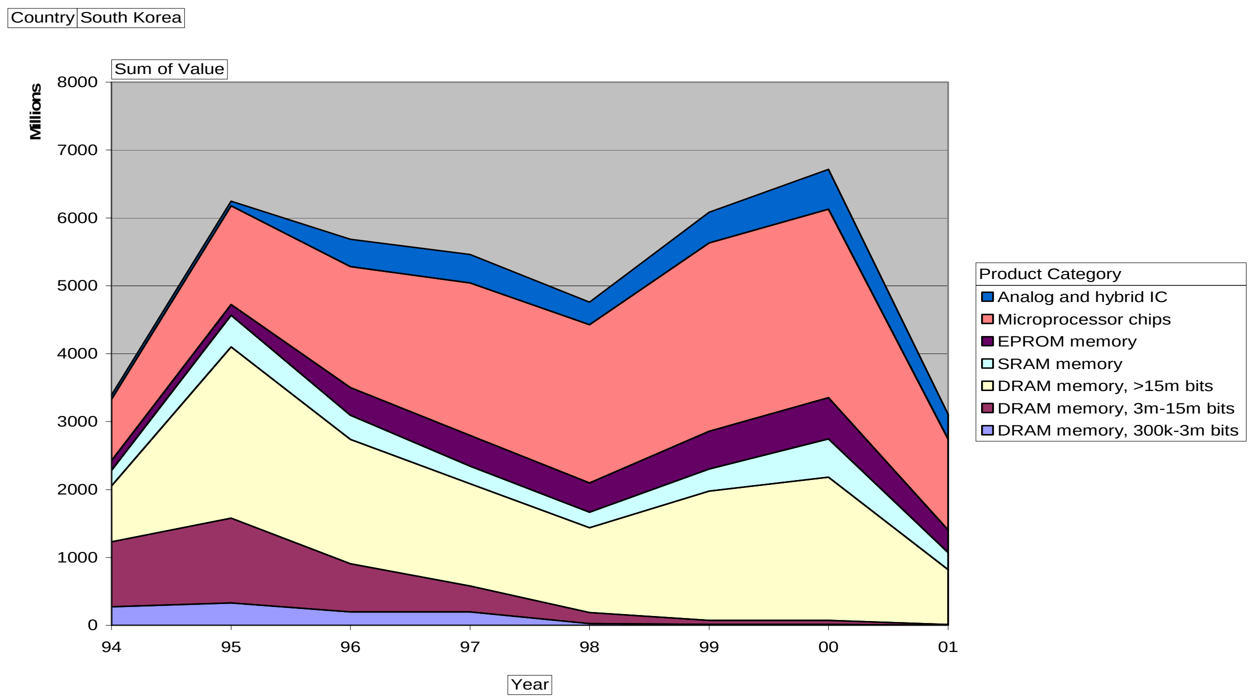


Figure 24: Taiwan Exports of Semiconductor Products

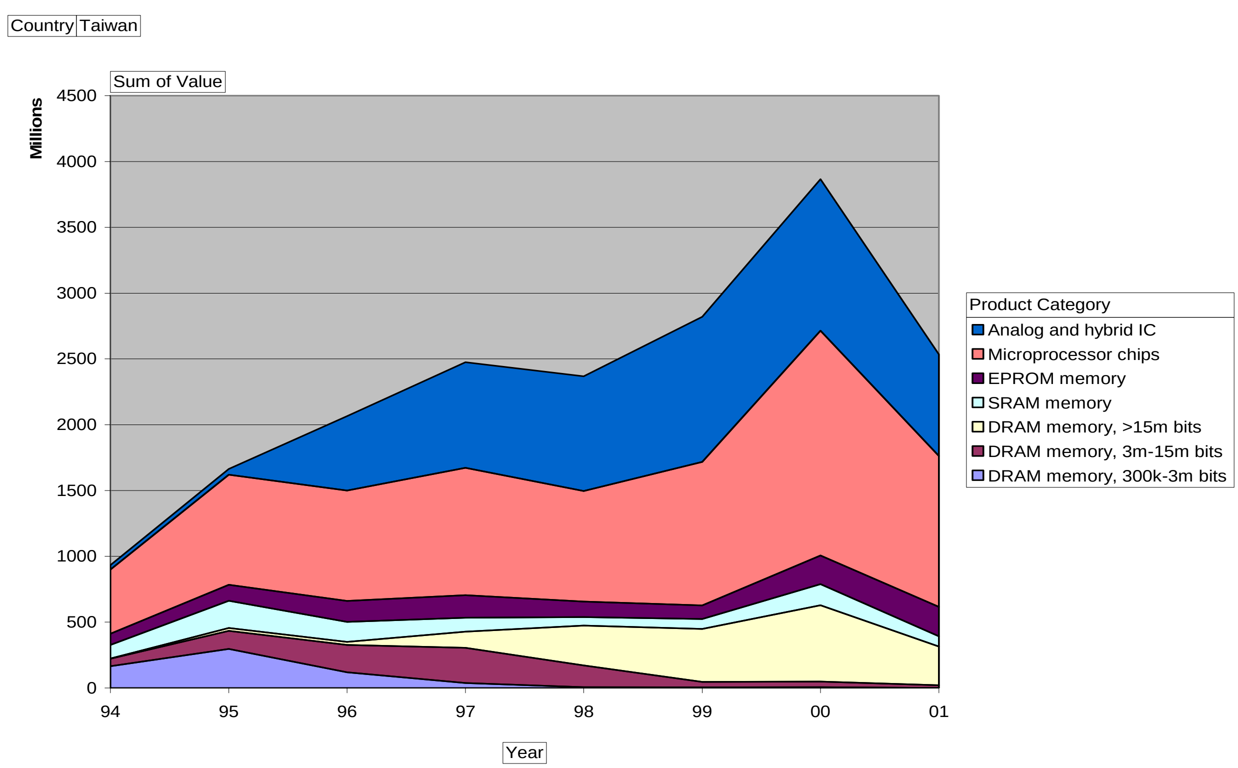


Figure 8.13: Semiconductor Export Prices to the U.S. ($)

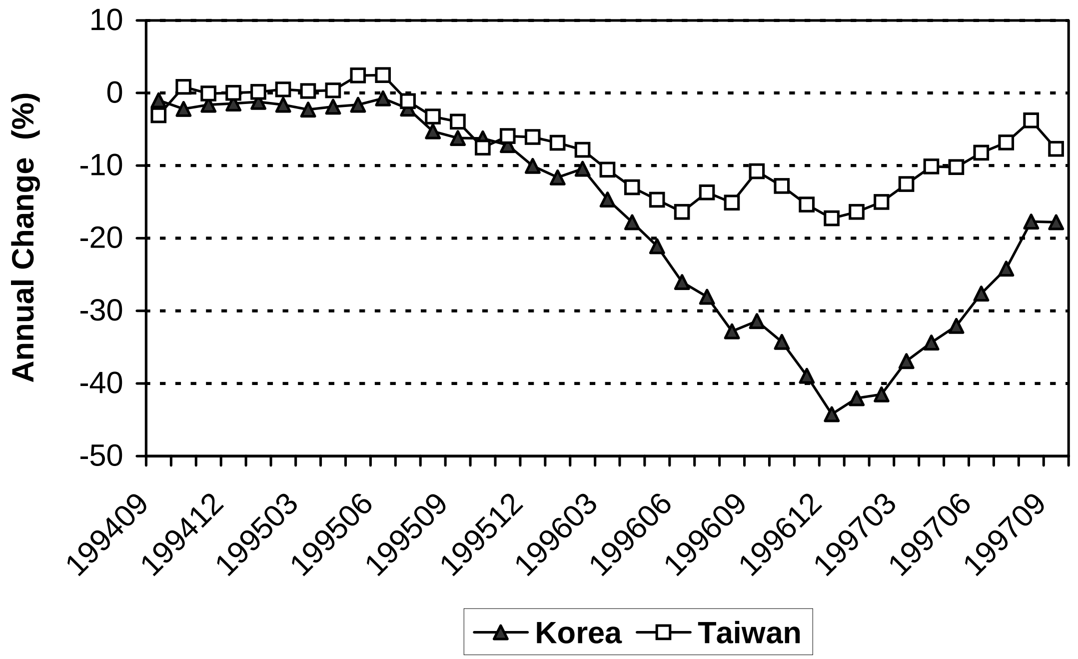
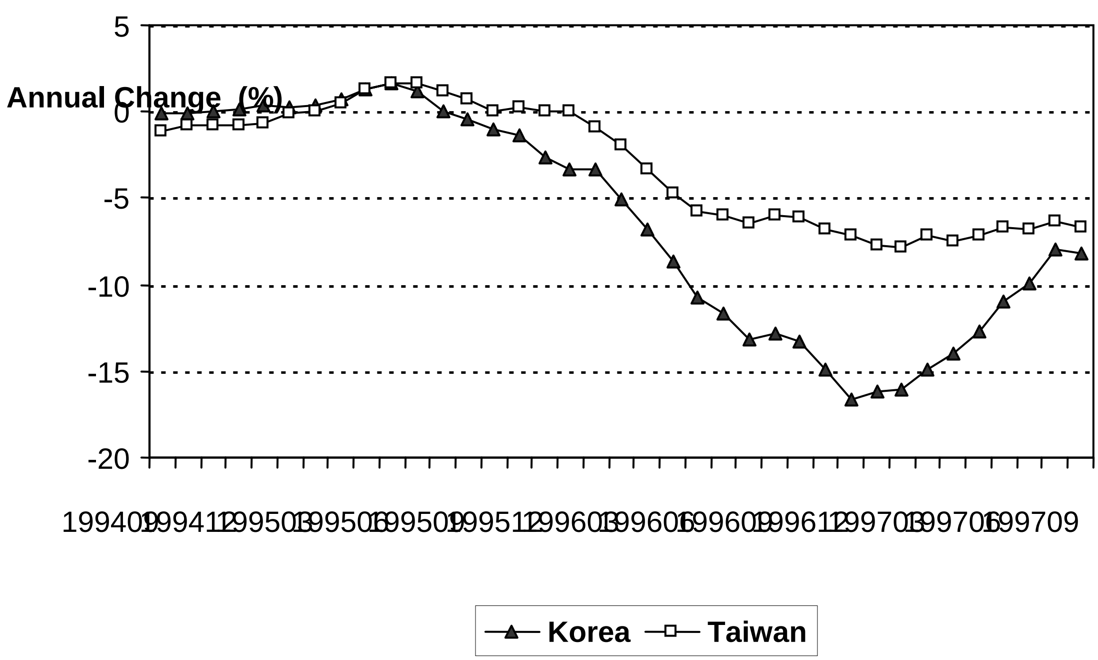


Figure 26: Aggregate Export Prices to the U.S. ($)



Endnotes

[1] These data are available at www.internationaldata.org.

[2] Worldwide bilateral import and export data for most countries, from 1970-1992, is available from Feenstra, Bowen and Lipsey (1997), based on data from Statistics Canada; this has been updated to 1997 by Feenstra (2000), and both databases are described as www.internationaldata.org. However, that data is available at the 4-digit Standard International Trade Classification, which is considerably more aggregate than the 7-digit TSUSA data for the U.S. from 1972-1989, or the 10-digit HS classification for 1989-2001, both which we use.

[3] In order to depict this trend graphically, we included all seven-digit categories of footwear whose total value exceeded $10,000,000 US in any year period between 1972 and 1985.

[4] The nine 3-digit HS categories with Korean exports to the U.S. exceeding $500 million in 2000 are outer garments (611,620), compressors, air conditioners and refrigerators (841), office machines and parts (847), electronic devices for cars, lighting and communication (851), video, radio and TV equipment (852), electric circuits and other apparatus (853), semiconductors and integrated circuits (854) and motor vehicles and parts (870).

[5] Within the entire group of 18 industries where Taiwanese exports exceeding $500 million in 2000, average exports are $1.8 billion. In addition to the nine 3-digit HS categories detailed in the previous footnote, the other nine industries with Taiwanese exports to the U.S. exceeding $500 million in 2000 are certain plastic products (392), wires, nails and screws (731), fasteners (830), machine tools (846), molds and fittings (848), electric motors and devices (850), motorcycles, bicycles and parts (871), household furniture (940) and toys (950).

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[6] Biggart and Guillén (1999), p. 733.

[7] Biggart and Guillén (1997), p. 207.

[8] Biggart and Guillén (1999), p. 734. According to Biggart and Guillén (1997, p. 208), Taiwan has a small export market to Canada through the sales of Mercury Tracer cars, built by Ford Lio Ho Motors.

[9] Biggart and Guillén (1999), p. 731.

[10] Kim (2000), p. 68, citing Park, Jung-hu and Hong-eyn Kim, 1997, *Globalization Strategies of the Korean Automobile Industry*, Seoul: Korea Institute for Industrial Economics and Trade.

[11] Biggart and Guillén (1999), p. 735.

[12] From the Penn World Tables, version 5.6, Korean per capital income in 1990 was $6,673, and its population was 42.9 million, giving a GDP of $286 billion. Per capital income in Taiwan in 1990 was $8,063 and its population was 20.4 million, giving a GDP of $164 billion; Korea had this level of GDP some five years earlier. Since Korea is larger than Taiwan in terms of GDP, this factor alone would lead to greater product variety in Korea from our model of chapter 3.

Therefore, our finding in this chapter that Taiwan actually has higher product variety, despite the size advantage of Korea, reinforces the conclusion that the differing economic organization of the two countries must account for this.

[13] In Figure 3.14 of chapter 3, we show the economy's product variety of intermediate inputs as simulated from our model, and it has just the "reverse" pattern as found for final goods: equilibria with just V-groups have the greatest

variety of intermediate inputs, and equilibria with D-groups or U-groups have the least. This result was already hinted at above, when we noted that the V-groups in our model, like the largest *chaebol* in Korea, benefit from access to a wide range of differentiated intermediate inputs from the group firms. The reason these specialized inputs are developed is to lower their costs of final goods, so that the *wide range* of inputs and *narrow range* of final goods for the V-group equilibria go hand-in-hand. The key distinction in our model between final goods and intermediate inputs is that the former are *traded internationally,* whereas the latter are *not traded.* In other words, what we have called “final goods” can represent products sold to consumers or to firms, provided that they can be exported; in contrast, the “intermediate inputs” are not traded internationally.

[14] Thus, in 1993, both of the HS products that Taiwan sold in the U.S. were also exported by Korea, and in 1994, two out of the four HS products that Taiwan sold also had Korean sales.

[15] The sample mean of the product variety indexes for motor vehicles and bodies is -4.92, and the standard deviation is 0.43. The standard deviation of the mean is constructed as $0.43/\sqrt{3} = 0.25$. The ratio of the mean and its standard deviation equals -4.92/0.25 = 19.68, which has a t-distribution under the null hypothesis that the population mean is zero. The lower 5% value of the t-distribution (with 2 degrees of freedom) is -2.92, and since -19.68 > -2.92 we easily reject the hypothesis that the population mean is greater than or equal to zero.

[16] The sample mean of the product variety indexes for motorcycles, bicycles and parts is 0.56, and the standard deviation is 0.53. The standard deviation of the

mean is constructed as $0.53/\sqrt{3}=0.305$. The ratio of the mean and its standard deviation equals 0.56/0.305 = 1.84, which has a t-distribution under the null hypothesis that the population mean is zero. The lower 10% value of the t-distribution (with 2 degrees of freedom) is 1.89, and since $1.84 < 1.89$ we cannot reject hypothesis that the population mean is zero at the 90% level. However, at a slightly lower level of significance, this hypothesis can be rejected.

17 The price index that appears in the denominator of the formula above requires some explanation. Essentially, this compares the prices of *common products* between the two countries. If there is only a single common product, we would use its price ratio; with several common products, we need to take an average of their price ratios. Many formulas are available to compute the average of the price ratios, or price index. The formula we have used first takes the natural log of the price ratios for individual products, which we write as $\ln(p_{it}/p_{ik})$, where i denotes the individual products, exported from t = Taiwan or k = Korea. Note that the price index is computed only over common product, available from both country. Then we average these using the export shares from Taiwan and Korea, which we denote s_{it} and s_{ik}. These sales shares must sum to unity for each country, over the common products sold by both. For SIC 3711 in 1994, for example, there are two common products: the all terrain vehicles, and their bodies. Taiwan sells $4.6 million of the first, and $20,000 of the second, so the sales share of the first is 0.996 and of the second is 0.004. Similarly, Korea sells $7.2 million of the ATV and $25,000 of their bodies, so the sales share of the ATV is 0.0997 and of the bodies is 0.003. The price index, measured as a natural

log, is then obtained as:

$$\ln[(\text{Taiwan/Korea) Price Index}] = \sum_i \tfrac{1}{2}(s_{it} + s_{ik}) \ln(p_{it} / p_{ik}) .$$

This price index is used in the denominator of the product “mix” index, to “deflate” the ratio of unit-values and therefore obtain the product mix index. Finally, note that since the price index is written in natural logs, we would take the exponential before using it in the denominator of the product “mix” index. Alternatively, we can rewrite the product “mix” index as equal to

Product Mix Index = ln[(Taiwan/Korea) Unit Values] – ln[(Taiwan/Korea) Price Index],

and then directly use the log price index computed as above.

18 Five-digit industries were used for 1978-88, while 4-digit industries were used for 1989-94.

19 In the food industry, Taiwan has higher product mix despite being classified as a final good. As we have noted earlier, this industry also includes animal feeds, which are intermediate inputs. The transportation industry is a special case in which Taiwanese business groups' production is concentrated in automobile manufacturing and state-owned in shipbuilding, most of which is for domestic consumption rather than export.

20 Emily Thornton, “Bowing to Designers: Taiwan chip makers compete for contracts,” *Far Eastern Economic Review*, April 3, 1997, p. 54.

21 Lew and Park (2000), pp. 49-50.

[22] Lew and Park (2000), pp. 51, Table 3.

[23] Lew and Park (2000), pp. 51.

[24] Lew and Park (2000), pp. 51.

[25] Figures 8.13 and 8.14 are constructed from survey data on import prices into the U.S. from the Bureau of Labor Statistics (BLS), as described in Alterman, Diewert and Feenstra (1999). Specifically, the price index used is the Törnqvist formula using prices collected by the BLS and current annual export values from Korea and Taiwan in their sales to the U.S. Because the Törnqvist formula uses current rather than lagged export values, it gives a more accurate measure of export prices than other indexes.