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**Japanese U.S. Auto Transplant Production:  
An Analysis of the Roles of VERs and the Exchange Rate**

**Michael R. Cornstubble  
& Dr. Margaret Chapman, project advisor**

**April 25, 1997  
Senior Research Honors Economics Project Final Copy**

**Abstract:** *Since their introduction in 1982, Japanese auto transplants in the U.S. have skyrocketed in production, now producing many more cars than are imported. This study incorporates new refinements and revisions to attempt to identify the main factors that are responsible for the introduction of Japanese auto transplants and their massive growth in production over the last 14 years. The author develops two hypotheses from theoretical analysis of the factors contributing to production decisions. The first is that the voluntary export restraints (VERs) imposed on the Japanese from 1981-1985 are responsible for bringing the transplants to the U.S. and for creating major growth in their production. The second hypothesis is that after 1985, a different factor was responsible for sustaining growth in transplant production, the exchange rate. The author relies mainly on theory and observations of quarterly time series data to support his first hypothesis, but supports the second hypothesis with both theoretical and improved empirical analyses, with strong results throughout.*

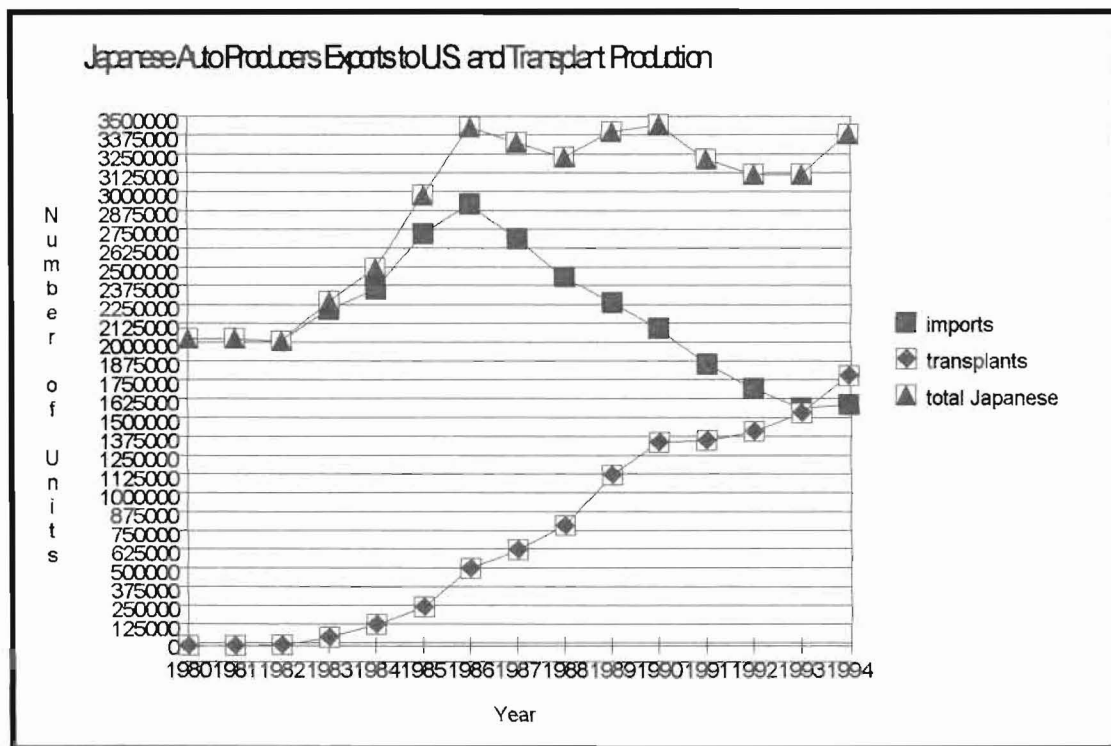
## I. Introduction

Of the many industries in which the U.S. trades internationally, few can match the fervor created by the automobile industry. More specifically, the rivalry between U.S. and Japanese cars has historically been one of the hottest debated topics across the United States, and not surprisingly, a very personal issue for the thousands of Americans employed in the U.S. big three auto makers (Chrysler, Ford and General Motors) and their many parts suppliers. After the oil crisis in 1973, Japanese cars became extremely popular because of their fuel efficient designs and excellent reliability, leaving the American auto industry shaken. They lost market share quickly, unprepared for the changing demand in automobiles and lagging behind the Japanese in quality. This loss in market share continued into the 1980s, creating great concern among those employed in the auto industry, as well as the many Americans who shared a sense of pride in American cars. This passionate sense of pride among staunch U.S. automobile protectionists led to pressure on the government by unions and other organizations to protect the welfare of the U.S. auto industry. Most protection has come in the form of tariffs or quotas on imports. In early 1980, fueled by concern over the U.S. auto industry's loss in market share, the U.S. government asked Japan to impose voluntary export restraints (VERs) of 1.68 million units on its automobiles to the United States from 1982 until 1984. Japan announced in May 1981 that it would comply with the request.

While the VERs temporarily boosted and protected the U.S. auto industry's market share, the VERs caused another significant effect that was certainly unintended by the U.S. government. Sales of Japanese cars actually increased in the coming years because major Japanese auto makers started up domestic production in the United States. This paper examines the reasons for increased Japanese auto production in the United States.

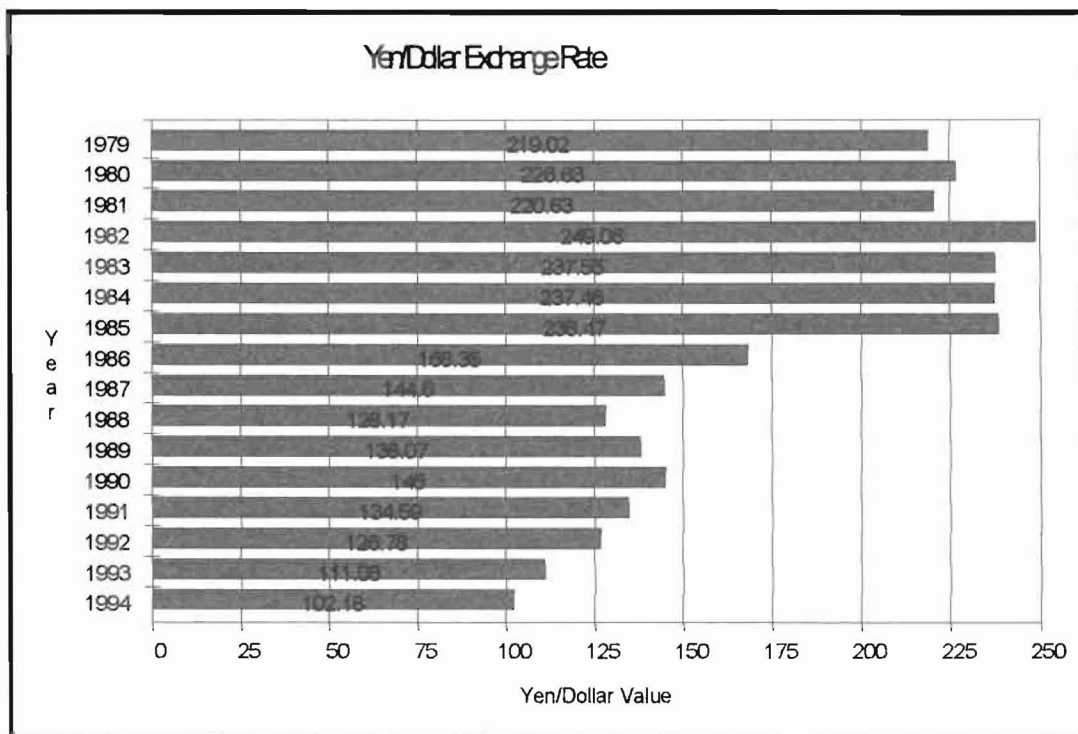
This paper hypothesizes that the VERs of the early 1980s were largely responsible for the introduction of Japanese domestic production in U.S. auto transplants and, until 1985, for their

Figure 1



Sources: Ward's Automotive Yearbook, Various Volumes and Business Statistics of the U.S.

Figure 2





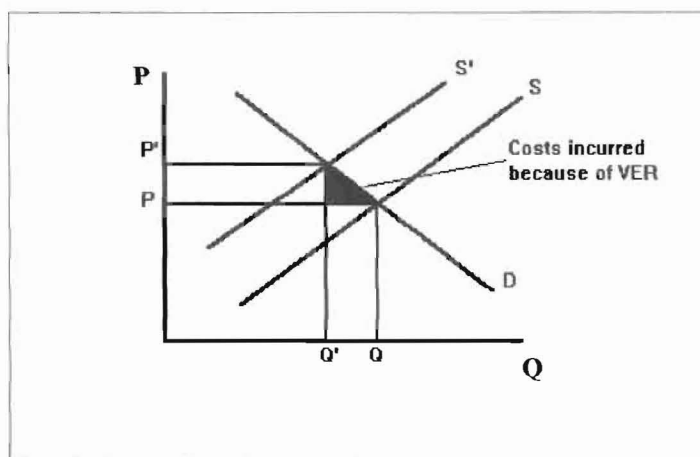
explosive growth. Although the United States-requested VERs expired in 1985 and import restrictions loosened greatly, Japanese production in the United States persisted at a heightened pace while exports continually declined over the years following 1986 (Figure 1). The number of exports depicted in Figure 1 exceed the VER quota because these figures include trucks, vehicles not covered under the VERs. The author hypothesizes that after the VERs expired, the reason for Japanese companies' decisions to continue domestic production changed. The appreciated yen that skyrocketed after 1985 (Figure 2) became the factor responsible for this persistent growth.

Section II will present background information on the research by discussing the related economic literature. Section III will discuss the theoretical framework in this project. Section IV will describe the sources of data and the data used in the empirical model in Section V. Section VI will discuss the results and the paper will conclude with remarks and recommendations for future research in Section VII.

## **II. Background**

While many authors such as Goto, Collins and Dunaway, de Melo and Tarr, Krugman and Richardson acknowledge VERs and the exchange rate as a major reason for increased Japanese foreign direct investment (FDI) in U.S. transplants, virtually no one has performed a study to examine the VER's or the yen-dollar exchange rate's direct roles in influencing domestic production decisions. Graham and Krugman acknowledge both of my hypotheses as being true in their book, Foreign Direct Investment, but give no support for their assertion. Most literature about the VERs of the early eighties seeks to quantify the monetary/welfare costs associated with the quotas. These costs were incurred because Japanese companies were able to reap monopoly profits by the restricted supply (Figure 3). In addition, Japanese companies were able to raise their prices effectively and increase profitability by exporting more well-equipped cars than before (Collins 151). U.S. companies were also able to raise their prices and make more profits although to a lesser extent (Collins 159). These additional costs to the consumer in the form of

**Figure 3**



inflated prices was the cost of the trade restraints.

Literature by Ries suggests that the VERs had a positive aspect for the Japanese companies because of the windfall profits associated with the restricted exports (Ries 259). A study by de Melo and Tarr also found that the Japanese companies experienced increased profits because of the VERs. This would suggest that moving operations to the United States in order to boost production would not be wise since they were earning inflated profits with their restricted supply, contrary to my hypothesis. It is important to point out that although it may be true that Japanese companies profited during the times of the VERs, this literature focuses only on the period of time while VERs were at their highest (1982-1985), not on the long run picture. In focusing only on the short run, this literature has neglected the important issue that in the automobile industry, the long run view is crucial to the success of any company. This is because it is an industry in which established market share is hard to gain and is very important. In the next section on theory, I will better address these arguments and discuss why Japanese companies decided to move production to the United States while apparently earning increased profits because of the VERs.

It seems clear that with a void of literature focusing directly on the research problem, the project will be breaking new ground and focus on support by theoretical and empirical evidence rather than past research.

### III. Theoretical Model

The model will include six main factors that have affected the Japanese companies' production decisions in U.S. auto transplants the most. These main explanatory variables are: 1) the VERs 2) the exchange rate, 3) wage rates in U.S. and Japanese auto industries, 4) U.S. economic performance, 5) market share of Japanese automobiles in the United States and 6) parts availability for producing the automobiles. In this section, I develop a theoretical model that uses these variables to explain the introduction and rise of Japanese domestic production in U.S. auto transplants.

#### *1) The VERs*

Underlying all analysis presented in this paper is the assumption that the Japanese auto producers are profit maximizers. Even though a short run decision may create short run windfall profits, as is the situation of the period of VERs (Ries 259), it may not create the highest profits in the long run because the restricted supply results in loss of market share and, therefore, may not be the best decision. In a dynamic sense, domestic production must be more profitable for the Japanese companies or else they would not have made the shift in production.

During the period of VERs, imports were limited at 1.68 million cars from 1981-1983, and 1.85 million cars in 1984 and 1985. Although VERs officially continued after 1985 at the level of 2.3 million cars, they did not have a significant effect on automakers' decisions because import levels were well below the VER level of 2.3 million units. As pointed out previously, Japanese cars were in high demand in the early 1980s, just as the VERs took effect. Under the VERs, Japanese companies were faced with a fixed supply under rising demand. This situation led to higher prices for the automobiles, but does this mean profitability went up as some suggest? After gaining market share of 21.8% in 1981 from only 12.2% of the industry sales three years earlier, Japanese automobiles were clearly in rising demand. A study by Collyns and Dunaway (1987) indicated that sales of Japanese automobiles would have been 45% higher over the entire

period of VERs in the absence of the restrictions. It therefore seems very likely that the profits Japanese companies were losing from a deficit in sales more than outweighed any monopoly profits earned because of the VERs. Being profit maximizers, Japanese companies recognized this big problem and searched for a way to supply more cars to the United States. Furthermore, the Japanese companies did not know whether the restrictions would be lifted or increased further, putting more pressure on their future earnings. Their answer was to create U.S. transplants and they quickly began to move production overseas to build cars exempt from the VERs, Honda being the first in 1982, closely followed by others (Table 1). The VERs seem to be the main motivating factor in bringing production overseas.

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**Table 1      Japanese Automobile Assembly plants in U.S.**

<i>Japanese Company</i>	<i>Location</i>	<i>Start year</i>
Honda	Marysville, Ohio	1982
Nissan	Smyrna, Tennessee	1983
NUMMI (Joint venture, Toyota and GM)	Fremont, California	1984
Mazda	Flat Rock, Michigan	1987
Toyota	Georgetown, Kentucky	1988
Diamond Star (Mitsubishi & Chrysler)	Normal, Illinois	1988
Subaru-Isuzu	Lafayette, Indiana	1989
Nissan-Ford	Avon Lake, Ohio	1991

*Source: Kenney and Florida, "Japanese Foreign Direct Investment in the United States."*

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## 2) *The Exchange Rate*

Until 1985, the dollar enjoyed a strong position against the Japanese yen, but after 1985, the yen appreciated rapidly and has continued in that direction ever since (Table 2). Although economic theory would suggest that under an appreciated dollar, it would be less attractive for foreign companies to invest in the United States, we observed considerable growth in FDI in Japanese auto transplants that started in 1982 and has continued ever since then. While the VER was the main motivating factor in bringing Japanese nameplates to U.S. transplants in the early

eighties, manufacturers' incentives changed gears after 1985. After 1985, VERs expired yet four more transplant operations opened their doors. The problem for the profit maximizing Japanese companies was no longer a restricted supply, but rather an appreciated yen. With a stronger yen, it takes more dollars to purchase products imported from Japan. In other words, Japanese goods would be more expensive relative to domestic goods. If importing the automobiles from Japan, companies would have to increase their prices to maintain the same income because of the exchange rate difference, but by doing this, they risk lowering their sales. Although the Japanese were superior to the United States in cost-cutting manufacturing methods, trying to battle the effects of the appreciated yen and remain profitable was a sizable challenge (Collins 1987, Crandall 1987). By moving production to the United States, Japanese companies effectively eliminated many of the exchange rate problems associated with importing the automobiles. They could take advantage of materials and labor that were relatively cheaper for them because of the strength of their currency, and thus control the prices of their automobiles.

The trend was clear. Before 1985, Japanese companies acted against what economic theory about exchange rates suggests firms would do. Constrained by the VERs, they invested heavily in the U.S. although their currency was weak, but after 1985, the behavior of the Japanese firms clearly complies with investment theory. The VERs were highly instrumental in bringing production of Japanese autos to the U.S., to the point of outweighing the effects of the unfavorable exchange rate, and the appreciated yen has been highly instrumental in sustaining their growth in domestic production. This trend will be supported by empirical data later in the paper.

### *3) Real wage in each country's auto industry*

Labor costs are obviously a very important consideration for automobile companies since they account for a large part of manufacturing costs. As profit maximizing companies, the Japanese companies would want to produce where the labor was the cheapest, unless other

benefits outweighed a higher labor cost. Table 2 shows a comparison between the wages in the United States and Japan measured with indices that control the exchange rate. The ratio of the two indices shows this relationship. As the number decreases, wages are either increasing in Japan or decreasing in the United States. By looking at the indices, one can easily see that wages have risen much more quickly in Japan than in the United States. In fact, until recently, wages in the United States remained quite constant while wages in Japan have risen almost every year. Wages have been pushed up in Japan over the last decade largely because of a labor shortage there. This situation makes producing autos in the U.S. ideal for the Japanese companies. As the ratio of wages has been getting smaller, the amount of Japanese nameplate autos produced in the United States has been getting larger. Therefore, the wage rate may also be an important factor that is responsible for the growing transplant production in the United States.

Although productivity considerations are important for companies, this measure is left out of my paper. This is for two reasons. First, a suitable and reliable productivity measure, such as unit labor cost is difficult to obtain. Second, I feel comfortable in leaving this measure out because studies have shown (Kenney and Florida 1991, Goto 1990) that Japanese companies have been highly successful in transferring their efficient production methods to the United States. Kenney and Florida noted nearly identical productivity in the Honda plant in the U.S. as in Japan. Therefore, productivity may not be much of an issue for Japanese companies deciding whether or not to move production to the U.S.

#### *4) U.S. Real GDP*

Automobiles are a big-ticket durable good so they are highly sensitive to changes in the overall state of the economy. Theory would suggest that we would observe lags in production when the economy is at its worst and boosts in production when it is healthy. For example, in a recession, many consumers are uneasy about their current financial state and will not make a large investment in an automobile, whereas during a period of high consumer confidence, buyers will be

more likely to make a large purchase. However, in the U.S. auto transplants, production has increased every year, some years at an incredible pace, even through recessions. Although growth rates are not consistent with the growth rates of the economy, one can see by observing

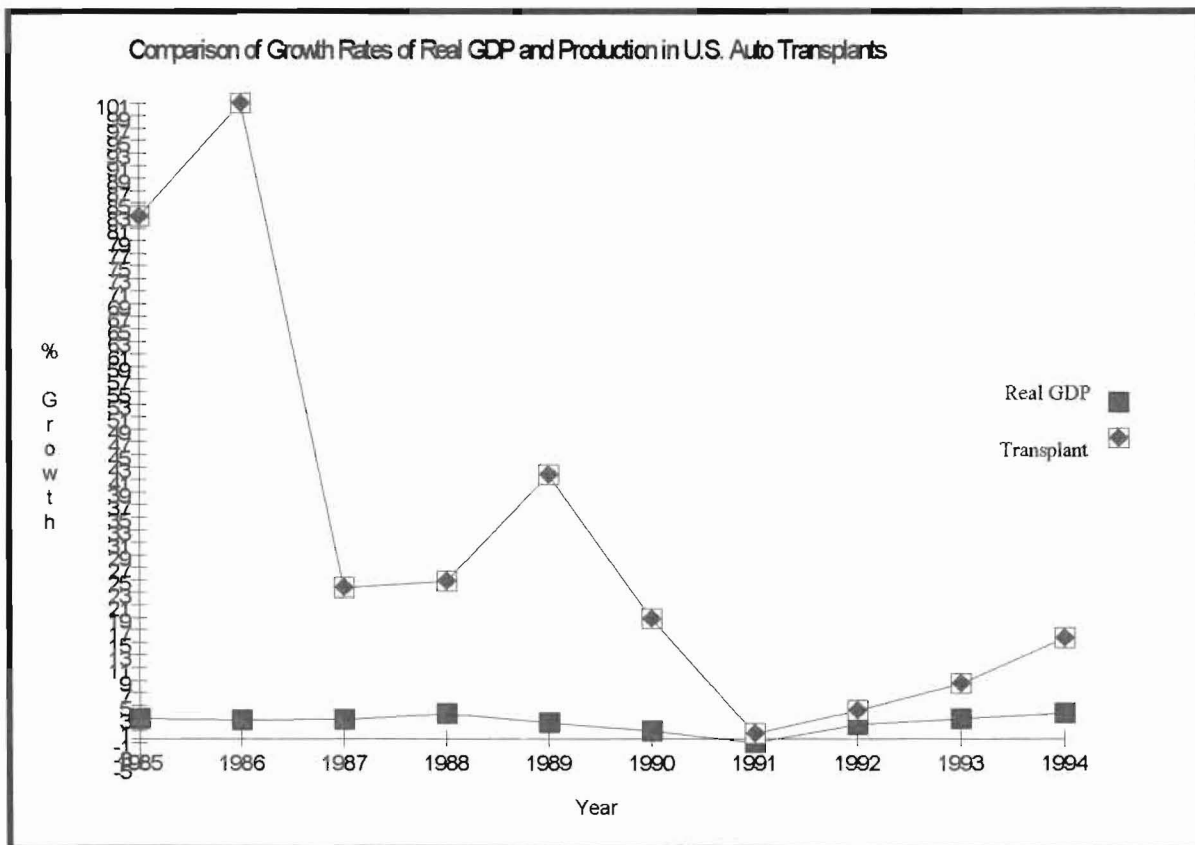
**Table 2 Comparison of Real Wages in Auto Industries of U.S. and Japan**

<i>Year</i>	<i>U.S. (1979=100)</i>	<i>Japan (1979=100)</i>	<i>Index Ratio</i>
1979	100	100	<b>1</b>
1980	108.68	106.27	<b>1.023</b>
1981	105.11	107.52	<b>.978</b>
1982	105.16	110	<b>.956</b>
1983	103.22	111.38	<b>.927</b>
1984	102.68	112.42	<b>.913</b>
1985	103.17	113.25	<b>.911</b>
1986	102.13	115.96	<b>.881</b>
1987	101.74	116.55	<b>.873</b>
1988	100.89	121.34	<b>.831</b>
1989	98.61	122.22	<b>.807</b>
1990	97.02	121.68	<b>.797</b>
1991	97.57	128.7	<b>.758</b>
1992	98.07	132.27	<b>.741</b>
1993	101.88	126.32	<b>.807</b>
1994	105.26	125.35	<b>.840</b>

*Source: Ward's Automotive Yearbook, Multiple Volumes, data adjusted for inflation with CPI (1987=100)*

figure 4 that the general trends of the growth rates in domestic Japanese production at least somewhat follow the trends of the economy, especially during the recession of 1990 and 1991 when transplant production plunged. The inconsistencies in the growth pattern of Japanese auto production in the U.S. as compared to the growth pattern of the economy can be mostly explained by three main factors: 1) demand for Japanese cars has been high 2) Japanese companies have relied more and more on domestic production in U.S. transplants to meet the needs of the U.S. market, and 3) during this time Japanese companies were in the process of setting up new factories that would obviously cause a great growth in production as they started

Figure 4



*Growth Rates computed with statistics from Business Statistics of the U.S. and Ward's Automotive Yearbook up operations for the first time.*

With the first factor, it has already been established that Japanese cars were in high demand. With such a high demand, we would expect to see them less affected than less desirable cars by changes in the economy. The second factor is important in explaining why growth rates of transplant production have been much more active than growth in the economy. As noted before, the Japanese have been exporting fewer cars to the United States each year and producing more domestically since 1986 (see Figure 1). These increases in local production are therefore not only an indicator of high demand for Japanese cars but also of the companies' new found reliance on domestic production to meet the needs of the North American market because it is more profitable for them to produce here. Regardless of economic trends, the Japanese were



producing more of their cars in the United States and less in Japan. The third factor is very obvious. Once a new transplant started production, there would be a sudden increase in the number of cars produced, making the growth rate appear abnormally high for that year or the next. Years of massive growth such as 1985 and 1989 are evidence of this effect. NUMMI started in 1984 and Diamond Star, Toyota, and Subaru-Isuzu all started in 1988 and 1989 and account for the observed abnormally high growth rates.

#### *5) Market Share*

To further address the issue of whether the Japanese profited by the VERs, one must consider the implications of losing market share in the auto industry. Ries, de Melo, and Tarr did not consider the importance of market share in their study in which they concluded that Japanese companies profited by the VERs. Since automobiles are products that are frequently very brand loyal buyer's items, automakers' pay close attention to market share which can be considered a rough proxy for preference of automobiles. Once a person purchases a car, assuming the experience was positive, they are more likely to purchase that brand of car again rather than another car. Under VERs, Japanese market share was restricted meaning some customers who would have purchased a Japanese car ended up substituting with an American one. This loss in market share is difficult to recover. Since these VERs hit at a time when demand for Japanese cars was just starting to explode (see Figure 1), the Japanese had no choice but to respond by shifting production overseas to avoid the VERs and regain profits and market share.

Another important aspect to consider is that with a limited number of exports, companies could not expand their product line offerings without reducing the exports of another model. Moving production of the most popular high-volume cars to the U.S., such as Toyota's Corolla or Nissan's Sentra, freed up space under the quota and allowed the Japanese to continue plans to offer new imports such as luxury cars, sports cars, and sport utility vehicles without compromising the sales of other models. Observation of this trend is the fact that the total

production of the Japanese companies has increased greatly with more types of models offered than ever. The current trend is that most high volume cars are now produced in the U.S. while the more expensive models are reserved for production in Japan.

Once the Japanese regained their market share, we would expect to see them continue to try to increase their market share, not level off. This is because, as profit maximizing companies, they would have an incentive to continue to increase their sales and earn more profits. In other words, when the going is good, the good keep going, which is certainly the case we see with Japanese auto makers who hold about 30% of the U.S. car market now, about double what they held fifteen years earlier (Ward's 1996).

#### 6) *Parts availability*

In Japan, auto producers utilize a close-knit system of suppliers. Within this system, suppliers who meet the needs of the Japanese companies' unique work organization are highly reliant on just-in-time (JIT) inventory systems. The requirements of suppliers under this system are much more demanding than traditional U.S. auto manufacturing. In the early 1980s, many U.S. suppliers were inadequate for the Japanese transplants because they lacked the knowledge or experience with this type of work organization or JIT, or they were just unwilling to comply (Florida and Kenney 1986). We would then expect this to be a factor that discourages Japanese companies from manufacturing here. What is observed by Florida and Kenney (1991) is that many Japanese companies have strongly encouraged their suppliers in Japan to set up shop in the United States in order to meet their needs. These suppliers, together with the growing number of U.S. companies that accommodate the Japanese organization, make up the first-tier suppliers for the Japanese, allowing them to manufacture successfully in the United States. This development has been highly significant in attracting domestic Japanese production.

Before Japanese parts suppliers moved to the United States and U.S. companies adapted to a JIT system, the Japanese imported their engines and drivetrains already assembled. They

would in some instances essentially ship disassembled cars over that simply needed to be "screwed together" to be ready for sale. This system worked well for the Japanese because while VERs were at their highest, there were never any restrictions on parts imports. Although this system was not as efficient as the supplier networks transplants utilize now, this alternative was the best for Japanese companies to increase supply while under the restrictions of the VERs. Since then, the Japanese companies producing in the United States now take advantage of the favorable exchange rate and improved supplier network and use many more U.S. made parts in their automobiles (Florida and Kenney 109).

#### **IV. Data Sources and Description**

Quarterly time series data from 1980, fourth quarter to 1994 are used in the empirical model. This period was chosen because it starts two years before transplant production began and ends with the most recent data available. Data utilized in this project were acquired overwhelmingly from yearly volumes of Ward's Automotive Yearbook. These specific data include transplant production, number of imports, market share, and automotive industry wage rates. Data about the U.S. economy were extracted from the websites of the U.S. Bureau of Economic Analysis (US BEA) and the St. Louis Federal Reserve Bank, the 1995 edition of World Tables and the 1995 edition of Business Statistics of the U.S. Exchange rate data were also acquired from the website of the US BEA. Finding detailed parts supplier data that indicate their country of origin and main customers proved to be a huge task beyond the scope of this paper, as Kenney and Florida indicated in their research (107). Hence, this paper will have to rely simply on a theoretical analysis of the parts suppliers issue, without empirical data to support the theory.

## V. Empirical Model

From the theory section, two main hypotheses emerge:

- 1) **The VER was the factor responsible for bringing Japanese production to the U.S. and, until 1985 when they expired, for the explosive growth in production.**
- 2) **The appreciation of the yen after 1985, coinciding with the expiration of the VERs, took over as the main factor that sustained and increased growth in domestic production of Japanese cars in U.S. transplants.**

This section presents the empirical model indicated by theory. The same variables discussed in theory will be incorporated in the model with the exception of the parts variable for reasons described earlier. An OLS multiple regression analysis is used to determine whether the variables explain the hypotheses that are supported by theory. The regression equation takes the form:

$$\text{PRODUCTION}_{\text{TRANSPLANTS}} = \alpha_0 + \beta_1 \text{VER} + \beta_2 \text{YEN}/\$(\text{VER}) + \beta_3 \text{WAGE} + \beta_4 \text{GDP} + \beta_5 \text{MKT}$$

Below, each variable is discussed individually in accordance with the two hypotheses put forward earlier. Table 3 defines the variables of the regression equation.

### *Independent Variable 1: VER*

A dummy variable was utilized in the regression analysis to capture the effects of a VER. Before a VER is implemented, maximum exports were theoretically determined by total U.S. demand for new cars. Although there were production capacity limits, the companies were allowed to export all the cars they wanted without a VER. While under the VER, a company had a specified limit on automobiles they could import. In a nut shell, either it was on or it was off. A value of zero was given for years in which there was a VER, and a value of one was given for years in which a VER was not in effect. These values were chosen because the next variable, YEN/\$, is an interactive variable that utilizes the VER variable to turn the variable on only during the period of no VERs. The importance of this will be explained fully

in the description of the Yen/\$ variable.

The VER variable was lagged by two years, or eight quarters, in the equation. A lag was incorporated in the equation because it takes time for companies to set up a factory in the states and begin production. A lag of two years returned the best results for both this variable and the others. The expected sign of this variable is negative. While restricted by the VERs, we expect to see Japanese companies producing more in U.S. auto transplants because of their profit confining supply shortages, than when they are not restricted.

**Table 3      Variable Definitions and their Expected Signs**

<i>Variable</i>	<i>Type</i>	<i>Explanation</i>	<i>Expected Sign</i>
PRODUCTION <sub>TRANSPLANTS</sub>	Dependent	Number of Japanese nameplate autos produced in U.S. transplants.	
VER	Independent	Dummy variable indicating when VERs were in effect. Takes on value of 0 during VERs, 1 with no VERs.	Negative
YEN/\$(VER)	Independent	Interactive variable that measures the Yen/\$ exchange rate during the period of no VERs. The value of this variable is multiplied by the value of the VER variable, effectively turning off the variable during the period of VERs and turning it on during the period of no VERs to isolate the production period hypothesized to be most affected by the exchange rate.	Negative
WAGE	Independent	U.S./Japan ratio constructed with indices of real domestic wages in auto production industries of U.S. and Japan	Negative
GDP	Independent	Real U.S. GDP in constant 1987 dollars.	Positive
MKT	Independent	Japanese companies' market share of all automobiles sold in the U.S.	Positive

### ***Independent Variable 2: YEN/\$(VER)***

This interactive variable measures the effects of the Yen/\$ exchange rate after the period of VERs, a factor hypothesized to greatly influence production in the United States. Since I hypothesize that this variable is responsible for increases in production only after the period of VERs, this variable is effectively turned off during the period of VERs through this interaction. Since the VER variable takes on the value of zero during VERs and one during non-VER years, the variable is only activated during the period of non-VER years. This interaction effect is very important in supporting the hypothesis since it isolates the period in question.

This variable was lagged two years like the VER variable for the same reasons. Exchange rates move very quickly and companies deciding to produce in the U.S. because of the more favorable exchange rate needed time to set up and produce in the states. Furthermore, since exchange rates can be rather volatile, companies would want to observe the patterns of the exchange rate for a while before making a major decision like moving production overseas. Companies like Toyota, Subaru-Isuzu, and Mitsubishi all arrived about two years after the yen appreciated greatly. Expected sign of this variable is negative because as the Yen/\$ exchange rate increases (more yen to buy a dollar), it would be more expensive to produce in the United States and companies would choose to produce where it is cheapest.

### ***Independent Variable 3: WAGE***

WAGE is a ratio that measures the level of wages in the auto industries of the U.S. and Japan against one another. This variable is included because labor is a major factor cost in producing automobiles and affects decisions to produce in the United States. Since an increase in the value of this variable indicates either wages are increasing in the United States or decreasing in Japan, the expected sign of this coefficient is negative. This is because if U.S. wages increase relative to Japanese wages, we would hypothesize that this would cause the Japanese companies to produce where labor is cheaper (in Japan), thus inhibiting transplant production and resulting in

a negative sign.

#### ***Independent Variable 4: GDP***

GDP was included in the regression equation because, as explained in the theory section, demand for big-ticket durable goods, like automobiles, is affected by the state of the economy. Therefore, this variable had to be included to control for changes in production caused by changes in the state of the economy. The expected sign for this variable is positive, since one would expect to see more vehicles being demanded with a healthy economy. This variable was not lagged because the auto industry responds immediately to changes in demand for autos by adjusting production accordingly. Furthermore, GDP does not need to be lagged because it was not responsible for bringing transplants to the U.S., but it has affected production decisions in them and needs to be included in the model.

#### ***Independent Variable 5: MKT***

MKT is the Japanese automakers' market share of all cars sold in the United States. This variable was also lagged two years in the regression. The MKT variable was included in the regression because, as explained earlier in the theory section, market share is a very important consideration for automobile companies because it can be considered a rough proxy for preference in automobiles. The expected sign for this variable is positive. While arguments can be made for causality to run both ways, i.e. for increases in production to cause increases in market share, or increases in market share to fuel increases in production, I will be arguing the latter. First of all, as market share increases, Japanese companies are obviously selling more vehicles. These increases in production allow companies to take advantage of economies of scale. Since many of the costs of producing an automobile are fixed, such as start up costs with the factories and operational costs of running the factory, additional automobiles can be produced cheaper as production increases. In other words, the costs can be spread over more and more automobiles and profits can be maximized. Also, as people's preferences for Japanese

automobiles increases, i.e. as their market share increases, Japanese companies would respond by increasing their production to meet the demand and expand their market share.

## **VI. Results**

The regression was corrected for auto correlation with the Hildreth-Lu method and run with OLS estimation. The results of the equation are given in Table 4. The analysis returned mixed results, with all variables but one resulting in the predicted sign. All variables are significant and the adjusted R squared is high, at .94. The results of each variable and how they apply to the hypotheses will be discussed in this section of the paper.

Hypothesis one was not supported by the results of this model. The VER variable returned with a coefficient of 265922.81, the wrong sign, and was significant. This result means that under the VERs, the model predicts that the Japanese produced about 265,922 less autos in the U.S. than they would have without the VERs. Although this result was unexpected, it is not necessarily disappointing.

This unexpected result may be explained by re-examining U.S. transplant production (Figure 1). VERs were in effect 1981, 82, 83, 84, and 85. With the two year lag incorporated in the model, the observed years with VERs are therefore 1983, 84, 85, 86, and 87. A look at the production figures shows that although during the period of VERs we see significant growth in transplant production, the non-VER years following 1987 have even greater growth in production. This observation is a reflection of the increased number of producers in the non-VER years than in VER years. By 1989, there were seven different transplants in production, but in 1987, only four were operating. With three more transplants in production after the period of VERs, obviously there would be more production than before.

With that said, it still does not explain why the results do not support the hypothesis that the VERs brought production to the U.S. and caused growth in production. For support of this hypothesis, one must look at the statistics and rely on theory and the literature of other



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**Table 4**                      **Regression Results**

<i>Independent Variables</i>	<i>Estimated Coefficient</i>
VER	265922.81 (5.2617)*
YEN/\$(VER)	-1090.71 (4.9434)*
WAGE	-208729.23 (6.3095)*
GDP	65.17 (21.7502)*
MKT	11502.18 (6.3043)*
Constant	-291790.90 (11.9766)*
Adjusted R <sup>2</sup>	.94
Durbin-Watson	1.87
t-statistics are in parentheses	
* indicates significance at .0001 level	

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researchers more than the results of this model. Let us take this in steps. First of all, it is clear that before the VERs there was no transplant production and during the VER period, four transplants came to the U.S. Next, it seems obvious that the Japanese companies were not moving to the U.S. during the early eighties because of the exchange rate. During that time, the high Yen/\$ exchange rate made production in the U.S. more expensive than production in Japan.

With these two important observations and the previous discussion in the paper in mind, I still maintain that the VERs were responsible for bringing the first four transplants to the U.S. and creating growth in transplant production.

A favorable exchange rate for the Japanese that almost perfectly coincided with the expiration of the VERs made transplant production more attractive and led to the introduction of new companies and even greater growth in production than before. So yes, there was less production in VER years than in non-VER years, as the model predicted, but this result does not completely reject the hypothesis. Although production was smaller during VERs, it seems that they were still responsible for bringing over at least four transplants and for the growth in production in those plants during the VERs.

Hypothesis two, however, was upheld very well by the empirical model. The exchange rate returned with a coefficient of -1090.71 and is significant at the .0001 level. While the coefficient appears to be small, the model predicts that an increase in the yen/\$ exchange rate of one yen per dollar results in a decrease of transplant production of 1091 cars. One yen is a very small amount of money, about a penny. To put this in better perspective, the model predicts that from 1985 to 1986, when the yen appreciated suddenly, production in transplants increased by 76,500 cars solely because of the rapid appreciation of the yen, a significant amount.

The wage rate also returned with a coefficient of the predicted sign, but with a larger coefficient of -208729.23, also significant at the .0001 level. The model predicts that an increase in the ratio of wages of one (which indicates a doubling of the U.S. wages relative to Japanese wages) would result in a reduction of production of about 209,000 cars in one year, *ceteris paribus*. Since labor is a major factor cost in manufacturing an automobile, it seems that the Japanese companies have placed a lot of importance on the relative wage rate when making production decisions, more than the author originally expected. An important observation of this result is that this model predicts that relative wage was significant during the entire production

span of the transplants, not just after the VERs expired. Therefore, relative wage seems to have influenced production decisions even during the period of VERs, an unexpected result. Despite this reservation, these two factors, the Yen/\$ exchange rate and the real wage rates in each country, both are supported as being very important factors in determining U.S. transplant production decisions, with the Yen/\$ exchange rate significant only after the VERs expired.

The GDP variable was very significant with a coefficient of 65.17. The model predicts that an increase of a dollar in the real GDP of the U.S. results in an increase of transplant production of about 65 cars. This small coefficient indicates that in and of itself, the state of the economy is not influencing the large growth in U.S. auto transplant production, unlike the other variables, but the high significance is evidence that production trends are affected by the state of the economy, exactly as was hypothesized.

Finally, the MKT variable also was highly significant and had a coefficient of 11502.18. With each percentage point gained in market share, the model predicts that production increased by about 11,502 cars. As preference leaned towards Japanese automobiles and their market share increased, Japanese companies responded by increasing production in auto transplants. While a variety of factors could be responsible for the increased demand or preference towards Japanese automobiles, the fact remains that as market share increased for the Japanese, they had an incentive to continue that growth and increase their production in the U.S. as the model predicts.

In trying to evaluate the results of the model, I realize that the study supports hypothesis two with some small reservations. First and foremost, it seems that during the times of VERs, only one goal existed for the Japanese companies, to increase supply which would maximize profits. During this period, the exchange rate was not the most important factor, and neither was the wage rate. However, after 1985, when the VERs expired, the Japanese companies had a choice. They were allowed to export as many vehicles as they wanted or they could produce locally. As this study has shown, Japanese companies went with the latter decision, meaning that

it was the most profitable for them. Multiple factors were important considerations during this time, factors like relative wage, and probably others that were not captured by the regression equation, such as parts origin and productivity issues. This differentiates it greatly from the period of VERs where essentially only one variable, the VER, was an issue. As for improving the results of hypothesis one, it proved to be intractable in my empirical estimation, again because of the difficulty in measuring other strategic decision variables.

## **VII. Conclusion and Suggested Future Research**

This paper analyzes the introduction and rapid growth of production in Japanese auto transplants in the United States. Two hypotheses were developed, both of which were strongly developed using basic profit-maximizing motivation and supply and demand theories. However, only hypothesis two was supported by the results of the empirical analysis. Despite the unexpected results from the empirical model for hypothesis one, the results were not disappointing.

Hypothesis one is best supported by theory and observation of trends in production rather than the empirical model in my project. In the results section, the reasons for this were discussed at length, but it comes down to the fact that during the VERs, the Japanese companies had one goal in mind: increase supply to maximize their profits that were restricted by the VERs. It is clear that transplant production was their answer to increase supply and increase their penetration of the U.S. auto market. Despite the lack of support by the empirical model, hypothesis one is well supported by this project.

The second hypothesis was supported both theoretically and empirically. The results of the empirical model fully supported the theory that the exchange rate was responsible for increases in transplant production. Even stronger results could be achieved if one remembers that, unlike during the period of restricted imports, Japanese companies had a choice of whether they wanted to produce in the United States or not. In deciding to produce locally, the Japanese

had several factors to consider, not just one, as is the case of the VER in the early eighties. Although the model did not return an extremely high coefficient for the exchange rate variable itself, the exchange rate is still very significant in production decisions because all of these factors relate to the exchange rate. This is because their prices (and consequently their effect on company profitability) are all affected by changes in the yen/\$ exchange rate. Therefore, the results of the model can still be interpreted to support hypothesis two since all input factors that encouraged Japanese companies to produce more since 1986 are affected by the exchange rate.

In future research on this topic, an empirical model that captures more of these other variables would be ideal for very strong expected results. One major factor that was not able to be captured in the empirical model was parts considerations, such as their country of origin and the number of transplant producers. However, as stated earlier, finding data as specific as this is difficult at best. Perhaps including a productivity measure, such as unit labor cost, would be beneficial to the analysis also, although relative wage is a rough proxy for productivity. Other recommendations for the researcher with ample time and access to very specific data on the auto industry would be to investigate how each company was affected by the VERs individually and how that affected their order of entry into the U.S. transplant market. Another interesting avenue of research would be to investigate the price elasticities of demand for the Japanese companies to predict which models would be produced in the U.S. and to calculate exactly how much profits they were gaining or losing because of the VERs.

This paper has addressed one of the most significant issues in the automobile industry and explained it with economic theory supported fairly well by empirical evidence. This study took a commonly observed trend in the auto industry and compiled and tested variables that help to explain this phenomena. Few authors have looked directly at the effects of the VERs and the exchange rate and how they have affected U.S. transplant decisions, but many have simply referred to the trend as given without upholding their theory. This paper has finally answered

with considerable certainty why the Japanese have shifted much of their production to the United States. The interesting results from this paper can help everyone to better understand the transitioning U.S. automobile industry and the factors that have contributed to its transformation.

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