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The economic effects of the Maquiladoras-offshore assembly plants in Mexico

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Rice University, 1992
RICE UNIVERSITY

THE ECONOMIC EFFECTS OF THE MAQUILADORAS—OFFSHORE ASSEMBLY PLANTS IN MEXICO

by

BRET CLONINGER

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

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ABSTRACT

This thesis examines the impacts of the Offshore Assembly
Provision (OAP) on Mexico and the United States. The first portion
of the thesis notes the importance of the maquiladora program (the
OAP in Mexico) to the Mexican economy and, because of the relatively
large size of the U.S. economy, the small impact on the U.S. Also, the
maquiladora plants have very low linkages into the Mexican economy,
i.e. few nonlabor inputs come from Mexico. The second portion of the
thesis is a literature review which discloses the result that a
hypothetical repeal of the OAP results in a small loss of welfare in
the U.S., a small gain in U.S. employment, and a small loss in
employment in Mexico. The third portion uses input-output analysis
to discover that maquiladoras provide a very small portion of the
expansion of Mexican exports since 1980.
Acknowledgements

I would like to thank my committee members, Dr. Ronald Soligo and Dr. Dagobert Brito for their time and efforts. Especially, I would like to thank my thesis director Dr. Kei-Mu Yi for his patience and the large amount of time he spent guiding the development of this thesis. Earnest thanks also goes out to my family and Kristina Ennis for their support and assistance. I would also like to thank the other graduate students at Rice who have provided much help. Thanks also to those who went to the trouble to mail many of the resources that I have used and some that I was, unfortunately, not able to include.
The Economic Effects of the Maquiladoras- Offshore Assembly Plants in Mexico

This thesis is intended to enumerate the impacts of the Offshore Assembly Provision (OAP), which provides tariff relief for maquiladoras (Mexican assembly plants that use U.S. components), on the U.S. and Mexican economies. The first section notes the weakness of the Mexican economy, the importance of the maquiladoras for the export sector, and provides a general description of the maquiladoras. The second section is a review of the available literature on Offshore Assembly Provisions with an emphasis on the articles discussing welfare and employment effects. Input-output analysis is used in the last section to examine the impacts of expansion of the maquiladora industry on the nonmaquiladora manufacturing sector, i.e. the backward linkages into the Mexican economy.

The developing countries' share of the world economy has increased from fifteen percent of real gross world product in 1960 to twenty-two percent in 1985. The Less Developed Countries' (LDC's) share of total manufacturing exports has increased from seven to sixteen percent in the same period\(^1\). Despite the progress, the U.S. and Mexico provide a graphic example of the structural contrast that still exists between between the First and Third World. In 1989 Mexico's population was 34 percent of that of the United States\(^2\), while its exports to the United States amounted to

\(^1\)Sewell, in Brock, p. 123.
\(^2\)1988 data -World Bank, p. 179.
just five percent of all American imports\(^3\) but accounted for over 70 percent of Mexico's exports\(^4\).

The Mexican economy has been weak in recent years. Gross Domestic Product (GDP) per capita growth was negative in 1986, 1987, and 1988, despite repeated devaluations against the dollar, and was slightly positive in 1989 and 1990, as is illustrated in Table 1. Inflation in 1990 was 29.9%, nearly twice the Mexican government's goal of 15.3% (perhaps accounting for some of the positive GDP/capita number in 1990), while Mexico's external debt amounted to $95.6 billion in 1989. Foreign exchange is needed to repay this sum, which is equal to 51% of the Mexico's Gross Domestic Product of $187 billion in 1989\(^5\). Though down from the 1987 peak of 76% of GNP\(^6\), this figure still represents a significant problem for the Mexican economy as debt was selling at 40% of its face value in Jan. 1989\(^7\). Mexico ran its first trade deficit since the 1950's in 1990, which amounted to $3 billion largely because of the slow U.S. economy and American business' "wait-and-see" attitude regarding the Free Trade Agreement\(^8\).

\(^3\)Reich, pp. 75-76.
\(^4\)The percent of Mexican exports destined for the United States is up from less than 60% six years earlier (IMF, Direction of Trade Statistics Yearbook 1989 in ITC#2353 p.1-4).
\(^5\)calculated from data on p. 2-3 of ITC#2353 and Economist Intelligence Unit p. 3.
\(^6\)ITC#2353 p. 1-1.
\(^7\)Prock and Torres in Fatemi, p. 173.
\(^8\)Economist Intelligence Unit p. 21.
Table 1\textsuperscript{9} Recent Data on the Mexican Economy

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Mexican offshore assembly operations, known as maquiladoras, have been very important to the Mexican economy in recent years. The maquiladoras were responsible for 32\% of all of Mexico's exports in 1989\textsuperscript{12}, compared with fifteen percent for crude oil alone\textsuperscript{13} or 34\% for oil and oil products\textsuperscript{14}, a sector which prompted high expectations in the 1970's but has not had the expected overwhelmingly positive effect on the efforts to develop Mexico. The maquiladoras, however, seem poorly equipped to be the new engine of development for the Mexican economy due to their limited linkages to the rest of the economy. On the other hand, they do provide a significant and increasing number of formal-sector jobs to the Mexican economy.

\textsuperscript{10}percent per annum, average.
\textsuperscript{11}in billions of dollars
\textsuperscript{12}See below, calculated from p. 1-4 ITC\#2353.
\textsuperscript{13}Calculated from table E-2 in ITC\#2353.
\textsuperscript{14}ITC \#2353 p. 1-2.
The offshore production option would seem to be an effective method for companies to avoid the high costs of American labor without incurring the additional costs of import tariffs. The nature and unique characteristics of the program has recently invited inquiry into the effects of the maquiladoras. Before discussing these studies, a description of the industry and less formal models may be helpful to better understand some of the issues. A critique of a number of formal models concerning the influence of Offshore Assembly Provisions (OAP's) in general, and the maquiladoras specifically, on both the host and domestic economy will follow. Finally, a different approach to investigate the effects of the maquiladora industry on the Mexican economy will be discussed along with an evaluation of its advantages and disadvantages.

I. DESCRIPTIVE ANALYSIS-The U.S. Offshore Assembly Provision

The OAP is defined in the U.S. by tariff items 9802.00.80 and 9802.00.60, which provide for tariff relief for imports of goods assembled from American components\(^\text{15}\). A user fee was initiated in 1987 on imports under provisions other than Harmonized Tariff Schedule of the United States (HTSUS or HTS) 9802.00.80 and 9802.00.60, resulting in shifts of imports to these provisions.

Correcting for the effects of the user fee\(^\text{16}\), imports would have

\(^{15}\)9802.00.80 is by far the larger of the two, by a factor of 20, so we can consider it to represent the U.S. OAP

\(^{16}\)When looking at the ITC tables one notices a curious fact, that from 1986 to 1989 the greatest share of duty-free imports shifted massively to Canada. In 1986 Canada controlled 25% of the total Offshore Assembly Provision imports in the Motor Vehicles category, increasing in 1989 to 85%, while Mexico's share dropped from 40% to 9%. The reason cited by the ITC for the shift is the APTA, the Automotive Products Trade Act of 1965, which allowed motor vehicles and parts coming from Canada to enter the U.S.
risen twenty-two percent to $43.9 billion under item 9802.00.80 during 1989. Mexico accounted for 65% of U.S.-origin content of U.S. OAP imports and Canada, 9%\(^7\).

The Offshore Assembly Provision claims a significant share of total U.S. imports from a number of countries, including Mexico, Sweden, Canada, Malaysia, West Germany, the U.K, Taiwan, and others\(^8\). Mexico leads with 44% of its exports to the United States being declared under the OAP provision 9802.00.80 in 1989. Trade with the United States accounts for 71.6% of all Mexican exports\(^9\). Maquiladoras were thus responsible for 32% of all Mexican exports in 1989, and accounted for nearly 40% of Mexican imports\(^{20}\). The

duty free. On December 1, 1986 the U.S. Customs regulations were amended to include a merchandise processing fee of .22% ad valorem until September 1987 and .17% since then, to cover salaries and expenses of customs operations. Exempted from this user fee were subheadings 9802.00.80 and 9802.00.60, inducing companies that were previously importing with a free rate of duty, as under the APTA, to shift their products to the two exempted subheadings.

According to a U.S. International Trade Commission (ITC) study, total U.S. imports from the rest of the world under item 9802.00.80 increased by 103% to $73 billion during 1989. The corrected results consider what would have happened if the user fee was not begun, that is goods that were shifted to the OAP provisions because the user fee was implemented on the original provision, be it MFN or APTA or some other. Malaysia is an example with reference to their semi-conductor exports that were formerly imported to the U.S. under Most Favored Nation status but, because of the user fee, are now declared under item 9802.00.80 (ITC #2365 p. 2-1).

\(^7\)In the uncorrected statistics, Mexico accounted for 32% of the total U.S.-origin content of imports under item 9802.00.80 in 1989 and Canada 45%. U.S.-origin content is the best measure of the importance of the Offshore Assembly Provision to the foreign assembler (Mendez, 1991, note 11). The reduction in duties, the incentive to use the provision, is due to the content that is of U.S. origin.(ITC #2365 p. 2-5).


\(^{20}\)calculated from p. 1-3 ITC #2353 and WEFA table v.9.
OAP accounts for 36% of Sweden's exports to the U.S. followed by Canada and Malaysia at 29% and 28%, respectively\(^{21}\).

**The U.S. O.A.P. in Mexico-The Maquiladoras**

The maquiladoras originated out of the "bracero" program begun because of a shortage of agricultural workers during World War II when the United States initiated a "temporary" program to allow Mexican workers to come to the U.S. for seasonal agricultural work. The Mexican government came to depend upon the program for jobs and foreign exchange. American labor union pressure was responsible for ending the program in 1964, creating a significant amount of unemployment on the Mexican side of the border. The creation of U.S. tariff items 806.30 and 807.00 (now HTSUS 9802.00.80 and HTSUS 9802.00.60\(^{22}\)) which would allow reimport of

\(^{21}\)A large part of Canadian and Malaysian exports to the U.S. were reclassified as OAP goods because of the introduction above-mentioned user fee in December 1986 (ITC #2365 p. 1-13).

\(^{22}\)HTS subheading 9802.00.60 (effective Jan. 1, 1989, formerly TSUS 806.30)

Any article of of metal (as defined in U. S. note 3 (d) of this subchapter) manufactured in the United States or subjected to a process of manufacture in the United States, if exported for further processing, and if the exported article as processed outside the United States, or the article which results from the processing outside the United States, is returned to the United States for further processing....... A duty upon the value of such processing outside the United States (see U.S. note 3 of this subchapter)

and subheading 9802.00.80 (formerly TSUS 807.00)

Articles assembled abroad in whole or in part of fabricated components, the product of the United States, which (a) were exported in condition ready for assembly without further fabrication, (b) have not lost their physical identity in such articles by change in form, shape or otherwise, and (c) have not been advanced in value or improved in condition abroad except by being assembled and except by operations incidental to the assembly process such as cleaning, lubricating and painting....... A duty upon the full value of the imported article, less the
partially finished or finished goods to the U.S. from Mexico, where duty is paid on only the value added outside the U.S. was announced in 1965.

The plants are called "maquiladoras" while the industry is called the "maquila" industry, after the miller who processes the grain but never actually owns it. The industry is also called "in-bond" because the product never legally leaves the home country, despite being processed abroad. In reality, the "in-bond" production option is not frequently used. Reportedly, the in-bond goods still have to undergo Customs procedures that involve registering with Mexican Customs as an importer and then registering with the Treasury Department as an importer of in-bond freight. However, to obtain this status a company must have been in business three years and show "just cause" for wanting to receive freight in-bond. Nonetheless, the industry is commonly called the "in-bond industry."

The maquiladora program has been a growing portion of the Mexican economy for most of its life, but the growth has been especially rapid since the mid-1980's. Having grown at an average

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23 The difference between the two tariff items is that 9802.00.60 is for metal goods reimported to the U.S. for further processing and 9802.00.80 covers everything else. The percentage of Offshore Assembly Provision (OAP) imports accounted for by item 9802.00.60 is about 1.5% in 1989, down from 10% in 1970, so we can consider 9802.00.80 alone without losing accuracy (calculated from ITC #2353 p. b-2).

24 Mitchie and Hagans, in Banamex p. 131, maintain that the word comes from the Spanish "maquilar" meaning "to do work for."

25 Goddard in Gibson and Renteria p. 141.

rate of seven percent since 1975, maquiladora plants numbered 620 in 1980. By 1986 there were 890 plants employing 270,000 people\textsuperscript{27} and, as of June 1991, there were 1,925 maquiladoras employing 452,399 people according to \textit{Twin Plant News}, doubling in size in less than five years.

This growth is hypothesized to be largely a response to the huge devaluations of the peso in the 1980's\textsuperscript{28}. Large devaluations of the peso began in 1982, with the peso falling 57% against the dollar in that year, 53% in 1983, and 28% and 35% in the following two years\textsuperscript{29}. In 1986 oil prices crashed, reducing Mexican export revenue by $5.63 billion, equal to 6% of GDP, requiring austerity measures for Mexico to continue to pay on the foreign debt\textsuperscript{30}. Included in that austerity were peso devaluations of 58% and 56% against the dollar in 1986 and 1987\textsuperscript{31}. As the devaluations proceeded there was an explosion of maquiladora investment as the price of investment in Mexico plummeted\textsuperscript{32}. Another result of the austerity has been the advent of debt for equity swaps, running from 1985-1988 and

\begin{footnotesize}
\begin{enumerate}
\item This number is from INEGI. The sometimes large discrepancies between American and Mexican maquiladora data will be discussed later.
\item Labor p. 19.
\item Zaman in Fatemi, p. 203.
\item Labor, p. 19.
\item The real exchange rate increased from 23 to 37 pesos/$ in that period. The formula $P_{80}(dP)^8=P_{88}$ provides prices in 1988 from a base in both countries of P=100 in 1980. $dP$ is the average annual inflation rate from 1980-88 (World Bank, 1990 table 13). The real exchange rate(R) is then calculated using the nominal exchange rate (E) from Sklair (p. 40) in the formula: $R=((E/P_{US}))/(P_{Mex})$ (from Krugman, p.393)
\item This increase in the real exchange rate indicates that the cost of producing in Mexico fell by 60 percent in this period.
\end{enumerate}
\end{footnotesize}
resulting in an estimated $1 billion of additional investment in maquiladoras\textsuperscript{33} during that period.

The total value of Mexican exports to the U.S. under item 9802.00.80 in 1989 was approximately $11.8 billion, 49% of which was dutiable (not U.S. produced)\textsuperscript{34}, having trended steadily upwards since 1969 when it was 34.7%\textsuperscript{35}. Thus, in 1989, the maquiladoras' value-added amounted to $5.8 billion, according to the USITC. The Economist Intelligence Unit (EIU) and the Wharton Economic Forecasting Associates (WEFA) both report about half of this amount at $3 billion in both the EIU Country Profile of Mexico for 1990-1991 and the WEFA Maquiladora Industry Analysis of May 1991. In any case, the Mexican value-added improves the current account balance and reduces the additional accumulation of debt (or allows payment of interest) by that amount, whether three or six billion dollars. Though WEFA and EIU do not report the sources for their numbers, from the magnitude of the difference from the ITC number one may suspect that they are using Mexican data\textsuperscript{36}.

\textsuperscript{33}Prock and Torres, p. 176 Fatemi, 1990.
\textsuperscript{34}ITC p. 1-13.
\textsuperscript{35}p.148 Grunwald and Flamm.
\textsuperscript{36}It is important to note the discrepancy between Mexican and American maquiladora data. A large part of this is because "SPP [Secretary of Programming and Budget] data are based on reports from the maquiladoras" and it is thus "possible, if not probable" that they are greatly underestimated(from Grunwald and Flamm), possibly to avoid Mexican taxes (p. 556, Mendez et al, 1991). Grunwald cites as an example the year 1983, when the U.S. estimate was more than twice the Mexican figure for the value of total maquila exports to the U.S. Several other sources of discrepancy emerge, including that the Mexican count of maquiladoras is based on all offshore production in Mexico, not just that bound for the U.S. Also, some maquiladoras do not use any U.S. inputs and are not included in the U.S. ITC data. Some maquila imports come from Mexican plants in "free zones" and are listed under free-zone regimes and are not included in Mexican statistics. Twin Plant News does not give any methodology and reports only that employee counts are "not available for some areas." I will distinguish between U.S.
Initially, the maquiladoras were limited to a 20-km strip along the border. In 1972 they were permitted in the interior by the Mexican government, but were limited to areas outside industrialized, polluted urban areas. Since then, incentives have been given to locate maquiladoras in depressed interior rural areas. Wharton Economic Forecasting Associates (WEFA) reports that, from 1980 to 1986, 88-89% of all maquiladoras were on the border. In 1986 the number dropped to 85% and by 1989, only 80% of all maquiladoras were on the border. WEFA expects this trend to continue and predicts that the percentage of all plants located at the border will fall to 69% by 1995. Having overloaded the border infrastructure, the maquiladoras must look elsewhere to grow.

WEFA reports that the Mexican government is placing high priority on improving the infrastructure, but the "current financial crisis" may well prevent effective action. Also, WEFA does not specify whether the government is concentrating on the interior or the border. The location of infrastructural improvements may well be an important determinant of whether the relative movement to the interior continues. INEGI provides a figure of 770 of 890 maquiladoras being border plants in 1986 which, at almost 87%, is consistent with the WEFA figures. Maquiladoras directly employ

(mostly ITC) and Mexican (mostly INEGI) data but, for the purposes of this discussion, I will regard Commerce's number as the more accurate one.

37 Labor, 1988, p. 17.
38 WEFA table V.2.
39 WEFA p. 41.
about 5% of all formally employed workers in Mexican border states\textsuperscript{41}.

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\textsuperscript{41} Labor, p. 22.
\textsuperscript{42} From Fatemi, p. 25 and calculated from USITC #2365 table B-22.
Of the $5.8 billion in Mexican value-added, the largest sector was motor vehicles, at fourteen percent of the total value of U.S. OAP imports from Mexico, followed by electrical conductors and television receivers at 11 and 10 percent of the total, respectively. Table 2 shows a decline of 3% from 1987 in motor vehicles' share of U.S. OAP imports, an increase of about 1.5% from 1987 in electrical conductors, and the same share as 1987 for television receivers. Textiles continues its descent from 11.5% in 1969 to 5.5% in 1989. However, in rank, textiles only dropped from 4th place in 1969 to 5th in 1987 to 6th in 1989. Overall, the top 4 maquiladora industries fell from 56.8% to 44.6% of the total by value from 1969 to 1987, reflecting the diversification of the industry. Schoepfle and Perez-Lopez, in their report to the Labor Department, note the same trend using Mexican data: from 1975 to 1979 the top three industries, apparel, footwear, and electronics, fell from 70% to 60% of the total number of maquiladora plants. The trend continued in the 1980's, as the top three industries' share fell to 53% by 1986. Also, from ITC data, semiconductors have fallen from 16.3% of OAP imports in 1969 to 2.3% in 1989, reflecting the move of U.S. companies to Asia.

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43 Part of the reason for the decline is that the Multifiber Arrangement that began to apply quotas to apparel maquiladoras in the 1980's (p. 106, Anderson in Fatemi).
44 Labor, p. 19.
45 Calculated from Labor, table 15.
46 Fatemi, 1990, p. 25.
47 Derived from p. 1-5, USITC #2365.
Low labor costs are the primary reason for the movement of plants to Mexico\textsuperscript{49}. The recent devaluations of the peso have concentrated this effect and considering the high marginal propensity to import on the border, the devaluations may have some significant effects on workers' standard of living. As can be seen in Table 3, the dollar value of maquiladora wages in 1986 was half of what it was in 1981 which could be simply a nominal result of the depreciations except that real wages have fallen similarly. Real wages for the workers peaked in 1976 and have fallen 44% since then. Barbara Crispin\textsuperscript{50} reports that part of the reason for this drop in wages is that since the devaluations of 1982 maquiladora owners have chosen to increase fringe benefits, such as free lunches, attendance bonuses, and transportation subsidies, to an average of 49% of an employee's pay rather than increase payroll. Nonmonetary compensation is nontaxable income in Mexico, so perhaps the maquiladoras are able to provide more compensation at lower cost by using fringe benefits in place of taxable wage increases. Since 1986, there has been a significant increase in the dollar value of wages of all manufacturing employees, from $1.50 to $2.32 in average hourly compensation cost in 1989, which is wages before deductions plus employer social insurance expenditures\textsuperscript{51}. Wharton Economic Forecasting Associates reports a similar increase from 1.07 to 1.62 in the same period\textsuperscript{52}. Because it includes all

\textsuperscript{49}Economic Policy Institute Briefing Paper p. 8.  
\textsuperscript{50}in Fatemi, 1990, p. 76  
\textsuperscript{51}ITC p.1-11.  
\textsuperscript{52}WEFA p. 78.
manufacturing workers, the WEFA-reported increase does not necessarily reflect an improvement in maquiladora wages.

Table 3\textsuperscript{53}—Hourly Wages for Mexican Maquiladora Employees

<table>
<thead>
<tr>
<th>Year</th>
<th>Workers</th>
<th>Technicians</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nominal</td>
<td>Real</td>
</tr>
<tr>
<td>1975</td>
<td>Ps.11.68</td>
<td>Ps.20.48</td>
</tr>
<tr>
<td>1976</td>
<td>14.50</td>
<td>22.27</td>
</tr>
<tr>
<td>1977</td>
<td>18.80</td>
<td>22.09</td>
</tr>
<tr>
<td>1978</td>
<td>21.59</td>
<td>21.59</td>
</tr>
<tr>
<td>1979</td>
<td>24.28</td>
<td>20.54</td>
</tr>
<tr>
<td>1980</td>
<td>27.86</td>
<td>18.66</td>
</tr>
<tr>
<td>1981</td>
<td>35.48</td>
<td>18.56</td>
</tr>
<tr>
<td>1982</td>
<td>58.93</td>
<td>19.40</td>
</tr>
<tr>
<td>1983</td>
<td>92.90</td>
<td>15.16</td>
</tr>
<tr>
<td>1984</td>
<td>148.82</td>
<td>14.64</td>
</tr>
<tr>
<td>1985</td>
<td>227.84</td>
<td>14.24</td>
</tr>
<tr>
<td>1986</td>
<td>397.92</td>
<td>13.34</td>
</tr>
</tbody>
</table>

especially considering the change to non-monetary compensation. Crispin cites a U.S. Embassy report of a"'fully fringed' daily wage [of] $7-9 per day" for the maquiladoras in 1988\textsuperscript{54}.

The European Community Offshore Assembly Provision

The European Community has a provision that is similar to 9802.00.80, called "outward processing relief arrangements," which allow assembly, processing, and repair of goods\textsuperscript{55}. It differs from the U.S. system in several ways. First, assume the existence of a

\textsuperscript{53}Table was calculated from INEGI payroll and employment data based on a 52-week year with five 8 hour days per week. Real wage were calculated using CPI from Mexico Close-Up in Banamex, 1989. Dollar value of wages calculated using the exchange rate listed in Sklair, 1989 p. 40.

\textsuperscript{54}Crispin in Fatemi, 1990 p. 76 citing "The Maquiladora Industry" a report by the American Embassy, Mexico City.

\textsuperscript{55}ITC #2365 p.9-1.
good that, when processed overseas, has enough value added to move it up to a higher duty rate. When assessing duty the EC subtracts the value of the duty at the lower rate on the original good when it left the country from the duty at the higher rate charged the entirety of the new good upon reentry. Thus, there is some tax on E.C. value-added. In contrast, the U.S. system charges duty at the higher duty rate on only the value added overseas\footnote{Examples from ITC #1365 (p.9-1, note 8) may serve to clarify: *US system: Product A, valued at $1000, and subject to a customs duty of 5 percent, is exported from the United States to be processed or assembled into product B. The reimported product is valued at $2000 and is subject to a duty of 10 percent. On reimportation, product B will be assessed duties on the difference between the values of product B and product A, or on $1000. Thus the amount of duties collected will be $100 ($1000 \times 0.10$). 

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- duties applicable to reimported compensating product (product B) = $2000 \times 0.10 = $200 
- amount of duties applicable to goods originally exported (product A) = $1000 \times 0.05 = $50 
- amount of duties to be collected = $200-$50 = $150* 

\footnote{Grunwald and Flamm, p. 26.}}. Thus importers generally end up enjoying less of an advantage under the E.C. system\footnote{ITC #2365 pp. 9-1 and 9-2.}. Secondly, all production sharing transactions must have prior approval of the EC member country receiving the reimports, reportedly a more cumbersome procedure. Also, much more of EC outward processing (offshore assembly) goes to third country markets or is previously covered by preferential or free trade agreements with EC members and is thus not counted under the outward processing arrangements. Because of all these factors, offshore assembly in the E.C. is only one percent of its imports versus 17% of US imports taken up by the U.S. O.A.P.\footnote{Examples from ITC #1365 (p.9-1, note 8) may serve to clarify: *US system: Product A, valued at $1000, and subject to a customs duty of 5 percent, is exported from the United States to be processed or assembled into product B. The reimported product is valued at $2000 and is subject to a duty of 10 percent. On reimportation, product B will be assessed duties on the difference between the values of product B and product A, or on $1000. Thus the amount of duties collected will be $100 ($1000 \times 0.10$). 

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\footnote{Grunwald and Flamm, p. 26.}}.
Because of the shortage of labor in West Germany in the 1970's, a more liberal attitude emerged towards offshore production from that country. Thus the West Germans accounted for 49\% of EC OAP imports in 1988\textsuperscript{59}. The French and the Dutch were responsible for 18\% and 14\% of the imports, respectively. Production was concentrated in Eastern European countries, accounting for 42\% of EC outward processing imports in 1988. Of Third World production, East Asia (Hong Kong, Singapore, and Taiwan) and North Africa (Morocco and Tunisia) accounted for 11\% and 4\%, respectively, of processing destined for the E.C.\textsuperscript{60}. French reimports have been largely from her former colonies in North Africa, amounting to two-thirds of total processing trade in 1978\textsuperscript{61}.

**Linkages**

The U.S. content of OAP imports from various countries can be determined by the percent of the value of OAP imports that is free of duty. There are major differences in the duty free share of 9802.00.80 imports from different countries. Mexico has the highest U.S. content, 51\% in 1989, which is down from 65\% in 1969 but the same as it was in 1983\textsuperscript{62}. The developed countries, Japan, West Germany, and Sweden have the lowest U.S. content at two percent and the U.K. has eleven percent\textsuperscript{63}. From the U.S. perspective this point is a strong argument in favor of maintaining the

\textsuperscript{59}ITC #2365 p. 9-7.
\textsuperscript{60}ITC#2365 pp. 9-15 and 9-16.
\textsuperscript{61}Grunwald and Flamm, p. 27.
\textsuperscript{62}Grunwald and Flamm, p. 13.
\textsuperscript{63}ITC #2365, p. 1-13.
maquiladora program. Of course, from the Mexican point of view, the high U.S. content of the maquiladoras illustrates the lack of backward linkages, that is, the lack of purchases from the rest of the Mexican economy.

Compared to the East Asians, the Mexican assembly operations have very minimal backward production linkages. The use of local materials in South Korean and Taiwanese export processing operations has increased from seventeen and nine percent, respectively, of total inputs "before 1976" to "1/3" and "half" of the total, respectively, by 1985. A survey by Edward George found that the maquiladoras only purchase 1.4% of their inputs locally (in Mexico) and Grunwald (p. 205, note 15) reports that Mexican capital provides only consulting, industrial parks, and packing and cleaning materials. The Mexican Secretariat of Programming and Budget (SPP) lists local content percentages for materials and components as .5% and .8% for the western and eastern borders with the U.S. and 8.5% for the maquiladoras in the interior in 1986. Mexican plants provided 3.6 and 6 percent of packaging materials for maquiladoras on the western and eastern borders, respectively, and in the interior local manufacturers provided 31.4% of the total. WEFA also reports that border maquiladoras purchased less than one percent of their raw material in Mexico, while interior plants

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64 Hagans and Mitchie in Banamex, p. 132; Rohr in Banamex p. 25; Sprinkle, pp. 10-11.
65 Grunwald and Flamm, p. 230.
66 Grunwald in Green, p. 205, note 11.
67 George in Fatemi, 1990, p. 225
68 SPP in Mexico Close-Up, statistical supplement to Banamex.
purchased seven percent locally in 1987, though the percentage fell to 5% in 1989\(^6\).

The difference between interior and border maquiladoras' use of locally produced inputs suggests that transportation expenses are a significant determinant of backward linkages and that a good strategy for Mexico's government to increase backward linkages is to more vigorously pursue maquila development in the interior\(^7\). Of course, from the political point of view, one might judge that the more serious threat to the maquiladoras comes from U.S. labor and thus the lack of linkages is a necessary political sacrifice to preserve the jobs directly arising from two U.S. tariff items.

Wages paid to the workers are also more likely to "leak" into the United States from maquiladoras on the border. Goddard reports estimates of marginal propensity to import for border residents range from .5 to .8\(^7\) versus .071 for the interior\(^7\). Seligson and Williams (p. 73) found only 4% of their survey sample reporting characteristics of an OAP-induced migrant: interstate migrants who moved to the border for work related reasons at 12 years of age or older and had heard of maquiladora work before moving. Thus, the maquiladoras are not the exact cause of the leakages, as 96% of the workers would presumably have lived near the border, and purchased

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\(^{6}\) WEFA, Table IV.2.

\(^{7}\) To encourage maquiladora expansion into the interior, the Mexican government could direct infrastructure improvements away from the border or could offer other incentives.

\(^{71}\) Comercio Exterior, 1971, as quoted in Goddard in Gibson and Renteria, p. 144

\(^{72}\) CIDEX in Goddard.
American goods, anyway\textsuperscript{73}. Even if the OAP is not a cause of migration, the leakage issue still diminishes backward consumption linkages and the foreign exchange accruing benefits of the OAP for Mexico. However, keep in mind that the 50-80\% figure is from 1971, an era of approximately 15\% over-valuation of the exchange rate.

Another method of estimating the effect of maquiladora employment on U.S. employment is to determine employment multipliers (Z): $\Delta Y_{\text{U.S.}} = (Z) \Delta Y_{\text{Mex.}}$.

J. Michael Patrick reviews the fourteen available regional studies of employment multipliers of maquiladora jobs on U.S. border communities from the mid to late 1980's and finds a wide variation, but a significantly lower mean (.28) than that Goddard used (.65). The standard deviation was .28 and, omitting the high and low values, the sample mean was .20 with a standard deviation of .15\textsuperscript{74}.

Grunwald and Flamm provide several reasons for the lack of backward linkages from the border maquiladoras to the Mexican economy. Firstly and their preferred idea, the proximity of the United States lowers transport costs and provides less incentive to purchase locally. This idea is supported by the greater use of local materials by maquiladoras in the interior of the country, as noted above. Also, the Mexican components are charged duty while American inputs do not add to the duty, raising the relative cost of

\textsuperscript{73}The survey was given in the era of overvalued exchange rates in the summer of 1978 and the estimates of MPI are from the early 70's(Seligson and Williams, p. 7).

\textsuperscript{74}calculated from J. Michael Patrick in Fatemi, 1990 p.62.
using Mexican inputs. In addition, somewhat indirectly, they note that Mexico's highly protected industries cannot keep production schedules and quality up to the necessary standard and inefficiencies price them out of the market\textsuperscript{75}. Haynes Goddard cites a survey published in 1980 of 571 maquiladoras that asked why more local materials were not used. Reportedly, poor quality was noted by 27.6\% and higher prices in Mexico was cited by 18.8\%\textsuperscript{76}. During the 1970's, exchange rates were overvalued by amounts ranging from 4.4\% to 26.8\%, according to Goddard's estimates\textsuperscript{77}, leading to losses of foreign exchange, decreased foreign investment in Mexico, and weakened backward linkages (all of which contribute to increased foreign debt which has been a dominant concern for Mexico in the 1980's).

Forward linkages were legally forbidden until 1979 when some maquiladoras were permitted to sell up to 20\% of total production in Mexico\textsuperscript{78}. In December 1989, the amount they could sell locally increased to one-third of total sales, though requiring a permit. Few permits have been issued as of February 1991\textsuperscript{79}. Thus, up to this time, forward linkages from the maquila sector were largely forbidden. As we have seen, backward linkages were limited directly by the overvalued exchange rate and duty requirements on

\textsuperscript{75}Grunwald and Flamm, pp. 230-231.
\textsuperscript{76}Centro de Investigacion y Docencia Economica, Mexico, D.F. 1980 cited in Goddard in Gibson & Renteria p. 152.
\textsuperscript{77}Goddard in Gibson and Renteria, p. 147.
\textsuperscript{78}Labor, p. 17.
\textsuperscript{79}ITC #2353 pp. 1-7 and 1-8.
Mexican inputs and indirectly by inefficiency fostered by import substitution policies.

Harley Shaiken provides anecdotal support from industry when he reports on one auto company, three electronics companies, and one computer company, all anonymous. The auto company negotiated to be allowed to sell twenty percent of the plant’s output in Mexico in exchange for a requirement that 30 percent of the inputs by value be sourced in Mexico. Since the company uses a Just-In-Time production system (which eliminates inventories and requires the ability to adhere to precise schedules), problems with Mexican infrastructure require that the auto company’s Mexican suppliers be located in the same industrial park. As the materials manager reports "The Mexican railroad is not exactly the most punctual. . . In transit it can be anywhere from ten days to thirty days" [from Monterey to their anonymous location]. Of the Mexican suppliers, the quality control manager said they "compare very favorably. [They're] not without problems, but they seem to take corrective actions and have a good concern for correcting problems" (p. 41).

The three electronics maquiladoras are reported to source less than 1 percent of their component parts in Mexico. A vice-president notes: "Mexico is [a] very difficult [place] . . . to source material. The availability is very poor, and when you do find it the quality is a big problem, cost is a big problem, schedule is a big problem" (p. 104). A plant manager is quoted as saying "Mexico really doesn't have an infrastructure to support an electronic industry" (p. 104).
The computer plant, on the other hand, sources 30% of its parts in Mexico, initially because of local content requirements. Thus, the purchasing manager reports: "any Mexican vendor can be [competitive] worldwide" and the materials manager also notes the good quality, price, and timing of Mexican producers (p. 114). A reason for the good experience of the computer plant is that they have been willing to work with the vendors and have attempted to develop a strong network of local suppliers, because of the local content requirement. There is undoubtedly some additional cost from local content requirements, and that would probably reduce the number of maquiladoras, but it is also a way to force development of local suppliers.

II. FORMAL MODELS

There have been a number of attempts to formally model the effects of Offshore Assembly Provisions and the maquiladoras as they relate to various aspects of the economy. Several studies dealing with the welfare effects, including work by J.M. Finger in the mid 1970's, and Kenneth Flamm and Jose Mendez in the 1980's (and currently), use partial equilibrium models which examine the effects of removing the OAP on the industries directly involved. The employment effects of a repeal of the OAP are investigated in a study done by Jose Mendez, Tracy Murray and Donald Rousslang. The Wharton Economic Forecasting Associates use a macro model to predict the effects of exogenous changes in policy variables on maquiladora industry variables such as employment. A broader framework for examining the Mexican involvement in the American
provision is provided by Gene Grossman when he examines the impact of the OAP on the protective effects of tariffs. Trade balance effects have been evaluated by Richard Boltuck et al and Finger while volatility of offshore production has been analyzed by Kenneth Flamm. Tain-Jy Chen with De-Piao Tang and Flamm examine the wage relationships within the context of an Offshore Assembly Provision.

The partial equilibrium models differ from general equilibrium models in that they ignore both income and price effects. Income effects are the impacts of the maquiladora industry price changes on consumers' incomes, and the effects of these income changes on prices in the maquiladora industry and other sectors. To illustrate, assume that the Offshore Assembly Provision is repealed, causing a decrease in incomes of U.S. components' producers and an increase in the incomes of U.S. assemblers. American components industry managers, owners, and workers would demand less of all goods, including offshore, foreign, and domestic assembly and also the components embodied in these assembled goods. Conversely, U.S. assembly industry managers, owners, and workers would demand more of all goods, including assembly and components.

Price effects postulate that the change in prices in markets directly affected by the repeal of the OAP would affect prices in other markets, such as those for complementary or substitute goods. Both of these consequences are ignored by partial equilibrium analysis (except Mendez, who accounts for some price effects) and eventually cause significant evaluative problems as the market
being isolated in the study becomes larger\textsuperscript{80}. It can be concluded that as the maquiladora sector expands, partial equilibrium analysis becomes more problematic.

Most of the partial equilibrium models examined here have common assumptions in addition to those embodied in partial equilibrium analysis. The basic scenario is of two stages of production: components production and the use of these components in the production of a final good. The models generally assume that there are two countries producing the good, the domestic and the foreign country, where the domestic country has imposed a tariff to which the OAP provides an exception, and the foreign country is where offshore assembly takes place under the provision described above. Purchasing choices are divided between three goods: 1) offshore assembly using U.S. components (OAP imports) 2) offshore assembly using foreign components (nonOAP imports) and 3) entirely domestic goods. Fixed input coefficients for inputs of both primary and intermediate goods are also generally assumed. Given these common assumptions, the comparative static effects of repeal of the Offshore Assembly Provision are examined and yield the result that OAP repeal has relatively little effect on involved industries.

\textbf{Welfare}

J. M. Finger was the first to analyze the U.S. OAP, and his articles continue to be influential. In his article in the \textit{American Economic Review} in September 1976, Finger uses a partial

\textsuperscript{80} Cornwall, pp. 80-83.
equilibrium model to examine the effects of the OAP on a number of domestic variables: prices and outputs, trade balance, and welfare. Since this is partial equilibrium, he fails to consider any spillover effects on other sectors and resulting feedbacks into the OAP sector. Finger implicitly assumes that there are no foreign components in U.S. assembly when he notes that, "because OAP imports contain domestic components and are assembled abroad, we know" that there are more assembled goods produced overseas than components and more components produced domestically than assembled goods.\textsuperscript{81} It also becomes evident that an unstated assumption of Finger's is that the foreign assemblers initially producing OAP imports do not substitute foreign components when the OAP is repealed (or the OAP imports would shift massively to nonOAP imports).

Finger's analysis, though mostly done in a mathematical framework, can be analyzed graphically. In figures 1 and 2 both stages of production, components production and assembly, for each sector\textsuperscript{82} are represented. Within each stage the effects on the domestic (U.S.), foreign, and total quantities and prices are outlined. In figure 3 the total effect of removal of the OAP on the entire sector is graphically demonstrated in order to illustrate domestic consumer surplus effects. Since Finger defines the foreign supply functions as export supply functions, the changes brought about by

\textsuperscript{81}this assumption will be discussed further in Grossman's article.

\textsuperscript{82}The sectors are defined by the "7-digit TSUS categories" as determined by the U.S. Tariff Commission (this is from 1976).
Figure 1  Assembly

Figure 2  Components

Figure 3  Total Production in the Sector
removal of the OAP effect consumer surplus only in the U.S., as seen in figure 3.

Finger's analysis, though mostly done in a mathematical framework, can be analyzed graphically. In figures 1 and 2 both stages of production, components production and assembly, for each sector\textsuperscript{83} are represented. Within each stage the effects on the domestic (U.S.), foreign, and total quantities and prices are outlined. In figure 3 the total effect of removal of the OAP on the entire sector is graphically demonstrated in order to illustrate domestic consumer surplus effects. Since Finger defines the foreign supply functions as export supply functions, the changes brought about by removal of the OAP effect consumer surplus only in the U.S., as seen in figure 3.

Recall that Finger assumes that OAP imports, nonOAP imports, and domestic assembly are all perfect substitutes, which effectively determines prices given the arbitrage conditions that Finger provides: That is, in the absence of tariffs the price received by the producer equals the price paid by the consumer (consumers are always in the U.S., or "domestic" country), noted as $P(\text{nt})$ in figure 1. It is thus impossible for domestic producers to raise their prices since consumers would simply switch to foreign goods.

In the market for assembly, figure 1, the existence of a tariff with an OAP causes prices received by the domestic producers $P(d)$

\textsuperscript{83}The sectors are defined by the "7-digit TSUS categories" as determined by the U.S. Tariff Commission (this is from 1976).
to be higher than in the nontariff case $P(\text{nt})$ because their competition, foreign assemblers, have had a cost increase. The installation of a tariff with an OAP causes prices received by the foreign producers $P(\text{f})$ to be lower than in the nontariff case $P(\text{nt})$. The consumers pay the higher price $P(\text{d})$, and the difference between $P(\text{f})$ and $P(\text{d})$ is tariff revenue received by the government. Upon removal of the OAP, foreign assemblers must pay tariffs on components produced in the U.S., lowering the price they receive to $P'(\text{f})$ and raising the price to the consumers (since the costs of foreign assembly have risen while the costs of domestic assembly have not changed) to $P'(\text{d})$.

A decline in the quantity produced results from the shifts in prices and supplies. In the foreign assembly market, the supply shifts back from $S$ to $S'$ upon repeal of the OAP because the foreign producers must pay more tariff on their inputs, i.e. their input costs have risen. At the same time the tariff enables the domestic assemblers to raise their prices from $P(\text{d})$ to $P'(\text{d})$ because of the higher tariff costs of their competition. The foreign assemblers must also charge price $P(\text{d})$ in order to get their price $P(\text{f})$. The difference between the price paid by the consumers and that received by the consumers is a determinant of tariff revenue. Thus, production shifts from point a to point b upon repeal of the OAP and the quantity produced shifts from $Q$ to $Q'$.

In the market for components, figure 2, the cost of using domestic components has risen, so assemblers will switch to foreign components. Thus the price of domestic components falls
from P(d) to P' and the price received by foreign components producers rises from P(f) to P' upon repeal of the OAP, equalizing the price of components.

The supply curves must be examined when determining the effect of repeal of the OAP on quantities produced. To explain what appears to be a supply shift in the foreign components market the story must be reversed, moving from no tariff to a tariff to a tariff with an OAP. Initially, without a tariff, there is no difference in the cost of using foreign and domestic components (zero transport costs are assumed). When a flat rate tariff on imports of finished goods is instituted it does not effect the relative prices of foreign and domestic components. Thus whether domestic or foreign components are embedded in assembly, foreign assemblers pay the same tariff, and therefore the supply curves are not affected. Some of this tariff is absorbed by components producers in the form of lower prices paid for their products (by the amount of P(nt) - P').

When an OAP is instituted the relative cost to assemblers of using domestic components falls and the price of domestic components correspondingly rises to P(d) while the quantity of domestic components purchased rises from Q' to Q. Conversely, the relative cost to assemblers of using foreign components has risen and the price of foreign components falls to P(f) and the quantity of foreign components used falls from Q' to Q. In order to represent this quantity decline in price paid by consumers in the domestic market P(d) the supply curve of foreign components is shown to shift from S' to S and production in consumers prices shifts from
point d to point c, though in prices received by foreign producers there is simply a movement along the S curve from d to e. Thus, returning to Finger's chronology, repeal of the OAP is represented by a shift from S to S' and a convergence in prices to P' because there is no longer any cost difference to the use of foreign versus domestic components.

Thus in the total components graph, the OAP case equilibrium is represented by the point h where the S' curve intersects the OAP price (the average of P(f) and P(d)). Thus, as in the foreign components market, the initiation of the OAP is represented as a backward shift of the supply curve to S in order to account for the quantity shift from Q' to Q in domestic components prices (consumers' prices). Production shifts from f to g to reflect the total quantity purchased in the price paid by domestic consumers P(d). In the price received by foreign producers, initiation of the OAP simply results in movement along the S' curve from h to f. As above, because there is no change in input prices for components, there is no actual shift in supply. Thus upon repeal of the OAP, production shifts from g to f and the total quantity of components in the sector falls from Q to Q'.

The reason that components prices equalize while assembly's price disparity increases is that repeal of the OAP removes the cost differential between use of foreign and domestic components (recall that they are perfect substitutes) while it increases the amount of tariff that must be paid by foreign assemblers, lowering the price received by foreign assemblers while raising the price of assembled
goods to consumers (the difference being tariff revenue on which subject more will be said later).

Figure 3 is useful to examine the overall impacts of a removal of the OAP. The supply curve for the sector shifts back because the only "real" supply shift is in assembly. That is to say, the only change in input costs upon repeal of the OAP is an increase of foreign assemblers' cost of using domestic components, inducing a backwards shift of the supply curves in figure 1. The demand for the output of the sector is unchanged because there has been no change in the relative prices of the outputs of the different sectors nor has consumers' income changed. In sum, sectoral prices rise and the quantity output of the sector falls.

The welfare effects are determined by looking at the change in consumers' surplus, the change in U.S. producers' surplus, and the transfers directly arising from the tariff. The original consumers' surplus in Figure 3, area $CS' + A + B$, is reduced by the amount of area $A + B$ due to the backwards shift in supply resulting from removal of the Offshore Assembly Provision. The change in consumers' surplus is calculated by Finger in the formula:

$$\Delta CS = (-dP_j)Q_t + \frac{1}{2} (-dP_j)(dQ_t)$$

where $P_j$ and $Q_t$ are the initial prices and quantities and $dP_j$ and $dQ_t$ are the results of the removal of the offshore assembly provision. In proportional terms:

$$\frac{\Delta CS}{P_jQ_t} = -\frac{dP_j}{P_j}(1 + \frac{1}{2} \Gamma \frac{dP_j}{P_j})$$
where $\Gamma$ is the demand elasticity for the finished product.

Producers’ surplus in the domestic assembly and domestic components markets is defined by the area under the price and left of the supply curve in Figures 1 and 2. Since the supply curve does not shift in the domestic portion of the sector, the change in producers’ surplus is entirely a result of the price changes resulting from repeal of the Offshore Assembly Provision. Thus producers’ surplus in assembly increases by the amount of area $D$ in Figure 1 and components producers’ surplus declines by area $C$ in Figure 2 upon the ending of the OAP. For producers’ surplus in each sector Finger uses the formula:

$$\Delta PS = (dP)Q + 1/2(dP)(dQ)$$

which yields: $$\frac{\Delta PS}{PQ} = P^*(1 + 1/2 \phi P^*)$$

where $\phi$ is the supply elasticity for the final good and $P^* = dP/P$. To arrive at the total change in producers’ surplus one simply adds areas $C$ and $D$.

The changes in prices and quantities due to the repeal of the OAP are somewhat absorbed by the U.S. government in tariff revenues. There is a welfare loss in the components markets, due to the higher price $P'$ received by foreign components manufacturers after removal of the Offshore Assembly Provision. Money that was initially tariff revenue has been shifted to pay for the higher prices of foreign components. The equation for welfare loss due to tariff losses given in Finger can be manipulated to derive:
\[
\text{Loss} = dP_{fc} \left( Q_{fc} + dQ_{fc} - \left( \frac{1}{1+T} \right) dQ_{dc} \right)
\]

This equation shows that the shift of government tariff revenues to increased payments for components' imports (as embodied in foreign assembly) is due to the increased price of foreign components multiplied by the total imports of foreign components after repeal less the absolute value of the decline in quantity of domestic components used. In Figure 2 this is shown to be area F less area G.

A welfare gain due to a shift of income from foreign assemblers to domestic tariff revenue is another result of the OAP repeal. Producers' price and quantity of foreign assembly falls while domestic assembly's price (and consumers price) increase upon repeal. This increases the disparity between the producers' prices in domestic and foreign assembly, which is accounted for by an increase in government revenues from tariffs, mostly coming from domestic consumers and assemblers. Some of the increase in tariff revenues comes from foreign assemblers, and is a welfare gain for the domestic economy. The formula for this gain in Finger can be manipulated to derive:

\[
\text{Gain} = -dP_{fa} Q_{fa} + -dP_{fa} dQ_{fa}
\]

which, in figure 1, is represented by area E. In sum the welfare gain to the U.S. economy due to the repeal of the OAP is measured by:

\[
\text{gain} = \text{area } (D - C - A - B - F + G + E)
\]
Mendez updates Finger's analysis and data and, referring to studies that indicate that the law of one price\(^{84}\) is violated regularly for specific product categories (see Mendez' citations of Isard, 1977 and Kravis and Lipsey, 1978), is able to assume that consumers view foreign and domestically assembled goods as imperfect substitutes. He is thus able to examine some feedback effects, which is his major innovation. He discusses the effects of removal of the OAP on supply and demand for each of the goods (OAP imports, non-OAP imports, and domestic substitutes). The graphical analysis of the removal on the domestic assembly market, offshore assembly imports, and non-OAP imports are displayed in Figures 4a, 4b, and 4c, respectively and the graph of the domestic components market is Figure 5 (on the next page, all from Mendez 1991).

Mendez, assuming that OAP and nonOAP goods are imperfect substitutes, allows for simultaneous price changes. That is, if the OAP is cut off, the supply curve of (formerly) OAP imports shifts up (supply elasticity for OAP imports is infinite: the OAP is a small part of the economy) from \(S_0(t)\) to \(S'_0(t)\) because of the increase in components costs. Tariff-inclusive prices rise from \(P_0(t)\) to \(P'_0(t)\) and quantity imported of OAP goods falls. Demand curves in the other two markets shift out, reflecting a shift from OAP imports to nonOAP imports and domestically assembled goods.

---

\(^{84}\)That states that given competitive markets without shipping costs or tariffs, identical goods selling in different countries should sell at the same price, in a common currency (Krugman and Obstfeld, p. 379). The violation of this "law" is that consumers do not see the two goods as identical and the goods sell for different prices in different countries (ibid, p. 384).
In the components market, a fall in demand for OAP goods\textsuperscript{85} leads to a fall in foreign assemblers' demand for domestic components, which is not uniquely shown but is the shift from $D_{co}$ to $D_{co}'$. The shift to domestic assembly from offshore assembly also

\textsuperscript{85}Mendez does not state explicitly why this happens. It was the upward supply shift that led to the decrease in quantity of OAP imports, so perhaps it should be the fall in supply of OAP goods causing the following effect.
causes an increase in demand for domestic components from domestic assemblers from \( D_{cd} \) to \( D'_{cd} \) (Mendez also seems to assume that domestic assemblers use only domestic components). The total effect is shown on the right side of Figure 5, which assumes that the offshore assembly decline in demand for domestic components is larger than the domestic assembly increased demand for domestic components. This relationship is made explicit in the formula for the change in supply of domestic components:

\[
\left[ \Gamma_d \frac{dS_d}{S_d} + \Gamma_o \frac{dS_o}{S_o} \right] = \frac{dS_c}{S_c}
\]

where \( \Gamma_d \) is the share of domestic components used in the domestically assembled product and \( \Gamma_o \) is the share of domestic components used in OAP imports. Thus the equation says that the change in supply of domestic components is determined by the relative size of the change in demand for domestic components by offshore and domestic assemblers.

The feedback effect from the lower price of domestic components into the price of domestically assembled goods is indeterminate, a priori, since there are two, possibly offsetting, effects of the fall in prices, as shown in Figure 4a. The first is the expected increase in price and quantity of domestic assembly due to the previously noted increased demand for domestic assembly because of the repeal of the OAP. The second effect is the reduction of price of domestic components which shifts supply of domestic assembly (which is not infinitely elastic) out, from \( S_d \) to \( S'_d \). The a
priori relationship between the two shifts is unknown and thus one cannot be sure of the direction of change in price of domestically assembled goods, though the quantity assembled domestically almost certainly increases.

This uncertainty contributes to ambiguity as to the demand for nonOAP imports. Initially demand for nonOAP imports increases, but if the price of domestically assembled goods falls, then demand for nonOAP imports would shift back inwards from $D'_n$ in Figure 4c, with the relative final quantity being unknown. Of course, if the price of domestically assembled goods increases, demand for nonOAP imports increases even more. A similar situation exists for OAP imports where if the price of domestic assembly increases then $D_o$ increases to $D'_o$, and quantity produced increases somewhat from $Q'_o$ to $Q''_o$.

The uncertainty of prices for domestically assembled goods because of the changes in both supply and demand in the domestic assembly market also lead to problems for consumers' surplus calculations. To account for these effects, Mendez employs an approximation of consumers' surplus from Mokre and Tarr (see Mendez' references):

\[
CS = - [P_o D_o[ 1 + (1/2)(dS_o/S_o)] (dP_o(t)/P_o(t))
+ P_d D_d [1 + (1/2) (dS_d/S_o)] (dP_d/P_d)] \quad (*)
\]

where the o represents offshore and the d is domestic. Since the model is static the points examined are always equilibria, and thus
the amounts supplied equal the amounts demanded, \( S_j = D_j = Q_j \) (where \( j \) represents the type of final good: domestic (d), offshore assembly (o), or entirely imported (n)). After substituting \( Q \) and multiplying through by \( P_o D_o \), the offshore assembly portion (the first term) of the above equation becomes:

\[
[P_o Q_o + \frac{1}{2} P_o dQ_o] \frac{dP_o(t)}{P_o(t)}.
\]

This term is the area formed by \( dP_o(t) \) and \( Q_o \) in figure 4b minus half the area formed by \( dP_o(t) \) and \( Q_o - Q_o'' \). The new first term literally measures the area which is below \( P_o \) and is similar to the above (see figure 4b) and the higher area is derived when the lower area is multiplied by the proportional increase in \( P_o(t) \). In sum, the approximate gain in consumer's surplus is the area \( c + d \) in figure 4b from Mendez.

The second portion of equation (*), representing the area of \( a + b \) in figure 4a, is derived by using a similar approximation. The S's and D's are replaced by \( Q_d \)'s and, after multiplying through, results in the term:

\[
dP_d Q_d + \frac{1}{2} dP_d dQ_d
\]

In figure 4a the first part of the term is area a and the second portion is the approximation represented by area b. Thus instead of, in figure 4a, combining the area above the price determined by the intersection of \( S_d \) and \( D'_d \) and to the left of \( D'_d \) with the area above the price determined by \( S'_d \) and \( D'_d \) and to the left of \( D'_d \) and the original consumers’ surplus, Mendez approximates this process by summing areas a and b. This approximation reportedly produces
smaller errors than attempts to calculate the exact consumers' surplus. Because the change in price of goods assembled offshore never exceeds 14%, the difference between the approximation and the true welfare change is no more than .5%.\(^8\)

Repeal of the OAP produces contrasting effects on the producers' surplus for domestic assembly and domestic components. Domestic assembly producers' surplus is increased by both more rents to previously existing value added and the addition of new value-added\(^7\) in the formula:

\[
PS_a = \alpha_a P_d D_d \left(1 + (1/2) (dD_d'/D_d) \right)(1/\varepsilon_a)(dD_d'/D_d)
\]

where the subscript \(a\) is assembly and \(d\) is domestic and \(\varepsilon_a\) is the supply elasticity of domestic value added. \(\alpha_a\) is the share of domestic value added in the value of the domestically assembled product. Since \(\varepsilon_a = \frac{w}{Q} \frac{dQ}{dw}\) (where \(w\) is cost of value-added) the equation can be simplified into: \(PS_a = dW \left[Q_d + \frac{1}{2} dQ_d\right]\)

The first part of this equation represents the increased producer rents to existing supply and the second part represents the increased producer rents due to the increase in supply of domestic assembly.

\(^8\)The method of calculating this difference is in the note to Table 2, Mendez 1991.
\(^7\)Rents earned by new value-added is approximated by half the change in the price of value-added times the change in quantity of value-added.
The loss of producers' surplus for domestic components is represented in figure 5 by the area $P_C P'_C$ less $ijk$. This area is produced by the decline in demand:

$$PS_C = (\alpha_c P_d D_d + \beta_c P_o D_o)[1 + (1/2)\varepsilon_c (dp_c/p_c)](dp_c/p_c)$$

where the subscripts $c$, $d$, and $o$ represent component, domestic, and offshore. Coefficient $\alpha_c$ is the percent share of domestic components used in the value domestically assembled goods and $\beta_c$ is the percent of domestic components embodied in foreign assembly. If this equation is again divided into its two parts, each portion is identical to Finger's calculation of producers' surplus:

$$PS_C = \alpha_c P_d D_d \left[1 + \varepsilon_c \frac{dp_c}{p_c}\right] \frac{dp_c}{p_c} + \beta_c P_o D_o \left[1 + \frac{1}{2} \varepsilon_c \frac{dp_c}{p_c}\right] \frac{dp_c}{p_c}$$

The sign of total producers' surplus is thus dependent on which of the producers' surplus equations, the components or the assembly equation, provides the larger result.

The third element of welfare change due to repeal of the OAP is the change in tariff revenue received by the government:

$$\Delta TR = t[(P_o D_o ((1-\beta_c)(dS_o/S_o) + (1 + (dS_o/S_o)[(dP_o(t)/P_o(t)) + (dP_o/P_o)]) + P_n D_n(dD_n/D_n)$$

This equation can be rewritten by substituting $Q = D = S$ and dropping all OAP import subscripts (o) and leaving the nonOAP import subscripts (n):

$$\Delta TR = t[P_d Q(1-\beta_c) + (PQ + PdQ)(dP(t)/P(t)) + (PQ + PdQ)(dP/P) + P_n dQ_n]$$
The letters in parentheses below the equation represent the areas on figures 4b and 4c that change hands in the redistribution caused by repeal of the OAP. That is, area e represents a loss while area g represents a gain, and areas c and f are transfers from consumers and domestic components producers, respectively.

This analysis ignores income effects in examining the removal of the Offshore Assembly Provision. Mendez' model attempts to take into account the feedback from the change in price of the domestic components while Finger ignores this effect. Thus, Mendez develops a "more general" partial equilibrium model. Mendez also concentrates on a microfoundation for his model when he assumes that the consumer uses a fixed ratio of substitution when choosing between the m product groups and so employs Cobb-Douglas Utility Functions.

Flamm in Grunwald and Flamm (1985), uses semiconductor data to assess the welfare loss of removal of the OAP. He uses a second order approximation of consumers' surplus to evaluate welfare effects:

\[
\frac{\text{Loss}}{P_o Q_o} = m \left[ 1 + \frac{m \eta_{Qo}}{2} \right]
\]

where \( \eta_{Qo} \) represents the price elasticity of demand for semiconductors as an input and \( P_o Q_o \) is the value of semiconductor output with offshore assembly. \( m \) represents the proportional increase in assembly costs of assembling entirely in the U.S. compared with the costs of offshore assembly, which is the same as
Finger's $\frac{dP}{P}$. Thus, Flamm's method of calculating consumers' surplus is the same as Finger's, and has the same omissions, with the additional fault of ignoring the offsetting gain in producers' surplus and the gain of tariff revenue when an OAP is repealed. As Finger showed, the effect is still negative but should be significantly offset by the gain in producers' surplus.

To get his results Finger has to assume a number of parameters, such as supply and demand elasticities. These come from his own calculations and those of Stephen Magee. When he uses these parameters to estimate the welfare changes, Finger discovers that the loss of total consumer surplus of $1,424$ million and the loss of tariff revenue of $346$ million is partially offset by a total gain in producers' surplus of $1,349$ million. The effect of the removal of offshore assembly is a definite, though small, loss in welfare. Finger makes no specific comment about the interpretation of these totals. From his sensitivity analysis, he finds that the choice of parameters is not critical, indicating robust results.

Mendez found similar changes. Removal of the Offshore Assembly Provision benefitted the government and domestic assemblers at the expense of consumers and domestic components manufacturers. Consumers suffer by far the most, with losses in consumers' surplus amounting to $541$ million compared with only $119$ million loss in components producers' surplus, and gains of $261$ million and $279$ million for assembly producers' surplus and the government (tariff revenue), respectively. In sum, the worst
case seems to be a loss in total domestic welfare of $98 million. Because these effects are derived from a partial equilibrium analysis, Mendez notes that these totals cannot be interpreted as aggregate effects. That is to say, that the analysis has not considered the interactions between the sectors because of their changes in output (the price effects).

Flamm, in his analysis of the loss of consumers' surplus finds welfare losses that range from six percent to twelve percent of consumption of semiconductor devices. The value depends on the values chosen for the cost advantage of foreign assembly and the elasticity of demand for semiconductors. The highest welfare loss was found, as one might expect, when using the highest cost advantage (m) and highest (negative) price elasticity. Thus a price elasticity of -1.5 and an excess cost of 13% for production in the United States yields a welfare loss of 12% of the consumption of semiconductors.

**Employment**

Mendez, Murray and Rousslang's analysis (1991) of the employment effects uses the same scenario as Mendez' welfare analysis: two-stage production process, fixed coefficients, perfect competition, and imperfect-substitutes. Thus their results are again adequate for the disaggregated sectors but, because they ignore other macroeconomic effects such as exchange rate changes and price effects, the sectoral results cannot be easily converted to aggregate changes. Another assumption is that foreign assemblers
using U.S. components cannot substitute foreign for U.S. components upon repeal of the OAP, resulting in overstated employment changes as foreign assemblers cannot act to minimize the damage of repeal.

To derive employment increases in domestic components and assembly as a result of the repeal of the OAP, Mendez et al use the equation:

\[ dL_d = [a_{id}] [I-A]^{-1} [d(P_dQ_d)] \]

where \( dL_d \) is the vector of changes in employment in U.S. industries, \( I \) is the identity matrix, \( [a_{id}] \) a diagonal matrix whose diagonal elements are the number of workers in domestic assembly and components industries per $1000 final output," A is the matrix of input coefficients from the 1977 U.S. input-output table, and \( [d(P_dQ_d)] \) is the diagonal matrix of changes in production in U.S. industries. \( [I-A]^{-1} \) is the Leontief inverse of the A matrix, which gives the effects of increasing demand for a given column on the outputs of the different row elements of the column\(^{88}\). Thus the equation provides us with the effects of a change in output for the domestic assembly sector on sectoral employment. They use a similar equation for losses in U.S. components industries except for using diagonal matrices of the number of workers in domestic components industry and OAP import changes that are weighted by percent by value of U.S. components.

\(^{88}\)see last section of this paper.
For Mexican industry, they employ a similar equation that uses diagonal matrices of the number of assembly and components workers in Mexican plants (using U.S. data because of the previously noted discrepancies) per $1000 of U.S. OAP imports. Thus, the equation measures the number of jobs in each sector that are lost in Mexican assembly plants when the OAP is repealed.

Having used 1986 data, Mendez et al were able to get losses and gains in man-years of employment on a sectoral basis for 64 sectors. For most sectors the losses were very small, with by far the largest net U.S. gain is in the apparel sector, at 7301 jobs gained, and the largest net loss is in the fabrics, yarn, and thread mill sector at 8945 U.S. jobs lost. In Mexican assembly (maquiladora) plants job losses rise no higher than 849 jobs lost in the apparel sector. These changes are small in light of the nearly 300,000 maquiladora employees in that year. It thus appears that maquiladoras have grown up for reasons other than the existence of the OAP, such as devaluations of the peso and increased competition from other low wage countries.

The Wharton Economic Forecasting Associates (WEFA) use an entirely different methodology. They employ a large macroeconomic model of the economy to simulate the aggregate effects of a change in policy. Reportedly, they developed a trade import model and, using certain assumptions about the two economies, they are able to predict various macroeconomic variables, including employment\(^89\).

\(^{89}\)Schoepfl and Perez-Lopez in Fatemi, 1990, p. 42.
This model enables WEFA to predict the aggregate direct and indirect effects of the policy parameters. The key then to accurate forecasting, assuming a good model, is developing accurate predictions of policy changes.

Wharton Economic Forecasting Associates are primarily concerned with predictions of rates of employment growth in the near future. In the most recent Maquiladora Industry Analysis of May 1991, WEFA predicts that maquiladora employment will continue to rise, given certain assumptions about the “main drivers of the forecast”. They believe that U.S. GNP growth will slow to .1% in 1991, will recover to 4.2% in 1992, and will stabilize at 3.3%, 2.7%, and 2.9% in 1993, 1994, and 1995. They expect similar trends in U.S. industrial production. Imports are predicted to decline by 2.7% in 1991 and rise by 5.3% in 1992, and continue rising. The Mexican average real exchange rate should appreciate by 8.9% in 1991, as Mexico’s government continues to use the exchange rate to reduce inflation. From 1992, the Mexican government is expected to prevent real effective appreciation of the peso. They expect maquiladora wages to continue to rise as they have since 1986-87.

Given these assumptions, maquiladora employment growth should continue to expand, but not at the 21-22% rate recorded in 1987-88. WEFA expects that maquiladora employment will rise by 7.8% and 7.0% in 1990 and 1991. It should increase by 14.9% and 15.6% in 1992 and 1993, and slow to 10.1% and 8.6% in 1994-95 (table IV.10). In their sectoral predictions, WEFA expects that services, food, transportation equipment, and electric and
electronics will all record the average employment growth rates of about twelve percent. The largest sectors will continue to be electric/electronics at 39% of 1995 total maquiladora employment and transportation equipment at 22% of total maquiladora employment in 1995\textsuperscript{90}.

**Trade Effects**

Gene Grossman provides a more general theoretical framework for partial equilibrium analysis of the effects of the Offshore Assembly Provision, using relative sizes of consumption, outputs, shipping costs, and trade barriers. He examines the impacts of the distortions created by the OAP on the protective effects of tariffs. Thus, his analysis compares the cases before and after the initiation of the Offshore Assembly Provision. His innovation is the application of recent intra-industry trade\textsuperscript{91} models to the OAP and the inclusion of a previously omitted possibility, imports of foreign components. There are four types of consumer goods: domestic production with foreign components (ignored previously), domestic production with domestic components (domestic goods), foreign assembly with foreign components (nonOAP imports), foreign assembly with domestic components (OAP imports). Assumptions include an input coefficient of one for components' composition in final goods\textsuperscript{92}, small country, perfect substitutes, and no tariffs in the foreign country.

\textsuperscript{90} calculated from WEFA table IV.11.
\textsuperscript{91} two-way trade in identical commodities
\textsuperscript{92} That is, one unit of input produces one unit of output, a simplifying assumption.
Grossman considers four possibilities for the structure on which the provision is imposed. These cases are distinguished by the relative size of domestic consumption versus domestic intermediate and domestic final goods' production (which determines whether there are imports and of what type) and the relative size of shipping costs and barriers to intermediate goods' imports. The idea is that arbitrage will equalize final goods' prices, and the domestic producer must make a decision whether to produce domestically with foreign components, produce domestically with domestic components, or move production overseas to take advantage of the Offshore Assembly Provision. Barriers to intermediate goods' imports are said to be small when

\[ S_m < \frac{1}{2} (t_j - t_m) P_m^f \]

where \( S \) is shipping costs, \( t \) are tariff rates, subscripts \( j \) and \( m \) represent final and intermediate, and \( P_m^f \) represents the price of foreign components. Low barriers to component imports (or dutiable imports) are thus defined by shipping costs that are less than half the difference between tariffs on final and intermediate goods times the price of foreign intermediates. By rearranging the inequality, Grossman arrives at the conclusion that shipping plus the tariff-inclusive price paid for imported foreign components is less than the tariff-inclusive price of importing foreign final goods that embody those foreign components:

\[ S_m + \frac{1}{2} (t_m P_m^f) < \frac{1}{2} (t_j P_m^f) \]
This result leads to intra-industry trade as noted below. Of course, for this scenario to be nontrivial it must be possible to have lower tariffs on intermediates than on final goods (cascaded tariffs).

The first case is where domestic final good consumption is less than domestic intermediate goods’ output (the terms “intermediate goods” and “components” are used interchangeably), so domestic consumers use only goods that embody domestic components (with components left to export). Thus, an offshore assembly provision provides no additional benefit to the domestic components industry and only serves to benefit domestic consumers.

The second case is one where domestic consumption of final goods exceeds output of both domestic intermediates and domestic final goods and there are low tariff barriers to the importation of intermediate goods. Thus, there is importation of entirely foreign final goods. Also, the shipping costs are lower than the tariff barriers to dutiable imports, so foreign producers import all of their components to qualify for the OAP and even pay a premium up to the difference between shipping costs of intermediates and tariff costs. This outflow of components leaves domestic assemblers with a dearth of components and, since the costs for foreign intermediates inclusive of shipping and tariffs are lower than the costs of domestic intermediates inclusive of the premium paid by foreign assemblers, domestic assemblers use foreign intermediates. Thus there is two way (intra-industry) trade in identical intermediates. Here the domestic components industry is assisted and domestic assembly loses output by the amount of the additional cost of
importing components but domestic consumers gain nothing (quite the opposite result of those produced by Finger and Mendez).

In the third case, final goods consumption is large and barriers to components' imports are large which allows us to assume that no components are imported. Grossman argues that this case is what Finger implicitly assumes when domestic assemblers use only domestic components in his model. The results Grossman expects from imposition of an OAP in this case are increased protection of the domestic components industry and lower prices to consumers at the expense of domestic assemblers, which are the results achieved by Finger and Mendez.

The fourth and final case offered by Grossman is the intermediate situation where domestic final goods consumption is larger than domestic components' production but not larger than production of both domestic components and domestic final goods \((Y_m < C_j < Y_m + Y_j)\), where \(m\) is intermediate and \(j\) is final) and there are, as in case 2, low barriers to imports of intermediates. Imports of foreign assembled goods which use domestic components (OAP imports) account for all imports necessary to satisfy domestic consumption. To provide intermediates for domestic production there must be some imports of foreign components for domestically assembled goods. Thus, once again we have intra-industry trade. Here, domestic assembly loses protection and the domestic components industry gains protection while prices for domestically produced goods fall, benefitting the consumer.
A possibly unnecessary simplification of Grossman's analysis is the assumption of identical domestic and foreign components, which could be rectified by considering similarity of domestic and foreign components in exactly the same way that relative size of tariff barriers for intermediate and assembled goods is considered. That is, if foreign components are more similar in quality to domestic components than foreign assembled goods are to domestic assembled goods, then one could consider that a low barrier to import of intermediates.

Boltuck, Mendez, Murray, and Rousslang (1990) use a partial equilibrium trade model to examine the effects of removing the OAP on balance of trade. Like Finger and the others, they assume a two-stage production process where components manufacturing is the first stage and assembly of those components is the second stage. For each product, American consumers choose between three types of assembly: OAP, non-OAP imports, and domestically produced goods, assuming that OAP imports, non-OAP imports, and domestic good are imperfect substitutes as in Mendez (1991a). They then examine the effects that removing the OAP would have on U.S. trade, on export earnings of the LDC's, and on the specific industries effected. However, because they do not account for exchange rates and other macroeconomic effects theirs is another partial equilibrium model where, like Mendez and Finger, they cannot simply add up the individual sector trade effects to get an aggregate trade effect.
Boltuck et al. assume infinite elasticity of all supply curves, which is the small economy assumption, and fixed input coefficients. Domestic supply elasticities are difficult to obtain and they are likely to be infinite anyway because the domestic change in output from removing the OAP would be very small, so the infinite elasticity assumption seems reasonable to Boltuck et al.

This model cannot derive aggregate demand, as noted above, but Boltuck et al. can generalize about the sectoral effects of removing the OAP. The changes are small in most sectors, but in apparel, chemicals, and footwear and leather the OAP imports fall by 63, 75 and 34 percent, respectively. The weighted average decline is 4% in OAP imports and 14% in the components exports category. Non-OAP imports increase by an amount that is less than 1%, so domestic producers would have less import competition. Thus, removal of the OAP results in a decline of both OAP imports and components exports, with a significant loss of exports (8% weighted average) for Less Developed Countries. The analysis, as noted earlier, is better suited to intersectoral comparisons, but the trade deficit appears to increase somewhat.

Finger (1977), in his paper on the effects of the Offshore Assembly Provision on The Netherlands and Germany uses a similar scenario. He employs a partial equilibrium model which, as noted in other models, ignores spillovers and income effects. Thus total sales of each sector's output in the U.S. is unchanged, and OAP imports replace nonOAP imports and domestic assembly proportionally to their market shares.
In his previously discussed paper in the *American Economic Review*, Finger (1976) devotes space to trade balance effects. In his modeling he is unable to come to a conclusion as to the a priori effects of removal of the Offshore Assembly Provision on the trade balance, since the result depends on relative elasticities of supply. If the elasticity of supply of components is greater than the elasticity of supply of assembly, the trade balance should worsen.

Finger includes results from a variety of parameters in his sensitivity analysis, but suspects that the parameters indicating that elasticity of domestic supply of assembly is less than the elasticity of the domestic supply of components are probably more accurate. Using these, the removal of the OAP causes a decline of imports of assembled goods that is more than offset by an decrease in exports of components. Likewise, domestic assembly rises, but is offset by a decline in production of domestic components. Thus, showing less caution in making aggregate conclusions than Boltuck et al, Finger concludes that total imports increase and total exports decrease, worsening the trade deficit.

The parameters that Finger (1976) uses, with foreign assembly supply elasticities being forty to domestic assembly supply elasticities of one and domestic components supply elasticity being three to foreign components supply elasticity of one, lead one to expect that removal of the OAP should have a strongly negative effect on the trade balance, from the domestic perspective. In reality, the change is rather slight, with a reduction in net imports amounting to $200 million for 1972. The reason given is that
decreases in assembly imports are significantly offset by decreases in components exports.

**Wages**

Flamm (1984) uses portfolio analysis to examine the influence of wages and country risk on offshore assembly output levels and U.S. content. Flamm's scenario is of risk-averse firms choosing a portfolio of locations in which to invest. He employs data on U.S. semiconductor imports under tariff items 806.30 and 807.00 from five countries: Mexico, Taiwan, Korea, Hong Kong, and Singapore. Using a linear three-stage least squares approximation, Flamm produces estimates for rate of adjustment of investors' portfolio and price expectations as well as an estimate of a structural parameter, "which can be interpreted as the partial equilibrium elasticity of optimal capital invested in location i with respect to the dollar wage in location i" (p. 244, Flamm 1984). He also inserts dummy variables for location and year. He thus analyzes two elements: the volatility of investment and then the impacts of wage, country risk, and price changes on investors' portfolios.

From Flamm's model of the effect of wages and country risk on output levels and U.S content we derive the volatility of investment using the partial adjustment model:

\[ \ln K_{it} - \ln K_{it-1} = \alpha [\ln K^*_it - \ln K_{it-1}] \]

where \( K^*_it \) represents optimal capital investment, \( K_{it-1} \) indicates actual capital investment in the previous period, and \( \alpha \) is the speed
of adjustment of portfolio. The estimate for the rate of portfolio adjustment at .95 was statistically significantly different from zero and insignificantly different from 1, within a 95% confidence interval. This value represents very rapid movement of capital.

Investment is only moderately responsive to wage changes, but Flamm is able to reject the hypothesis of a completely inelastic response of investment to wages. In contrast, investment is rather elastic with a demand elasticity for labor of -1.1, that is, wages can increase without complete loss of investment. Because of the downward sloping labor demand curve, marginal revenue is below the wage charged the OAP industries, so the local government should be able to change wages to the point where marginal revenues equals the marginal social cost of removing that worker from the work force. As a practical example, he points out that Singapore may have been able to increase marginal revenues under a similar regime of shifting its export mix, expelling low wage workers, and raising wages.

Also, the change-in-country-risk dummies had coefficients that were insignificantly different from zero and thus country risk is no reason for the high mobility of capital. Flamm has no evidence to support him but he maintains his belief that capital is very mobile with respect to shifts in country risk.

Using the adaptive expectations model of inflation, Flamm finds that price expectations are slow to change. This means that people perceive changes in prices to be largely transitory, with a
very small permanent portion, and so do not quickly adjust their
inflation expectations. Thus firms' investment decisions are not
highly volatile because of their quickly adjusting expectations for
permanent cost increases from local inflation. Flamm is thus able
to discover the existence of high volatility of foreign investment
but is unable to discern its cause.

Also, Flamm found that in assembly, 1) labor and capital are
complementary, and 2) components can substitute for labor if wages
increase. If wages rise and the second effect dominates,
components will substitute for labor and capital, though not a great
deal (p.246). Thus, the assumptions in Grossman, Mendez, and Finger
that input coefficients are constant may be flawed.

Chen and Tang (1987) employ a data set from 52 multinational
electronics firms in a Taiwanese duty-free zone in 1980, chosen
because it typifies "the product life cycle explanation of offshore
assembly," to examine substitution between unskilled, skilled, and
white collar workers. Most previous relevant papers included both
technical, engineering people and office managers as skilled workers
and assumed substitution, while Chen and Tang differentiate by
including managers as white collar workers. They use the two-stage
Zellner method to estimate production functions which are then used
to estimate short-run Allen elasticities of substitution (AES)
between two inputs. They discover that white collar workers are
complementary to skilled and unskilled labor, contrary to a
reportedly large literature. Skilled and unskilled labor are
substitutes and both groups' own price elasticity is close to -1
(nearly identical to Flamm's estimate for the slope of demand). For offshore production this result is reasonable, because if the wages of unskilled workers increase, substitution causes demand to increase for skilled workers, yet in most LDC's skilled workers are in short supply and wages for both thus rise. The company is more likely to move and the amount of employment in all classes decline, including white collar.

An interesting result of Chen and Tang's work is that for a country to be attractive to offshore production it must have a good supply of white collar workers. If skilled workers are in short supply, it is possible to substitute unskilled workers (which is the initial premise behind the OAP) but white collar workers are complementary, and in Mexico and many countries the white collar workers brought in with the company are generally located only at the highest levels of the organization. Thus a minimal skills infrastructure is required, depending on how many white collar workers the company is willing to import.

This requirement for white collar workers may lead to an increase in inequity and since a country has to be fairly well along the development path to successfully host offshore assembly, this might very well widen the U in Kuznet's U model\textsuperscript{93}. That is, it would

\footnotesize
\textsuperscript{93}Kuznets' idea (AER, March 1955) is that in the initial stages of development inequality increases as the more astute take advantage of new opportunities and that later inequality declines. Meier (1989, p. 20) is careful to note that there "is not yet a refined theory to explain the determinants of inequality in relative income shares." He does note that a study by Ahluwalia in 1976 (see Meier for cite) found that the idea that inequality increases significantly in early stages of development and declines later is supported by cross-country data.
be a source of inequity at the stage of development when income should be equalizing. Of course, there is no determining where in Kuznets' U a country is ready for offshore assembly, so it might merely be a contributing factor to the initial increase in inequity, that is later removed as a middle class develops.

There are a number of distinctions between these various but similar models. An example is Grossman's consideration of a fourth good, one that is produced domestically but uses foreign components. He contends that those analyses ignoring this good represent special cases. Another difference among the models is the assumption of infinite supply elasticities, for which supply and demand graphs such as figures 1-5 may be useful to aid understanding. The assumption of infinite elasticity of import supply requires that the country be a small part of the world economy\textsuperscript{94}, and thus have little effect on it. Infinite elasticities of domestic supply result from the assumption that offshore production has a small effect on total domestic production\textsuperscript{95}. Mendez (1991), for example, assumes that only domestic producers have less than infinite supply elasticities in order to analyze domestic producers' and consumers' surplus, while foreign producers of U.S. imports are "price takers" (have infinite elasticities of supply). The assumption that the three goods are perfect substitutes for each other is used by Finger (1976) but Mendez (1991) assumes that they are imperfect substitutes in order

\textsuperscript{94}This is reportedly a standard assumption. See Mendez et al 1991, p. 555.

\textsuperscript{95}It is very difficult to find good estimates of domestic supply curves, and the elasticities are probably infinite for the small changes from removal of the OAP anyway.
to analyze the feedbacks among producers of the different goods, i.e.
to account for some of the price effects.

Most of the analysis done to date on the Offshore Assembly
Provision has been partial equilibrium. Uniformly, these studies
have noted that the effect of repealing the OAP is small in both
countries and even in the maquiladora sector itself. This uniformity
may be because of the inherent limitations of the method of analysis
or some as yet undiscovered problem. When one notices the lack of
backward linkages, the deficiencies of partial equilibrium analysis
diminish. That is, the maquiladoras do not purchase or sell locally
so price effects on other Mexican sectors would not seem to offer a
significant contribution. Income effects are in a similar situation,
since maquiladoras do not sell locally. Of course, it may very well
be that the results are correct, that the tariff provisions are not the
primary reason for investment in Mexico, but only an additional
incentive. The boom in offshore assembly investment might well
continue without the provisions because of the depreciation of the
peso or infrastructure improvements. Whatever the reason, the
studies have found that repeal of the tariff provisions 9802.00.80
and 9802.00.60 have small effects on aggregate maquiladora
variables and somewhat more significant effects on distribution
between sectors.
III. **INPUT-OUTPUT ANALYSIS OF EFFECTS OF MAQUILADORAS ON MEXICO**

One method of evaluating the effects of the maquiladora industry expansion during the 1980's on the Mexican economy is input-output analysis. This method, developed by Wassily Leontief in the 1930's, serves as a comparative static method of evaluating direct and indirect sectoral effects of a change in exogenous variables. Among the papers to have employed input-output tables is that by Mendez, Murray, and Rousslang (1991), who use this technique to examine the employment effects of the maquiladoras.

**Input-output**

Input-output analysis assumes a Leontief production function, which is of the form\(^{96}\) \(f(x) = \min\{x_1, x_2\}\), where \(x_1\) and \(x_2\) are inputs. Define the input-output coefficients as \(a_{ij} = \frac{z_{ij}}{x_j}\), where \(z_{ij}\) is the flow of good \(i\) to sector \(j\) and \(x_j\) is the output of sector \(j\). The input-output coefficients are thus technical coefficients and the Leontief production function can be redefined\(^{97}\) as \(f(x) = \min\left\{\frac{z_{1j}}{a_{1j}}, \ldots, \frac{z_{nj}}{a_{nj}}\right\}\).

This function specifies that firms always employ inputs in the same relative amounts, that is, once the input coefficients are established they do not change as output changes, though they may change over time.

\(^{96}\)Varian, p.10.
\(^{97}\)Miller, p. 12.
Given that one accepts this production function, input-output analysis is possible. Sectoral outputs depend on flows to other sectors (z's) and final demand:

\[ X_i = z_{i1} + \ldots + z_{in} + Y_i \]

This equation can be rewritten using the above definition of \( a_{ij} \) as:

\[ X_i = a_{i1} X_1 + \ldots + a_{in} X_n + Y_i \]

This equation shows explicitly that the output of sector \( i \) is dependent on the fixed input proportions plus final demand.

However, the \( a \)'s above include imported as well as domestically produced inputs. To examine the use of domestic inputs in the output of a sector the input-output matrix of \( a \)'s, denoted \( A \), must be multiplied by a domestic use matrix \( \mu \) to yield the domestic input-output matrix \( A^d \).

The \( X \)'s can then be grouped and, in matrix form, \((I-A^d)X = Y\). By rearranging this equation, we have

\[ X = (I-A^d)^{-1} Y \]

which answers the question, "given exogenous increases in output \( Y \), what is the effect on domestic sectoral output \( X \)?" \( R=(I-A^d)^{-1} \) is referred to as the Leontief inverse, in which the elements are represented by \( r_{ij} \). It accounts for all indirect flows, whereas \( A \) accounts for direct flows only. Thus, reading down the column \( j \) of the Leontief inverse gives the effects of a one dollar increase in
demand for the output of sector j on the output of each row sector i.

The Model

This analysis can be used to examine the effects of the expansion of maquiladora output on the Mexican economy. Considering the maquiladora expansion as an exogenous increase in exports we employ the equation:

$$X_j = \Sigma_j r_{ij} \Delta E_j + \varepsilon \quad (*')$$

where \( \varepsilon \) is the effects of all other exogenous output expansions and the discrepancy, such as domestic demand expansion, substitution of imports, and changes in input-output technologies over 1980-1988, while \( \Delta E \), called export expansion, is the increase in exports in the nonmaquiladora sectors and output expansion of the maquiladora sector over the same period.

A problem with using input-output analysis to examine the maquiladoras is the lack of input-output coefficients for the maquiladora plants. Two different methods for developing a proxy for maquiladora technologies are attempted. In the first method, I attempted to use both the Mexican (1978) and the U.S. (1977) input-output tables, aggregated to four-by-four matrices. The sectors were aggregated into nonmaquiladora primary (NP), nonmaquiladora manufacturing (NM), high linkage maquiladora (HL), and low linkage

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99This equation is an abbreviation of the growth decomposition equation in chapter 5 of Chenery, Robinson, and Syrquin, 1986.
maquiladora sectors (LL). The distinction between high and low linkage maquiladoras comes from the raw materials use Table V.9 in Wharton Economic Forecasting Associates' (WEFA's) Maquiladora Industry Analysis. High linkage maquiladoras are denoted as those using more than 9% local materials in 1980, which included the food, furniture, footwear and leather goods, and service sectors\textsuperscript{100}. These high linkage sectors are a small part of overall maquiladora production, around 9% of total production in the period 1980-1988. The distinction between maquiladora and nonmaquiladora sectors is determined by the existence of offshore production in the sector\textsuperscript{101}. By no means are all firms in the "maquiladora" or "maquiladora-concentrated" sector maquiladoras, but the coefficients of these sectors could serve as approximations of the maquiladora technologies. Reportedly, many maquiladoras use a similar technology to American production\textsuperscript{102}, though one might expect that the availability of cheap Mexican labor and the limitations inherent to production in Mexico would influence the production technology.

However, at this point we only have the aggregated input-output matrices which include imports in the coefficients. The matrix is thus not useful for analysis of effects of demand changes on the domestic economy. The matrices must be multiplied by a vector of ratios of domestic inputs to total inputs to arrive at $A^{d}$, the domestic input-output matrix\textsuperscript{103}. This matrix allows an analysis

\textsuperscript{100}See appendix 2 for sector by sector description of aggregation.  
\textsuperscript{101}See appendix 2 for description of sectoral aggregation.  
\textsuperscript{102}George in Fatemi, 1990, pp. 224-5.  
\textsuperscript{103}See Appendix 1, part 3.
of the effect of export expansion on each sector's output, which analyzes the backward linkages of maquiladora growth.

The relationship between the high linkage sector national coefficients and the low linkage sector national coefficients within each $A_d$ matrix, illustrates the distinctions between the high and low linkage sectors. Recall that the distinction between high and low linkage sectors is defined from Table V. 9 in WEFA (1991). The high linkage maquiladoras would be expected to have higher coefficients (more influence of an expansion of the high linkage sector on output of the other sector). That is, it is expected that $r_{PN\,LL} < r_{PN\,HL}$ and that $r_{NM\,LL} < r_{NM\,HL}$.

The second method of approximating maquiladora input-output coefficients combines Mexico's national input-output table of 1978 with the information from the WEFA table, and the results can be found below. The last two rows of the aggregated Mexican $A$ matrix (found in Appendix 1), representing the impact of output increases on maquiladora sectors, were replaced by 0's reflecting the assumption that maquiladoras cannot sell in Mexico. So an increase in demand for the output of, say, the primary sector has no effect on the output of maquiladoras. Also, the top right four elements that define the effect of an increase in output for the maquiladoras on the nonmaquiladora primary and manufacturing sectors of the Mexican economy were replaced by weighted averages of the raw materials inputs from the WEFA tables$^{104}$. This method thus

$^{104}$see appendix 1 for methodology
employs a measure of the use of local inputs in maquiladora output
directly as a maquiladora Input-Output coefficient.

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<tr>
<td>LL</td>
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</table>

The Results

Summing the coefficients of the aggregated Mexican and
American direct use matrices, given in appendix 1, we see that the
American input coefficients sum to about 2.13 out of a possible 4,
and the Mexican coefficients sum to 1.58. Since the capital input
coefficients are derived by dividing capital input flows by column
totals (input flows plus value-added)\(^{105}\), the difference between the
sum of the coefficients and 4 is the sum of the values-added. Thus,
American value added\(^{106}\) accounts for less than half of American
output and the Mexican value added accounts for a little less than
two-thirds of output. Since Mexico is less developed than the U.S., it
is reasonable to expect that their output would be more labor
intensive.

\(^{105}\)remember that these flows include imported inputs
\(^{106}\)value added is an approximation of labor input
When examining the domestic matrices, $A^d$, there are two important comparisons. The first is the comparison of the sum of all the values of the coefficients in each national matrix, showing the amount of domestic capital used in production. The sum for the U.S. domestic matrix is .8359 and the sum for the Mexican national $A^d$ matrix is .5937. Thus, as above, these sums indicate that the U.S. economy is more capital intensive than the Mexican economy. The second comparison is between the sums of the last two columns within each matrix, that is, the impact of an increase of output of the two maquiladora sectors on all four sectors. In Mexico's matrix, the high linkage column sums to .0410 while the low linkage column sums to .0052, a difference of a factor of ten. The U.S. matrix shows a similar relationship, with the high linkage column summing to .0528 and the low linkage column summing to .0062. These results are expected if the matrices are reasonable proxies\textsuperscript{107}.

The two matrices can be used to analyze the effects of maquiladora expansion on the nonmaquiladora sectors. The U.S. coefficients for the maquiladora-concentrated sectors are used as replacements for the Mexican coefficients to create a hybrid matrix that assumes that the maquiladoras use American input technology but that the nonmaquiladora sectors continue to use Mexican technology. The second matrix used is Mexico's input-output matrix in its entirety, which assumes the maquiladoras use the same

\textsuperscript{107}The Leontief inverse matrices tell a similar story.
technology as Mexico’s factories in those sectors. As noted earlier, reality is probably somewhere between the two.

In the calculations of the effects of export expansion on output for nonmaquiladora industry using the equation:

$$\Delta X_{NM} = r_{NM\,NP}\Delta E_{NP} + r_{NM\,NM}\Delta E_{NM} + r_{NM\,HL}\Delta E_{HL} + r_{NM\,LL}\Delta E_{LL} + \varepsilon$$

the hybrid matrix yields the result that demand increases from export expansion of all sectors from 1980-1988 have a $2.16 billion effect on nonmaquiladora industry output in Mexico ($\Delta X = $2.16 billion). Of this, the expansion of the maquiladoras has only a $19 million impact on the output of Mexican nonmaquiladora industries, which amounts to .9% of the total effect. The Mexican matrix yields the same result, with $16.3 million of a $2.16 billion increase accounted for by maquiladora expansion, amounting to .76% of the total.

One could anticipate these results by noticing the small size of the maquiladora coefficients relative to the nonmaquiladora coefficients in the $A^d$ matrix. The high linkage sector’s larger coefficient (than the low linkage sector coefficient) is offset by the small size of the output increase in that sector, at $453 million. The large size of the output increase in the low linkage sector, at $4.438 billion is offset by the very small size of the input coefficients from the Mexican economy. However, the intermediate use vector (the $\mu$ vector in Appendix 1) has some inconsistency that results from the lack of information on intermediate use in the nonmaquiladora sectors, so domestic final goods’ use coefficients
had to be substituted in those sectors. This problem would only affect the percentage of the total effect accounted for by the maquiladora sector and not the HL-LL comparisons.

In method 2, recall that the WEFA data is used for the columns of the Mexican input-output matrix that define the maquiladora sectors' use of inputs from the other sectors. This method provides permissible coefficients, albeit with some problems (see appendix 1). The Leontief inverse (R), which demonstrates the total effects of changes in maquiladoras exports on the other sectors, provides the result that the high linkage sectors have nearly ten times the impact of the low linkage sectors. Thus, the small size of the low linkage maquiladoras is compensated for by the large coefficient (as in method 1). As can be seen in appendix 1 both are less than .1, however, so the impact of the maquiladoras on nonmaquiladora output is small in both methods.

When calculating the effects of export expansion according to equation * above, one finds that each of the maquiladora sectors have less effect on nonmaquiladora primary goods than the nonmaquiladora industry, as is expected. However, the maquiladora expansion effect on nonmaquiladora industry output is greater than the effect of increases in demand for Mexican nonmaquiladora primary goods. Approximately 93% of the cause of the nonmaquiladora industry sector's output expansion in 1980-1988 is due to its own sector multiplier, that is, expansion of demand for its own exports has by far the largest impact on nonmaquiladora
manufacturing sector's output\textsuperscript{108}. Only 1.7% and 1.8% of nonmaquiladora industry output growth is due to high linkage and low linkage maquiladora expansion, respectively. Notice that despite being only 9% of the total maquiladora output, the high linkage sector has nearly the same overall impact on the Mexican economy as the low linkage sector.

\textbf{Evaluation}

One cause of the problems with using national input-output coefficients as a substitute for maquiladora coefficients as in method 1 may be that the sectors designated high linkage do not use a great deal more local raw materials than those designated low linkage. Furniture, food, and services all used around 10% local materials while the other maquiladora sectors used in the region of one or two percent local materials. Another possible problem is inaccuracies resulting from the attempt to aggregate the national matrices into sectors resembling those identified as maquiladora-concentrated by Wharton Economic Forecasting Associates, since the two sources do not necessarily define sectors in the same way. Also, the two national matrices do not necessarily define their sectors in the same way. However the U.S. and Mexican matrices were very similar in intersectoral relationships and even moving some of the more questionable sectors in such a way as to bolster the high linkage sector and weaken the low linkage sector failed to have a strong effect on the relationship.

\textsuperscript{108}Industry and manufacturing are used synonymously in this paper.
The second method provided reasonable input-output coefficients and thus believable Leontief inverses. One problem with this method is in combining the input-output coefficients and the raw materials coefficients into one matrix when the two types of coefficients are not necessarily comparable. Another problem is that there is no distinction in WEFA between primary sector raw materials and industry raw materials, so it is assumed that the relationship is the same between the two as in the Mexican input-output table, with primary coefficients accounting for 9.4% of the sum of the two. However, as seen above, the national tables are a poor replacement for the actual impacts of the maquiladoras, so there is no reason to believe that the ratio between primary and industry inputs should be the same for the maquiladoras as for the national economy, but there is no better method available. Also, the national coefficients for maquiladora-concentrated sectors were omitted and should perhaps be included in the nonmaquiladora primary and industry sectors. Despite the problems, this method does employ data on maquiladora raw materials inputs to develop the I-O coefficients, and is thus preferable to method 1.

For comparing the Mexican and the U.S. economies this analysis is beneficial. The aggregation does away with many sectoral measurement differences and allows comparison of the two matrices. One discovers that U.S. production is indeed more capital intensive than Mexican production. Also, the use of national coefficients as a proxy for maquiladora coefficients does not fail the most obvious test of its validity and thus we can use this
approximation to derive the result that maquiladoras have a small impact on the Mexican economy. Of course, there is little information about the technology used by the maquiladoras and its relationship to the national input-output matrices, so we have no way to determine the actual reliability of the use of the national matrices as proxies for the maquiladoras' input technologies. The second method is somewhat better, as it uses coefficients from the maquiladora industry itself, but it is still dependent on Mexico's national input-output matrix.

IV. CONCLUSION

Both the available literature and the input-output analysis demonstrate small impacts of the Offshore Assembly Provision on both the U.S. and Mexican economies. Finger's and Mendez' examination of the welfare effects of repeal of the OAP indicate very small welfare effects on the United States after offsetting changes in components exports and domestic assembly growth. Mendez, Murray, and Rousslang found that the employment effects of repeal of the OAP were also small and mostly intersectoral. The input-output analysis indicates that the maquiladoras have little impact on the output of the nonmaquiladora sectors, further indication of the small backward linkages from the maquiladora plants into the Mexican economy. Overall, the offsetting decreases in OAP imports and components exports indicate small domestic benefits, if any, to repealing the OAP and little harm to overseas assemblers and foreign nonmaquiladora sectors. It has been inferred by Mendez et al that these results indicate that the large increases
in offshore assembly result from some element other than the tariff provision, such as institutional or infrastructure improvements in Mexico or increased competition for the U.S. from low wage countries in Asia.

The maquiladoras are a small and growing part of the Mexican economy, providing one percent of overall employment and 5% of border employment. The future of maquiladoras is bright as the Free Trade Agreement seems bound to increase offshore assembly plants in Mexico as tariff barriers fall (in which case they would cease to be “offshore assembly” and would become “foreign investment”). If there indeed is room for wage increases as Flamm found, the increased demand for labor in the wake of a Free Trade Agreement should not prevent further investment in Mexico.

It is curious that no one has developed a Computable General Equilibrium model for the maquiladoras or offshore assembly. It would remove some of the shortcomings imposed by the lack of input substitution in the partial equilibrium models as well as relieve the dearth of analysis of feedbacks and income effects from the U.S. economy. Also, analysis of the technological structure of the maquiladora plants' inputs would certainly be useful for input-output analysis, as well as an indicator for the future impacts of a free trade agreement. Flamm's question as to the reason for the volatility of investment in foreign assembly has not been answered satisfactorily, nor has there been rigorous analysis of human capital effects due to the maquiladoras.
### APPENDIX 1-INPUT-OUTPUT MATRICES AND CALCULATIONS

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\[R_{U.S.}\]

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\[A_{Mex.}\]

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\[A^d_{Mex.}\]

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\[R=(1-A^d_{Mex})^{-1}\]

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Method 2 I-O

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Method 2 R

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<tr>
<td>LL</td>
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\[ \mu = \frac{.668}{.650} = .1306 = .0103 \]

CALCULATIONS

1) Export expansion

Export expansion for each sector was calculated from data in the World Bank's World Development Report, 1990. Table 16 provided percent of merchandise exports on for primary and manufacturing and Table 14 provided total exports in 1988 and the average annual growth rate of exports from 1980-1988. Using

\[ E_{1980(G)}^8 = E_{1988} \]

where \( G \) is the average annual growth rate of exports, the amount of exports in 1980 (in 1988 dollars) can be calculated. Export expansion for nonmaquiladora primary and manufacturing sectors is derived by multiplying the total exports in each year by the percentage of exports accounted for by sector i (from Table 16) and
expansion for nonmaquiladora primary and manufacturing sectors is derived by multiplying the total exports in each year by the percentage of exports accounted for by sector i (from Table 16) and subtracting the 1980 figure from the 1988 figure. The obvious problem with this calculation is that the World Bank's sectoral measures may differ from WEFA's and the input-output table's sectoral distinctions, but this procedure should provide a reasonable approximation. For the maquiladora sectors, WEFA provides the total output in the two years and, to get the relative shares of the low linkage and high linkage maquiladoras, the total output in each year is multiplied by the share of the two sectors in each year. After adjusting for inflation, the difference between these outputs is the export expansion for the maquiladoras, since the entire production is exported:

$$Y_{\text{maq1988}}(\% \text{ HL1988}) - Y_{\text{maq1980}}(\% \text{ HL1980}) = \Delta E_{\text{HL}}$$

A similar equation is used for the low linkage maquiladoras.

2) Method 2 Coefficients

To arrive at the top right 4 elements in the Method 2 I-O matrix, the weighted average of raw materials use coefficients was calculated first, by multiplying total output of each sector (for high linkage: food, furniture, and services) by the percent of local raw material used in the sector and dividing by the total high/low linkage output. This figure (for the high linkage sector, as an example) is multiplied by $\frac{a_{NI\text{ HL}}}{a_{NI\text{ HL}} + a_{NP\text{ HL}}}$ from Mexico's input.
output matrix, which gives us the element of the Method 2 input-output matrix in the high linkage column and the nonmaquiladora industry row. Thus, this number, .0643, is the amount of nonmaquiladora inputs into high linkage maquiladora output.

3. Method 1 $A^d$ Matrices

To arrive at the $A^d$ matrices, which represent the domestic input-output coefficients, it is necessary to multiply the A matrix by a vector of coefficients $(\mu_i)$ representing the shares of domestic intermediates in total raw material use for each sector. For the maquiladora sectors, the share of domestic raw materials was available in WEFA (1991). Thus for each maquiladora sector, the vector element was determined by taking a weighted average of the percentage of total raw materials use that was purchased locally (in Mexico) in the subsectors (as determined by WEFA).

It was necessary for the nonmaquiladora primary (NP) and nonmaquiladora manufacturing (NM) elements of the vector to calculate the percentage of final demand satisfied by domestic goods in the sector $i$: $\frac{Y_{i\ 1980} - I_{i\ 1980}}{Y_{i\ 1980}}$

The reason that these were not percentages of demand for intermediates satisfied by domestic goods is that there was no information on the source of intermediates as there was for the maquiladora sectors. Final demand was calculated from the formula: $D_i = Y_i - E_i + I_i$
APPENDIX 2-SECTORAL AGGREGATION OF INPUT-OUTPUT MATRICES
The sectors of the two I-O matrices are shown in Figure 3. The high linkage matrices were defined as those using more than 9% Mexican raw materials in 1980 and include: food, furniture, and services.

**U.S. Input-output sectors**
nonmaquiladora primary (NP): 3, 4, 15, 20
nonmaquiladora manufacturing (NM): 13, 21, 24-32, 35-42, 62, 63
high linkage maquiladora (HL)
  - food: 1, 2, 14
  - services: 4, 12, 13, 65-79
  - furniture: 22, 23
  - footwear & leather: 33, 34
low linkage maquiladora (LL)
  - textiles and apparel: 16-19
  - transport: 59-61
  - machinery: 43-52
  - electrics and electronics: 53-58
  - other manufacturing: 64

**Mexico Input-output sectors**
nonmaquiladora primary (NP): 3, 10, 23
nonmaquiladora manufacturing (NM): 24, 25, 29-47, 49, 50
high linkage maquiladora (HL)
  - food: 1, 2, 12-22
  - services: 60-72
  - furniture: 48
  - footwear: 28
low linkage maquiladora (LL)
  - textiles: 24-27
  - transport: 56-58
  - machinery: 51
  - electrics: 52-55
  - other manufacturing: 59

Note that in both cases toys and sporting goods were omitted because there is no comparable input-output sector. Aggregation involves adding the rows and columns according to the scheme listed below and dividing the aggregated matrix by the column totals that includes value-added. Value added is not included in the matrix of coefficients.
### Appendix 3
Mexico Input Output Table for 1978

1. Agriculture  
2. Livestock  
3. Forestry  
4. Hunting and fishing  
5. Coal and by-products  
6. Crude petroleum and natural gas  
7. Iron ore  
8. Non-ferrous metal ores mining  
9. Stone and clay mining and quarrying  
10. Other non-metal minerals  
11. Meat and dairy products  
12. Canned fruits and vegetables  
13. Wheat milling and wheat products  
14. Wet corn milling and corn products  
15. Coffee processing  
16. Sugar and by-products  
17. Oils and vegetable shortening  
18. Animal foods  
19. Other food products  
20. Alcoholic beverages  
21. Beer  
22. Bottled soft-drinks  
23. Tobacco and by-products  
24. Soft fiber yarn and fabrics  
25. Hard fiber yarn and fabrics  
26. Other textile industries  
27. Apparel  
28. Leather and leather products  
29. Sawmills  
30. Other wood industries  
31. Paper and paperboard  
32. Printing and publishing  
33. Petroleum refining  
34. Basic petro-chemical industry  
35. Industrial chemicals  
36. Fertilizers  
37. Synthetic resins, plastics and man-made fibers  
38. Drugs and medicines  
39. Soaps, detergents, perfumes and cosmetics
40 Other chemical industries
41 Oil cloth products
42 Plastic products
43 Glass and glass products
44 Cement
45 Other non-metallic mineral products
46 Iron and steel basic industries
47 Furniture and metal fixtures
48 Structural metal products
49 Other metal products
50 Machinery and equipment, except electrical machinery
51 Electrical machinery and apparatus
52 Electrical appliances and housewares
53 Electronic equipment and apparatus
54 Other electrical equipment and apparatus
55 Motor vehicles
56 Vehicle bodies and parts
57 Other transport equipment
58 Other manufacturing industries
59 Construction and installations
60 Electricity
61 Wholesale and retail trade
62 Restaurants and hotels
63 Transport
64 Communications
65 Financial services
66 Real estate letting
67 Professional services
68 Educational services
69 Medical services
70 Recreational services
71 Other services
72 Net direct imports
73 Total domestic and imported input
74 Gross value added
75 Total gross production value

U.S. Input-Output Table 1977

1 Livestock and livestock products
2 Other agricultural products
3 Forestry and fishery products
4 Agricultural, forestry, and fishery services
5 Iron and ferroalloy ores mining
6 Nonferrous metal ores mining
7 Coal mining
8 Crude petroleum and natural gas
9 Stone and clay mining and quarrying
10 Chemical and fertilizer mineral mining
11 New construction
12 Maintenance and repair construction
13 Ordnance and accessories
14 Food and kindred products
15 Tobacco manufactures
16 Broad and narrow fabrics, yarn and thread mills
17 Miscellaneous textile goods and floor coverings
18 Apparel
19 Miscellaneous fabricated textile products
20 Lumber and wood products, except containers
21 Wood containers
22 Household furniture
23 Other furniture and fixtures
24 Paper and allied products, except containers
25 Paperboard containers and boxes
26 Printing and publishing
27 Chemicals and selected chemical products
28 Plastics and synthetic materials
29 Drugs, cleaning and toilet preparations
30 Paints and allied products
31 Petroleum refining and related industries
32 Rubber and miscellaneous plastics products
33 Leather tanning and finishing
34 Footwear and other leather products
35 Glass and glass products
36 Stone and clay products
37 Primary iron and steel manufacturing
38 Primary nonferrous metals manufacturing
39 Metal containers
40 Heating, plumbing, and structural metal products
41 Screw machine products and stampings
42 Other fabricated metal products
43 Engines and turbines
44 Farm and garden machinery
45 Construction and mining machinery
46 Materials handling machinery and equipment
47 Metalworking machinery and equipment
48 Special industry machinery and equipment
49 General industrial machinery and equipment
50 Miscellaneous machinery, except electrical
51 Office, computing, and accounting machines
52 Service industry machines
53 Electric industrial equipment and apparatus
54 Household appliances
55 Electric lighting and wiring equipment
56 Radio, TV and communication equipment
57 Electronic components and accessories
58 Miscellaneous electrical machinery and supplies
59 Motor vehicles and equipment
60 Aircraft and parts
61 Other transportation equipment
62 Scientific and controlling instruments
63 Optical ophthalmic and photographic equipment
64 Miscellaneous manufacturing
65 Transportation and warehousing
66 Communications except radio and TV
67 Radio and TV broadcasting
68 Electric, gas, water, and sanitary services
69 Wholesale and retail trade
70 Finance and insurance
71 Real estate and rental
72 Hotels; personal and repair services (exc. auto)
73 Business services
74 Eating and drinking places
75 Automobile repair and services
76 Amusements
77 Health, educ. and social serv. and nonprofit org.
78 Federal Government enterprises
79 State and local government enterprises
80 Noncomparable imports
81 Scrap, used, and secondhand goods
Value added
Bibliography


Harris, Nigel, "Export Processing in Mexico," The Journal of Development Studies.
Lorey, David E., United States-Mexico Border Statistics Since 1900, UCLA Latin American Center Publications, Los Angeles, Ca., 1990.


