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The Effects of Peso Devaluation on Manufacturing, Export and Tropical Forests in Mexico: A CGE Analysis

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This study quantifies the effects of recent peso devaluations on the Mexican exports, imports, domestic production, employment, and economic growth. It also examines the effects on the level of tropical deforestation. We examine whether peso devaluations will lead to immigration from various urban non-agricultural sectors into shifting agriculture and thereby increase tropical deforestation. In addressing this question we employ a CGE model.

The results show that the peso devaluation would adversely affect many manufacturing sectors. This in turn forces low skilled workers to the countryside thereby increasing agricultural production at the expense of land now covered by tropical forests. Since many of these migrants have little skill at cultivating such marginal lands, they shift cultivation in a manner which increases runoff and has a negative impact on the size, quality, and value of tropical forests. Indeed, we have shown them to be both environmentally detrimental and economically significant.

I. Introduction

Recent devaluations of the peso by about 50 percent are expected to have dramatic effects on the Mexican economy in terms of exports, imports, domestic production, employment, and long-term economic growth. The effect of this devaluation, as one would expect, are not limited to Mexico alone as its consequences have been felt by Mexico's trading partners throughout North and South America. In March 1995, the Finance Minister of Mexico announced an austerity program that calls for higher interest rates and fiscal restraints which will have the effect of severely curtailing economic growth. One topic which has been largely neglected amid all of the recent policy debate, however, has been the effect of this crisis on environmental quality in Mexico. This is particularly alarming given the importance of this issue in the recent NAFTA accord and the gravity of Mexico's environmental problems. With this in mind, in the present study we attempt to quantify the effects of this recent devaluation on the level of tropical deforestation in Mexico (see, Repetto and Gillis (1988)).[1] The question we address in this study is whether the recent peso devaluation will lead to immigration from various

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1. Mexico has the sixth largest tropical forest in the world, covering 46,250,000 hectares which are being deforested at a rate of 1.3 percent per year (World Resources Institute (1991)). The five larger tropical forests are in Brazil, Indonesia, Zaire, Peru and Columbia. Most of Mexico's tropical forests are in the southern Yucatan state.

urban non-agricultural sectors into shifting agriculture and thereby increase tropical deforestation.

In addressing this question we employ a Computable General Equilibrium (CGE) model. Although such models have previously been employed to analyze a number of economic and environmental issues, this model is unique in that it provides a measure of the monetary output of a tropical forest sector. This, in turn, allows us to directly estimate the change in environmental degradation associated with currency devaluation.

After briefly discussing the literature in Section II, we present the empirical model in Section III. The empirical results of our simulation are given in Section IV, a sensitivity analysis is conducted in Section V, and policy implications are discussed in Section VI. Finally, in Section VII we present our conclusions.

II. Review of Literature

Given the gravity of the current situation affecting tropical forest throughout the world, it is not surprising that recently there has emerged a growing concern on the part of the economist as to the role of played by economic incentives on tropical deforestation. In their study of the Philippines, Cruz and delos Angeles (1988) have looked at the impact of resource management on shifting cultivation and the resulting deforestation. Along the same lines Vincent (1990) and Hyde and Sedjo (1992) have examined the rule of rent seeking by concessionaires harvesting timber throughout Southeast Asia. In the case of Latin America, important economic studies have been done on Brazil by Binswagner (1987) and Browder (1988), and on Mexico by Barbier and Burgess (1994). In all of these studies, however, the chief emphasis has been on the development and forestry policies of the countries rather than on terms of trade issues.

The present study then is (to our knowledge) the first quantitative investigation linking the effects of currency devaluation on deforestation. Hence, in the following, we review those studies which examine the relationship between deforestation and a variety of socio-economic factors (including exchange rate changes). There are many reasons for deforestation in developing countries, they include rapidly increasing population, extreme concentration of landholding that leave millions of people in search of land, and slow growth of job opportunities in both cities and the countryside. In countries where job opportunities for the majority of people have been scarce, poor rural households have moved into forest regions in search of available arable land (for details on these issues see Barbier and Burgess (1994)). In their studies Ascher and Healy (1990), Braga (1992), and Dean (1992), for example, show that poverty, subsistence agriculture, government development projects, and government subsidized ranching and logging are major causes of deforestation. Along these lines both Johnson (1991) and World Bank (1991) find that about 60% of tropical forest loss is due to agricultural settlement while the remaining 40% is roughly split between logging, roads, urbanization and fuel wood use.

Barbier and Burgess (1994) examine the extent to which government policies in the agricultural and livestock sectors have contributed to deforestation in Mexico. They point out that many empirical results have shown that agricultural expansion and pasture formation are two major causes of forest conversion. Evidence presented in their study indicates that this is also the case for Mexico. Palo *et al*. (1978) studies 72 tropical forest countries and find a strong link between tropical deforestation and population density, population growth, and increased food production. Capistrano (1990) and Capistrano and Kitker (1990) examine the influence of international and domestic factors on tropical deforestation. Their empirical findings show that high agricultural export prices induce agricultural expansion and deforestation. Their results also show the role of domestic structural adjustment policies such as exchange rate devaluation and increased debt servicing ratios on deforestation. Burgess's study (1993) of 53 tropical countries supports the hypothesis that population pressure is positively associated with forest clearance. Her empirical findings also show that rising per capita income and improvement in agricultural yields reduce deforestation. Muñoz (1992) conducts a cross-sectional analysis of forest cover and agricultural intensity for 434 rural productive units. The results of the analysis indicate that road and population density have an important influence on the probability of finding forest cover as opposed to agricultural areas and the size of the plot has a positive effect on forest cover but not agricultural area. With so much evidence connecting population pressure to deforestation, the next logical step is to quantify the relationship between various macroeconomic policies to population pressure and thereby measure their effect on deforestation. In order to do this, however, it is necessary to model the economic interaction between the government, various urban manufacturing sectors, and rural land-using sectors. The most comprehensive way to accomplish this is by means of a CGE model.

III. The Model

The CGE model used in this study is similar to those of Shoven and Whalley (1984, 1992). It is used to depict Mexico's economy both before peso devaluation and after the effects of peso devaluation are fully felt. The before-peso devaluation modeling of the Mexican economy uses the year 1994 as the benchmark. The CGE model shows the devaluation effects on various sectors of Mexico's economy. The model includes seventeen production sectors (of which eleven sectors produce tradables), twelve consumer goods, four categories of agents (consumers) ground by income, and the government. By analyzing the effects of devaluation sector by sector and concentrating our analysis on changes in agriculture, livestock and forestry products, we will then be able to present an analytical discussion of this recent devaluation and its impact on Mexico's tropical forests.[2]

The basic idea underlying a CGE model is the concept of *circular flow* where the land, labor, and capital belonging to the final consumers is purchased for use as primary inputs to various industries. The resulting industrial output is then used in the production of consumer goods which are in turn purchased by these same final consumers. This simple description of the economy is given in richer detail by the use of an 'input-output' matrix. This is necessary because more than just land, labor and capital are necessary to produce goods. Agricultural production, for example, requires not only land, labor and capital, but chemical fertilizers and pesticides, fuel, and financial as well. Hence, for agricultural production our model not

2. Externality value of tropical forests is dealt here with in the following manner. First, using a report by Pearce *et al.* (1993), we measured the value of tropical forests according to their value in soil conservation as well as the medical value of their bio-diversity. This estimate is then added to the livestock sector where it trades off with the value of the livestock output. The idea here is that the externality benefits of tropical forests will decline as they are overrun by wildlife grazing.

only shows the inputs of land, labor, and capital, but also the level of inputs coming from the chemical, oil and financial services sectors. The basic notion of an economy's circular flow is maintained but inclusion of an 'input-output' matrix shows how much of any industry's output is used as an input for other related industries.

Industrial production is not purchased directly by the consumers. It is used in various combinations to produce the final goods and services purchased by consumers. For example, food, as a final consumer good, requires inputs from agriculture as well as manufacturing, transportation etc. This information is given by the coefficients of a so-called transformation matrix. All production and consumption sectors are listed in Table 1.

Table 1 Production and Consumption Sectors

Production Sector	Consumption Sector
1. Manufacturing-Heavy	1. Food
2. Manufacturing-Light	2. Cars & Trucks
3. Grains	3. Alcohol and Tobacco
4. Forestry	4. Services
5. Livestock	5. Utilities
6. Fish	6. Housing
7. Agriculture-Other	7. Energy
8. Chemicals	8. Furniture
9. Mining-Coal	9. Gasoline
10. Mining-Other	10. Clothing
12. Services	11. Transportation
13. Natural Gas & Oil	12. Savings
14. Refinery	
15. Food	
16. Wood Products	
17. Electricity	

Being rational, producers are assumed to maximize profits and consumers are assumed to maximize utility. In the model, producers have production functions with constant elasticities of substitution between labor and capital, which may take any value between zero and infinity. The production function of the agriculture and forestry sectors also includes land as the third factor of production, which is entered through a nested CES production function. Land is entered into the ordinary CES production function by having a compound input of *both* and land capital that takes the place of the capital input in an ordinary CES production function.[3] Nesting CES production functions is then done by defining this compound input as one CES production function which is entered into a second production function as a single input along with labor. Our production is defined as $X = f(L, Z)$, where L refers to labor and Z is a compound input which includes both capital and land. The elasticity of substitution between land and capital Z, however, can now differ from that between labor and Z in the X production

3. In an ordinary CES production function the elasticity of substitution is constrained to be equal between all inputs.

function. It is assumed that no technological change occurs between the benchmark year and the year in which the full effect of peso devaluation is felt.

The model's agents (i.e., consumers) are endowed with different amounts of land, labor and capital. Consumer behavior is responsive to prices and there is a different set of preferences for each income level category. Presented with the prices of he final goods, each agent decides how much to buy of each good, and how much to save. There is also a trade-off between labor and leisure. The economic agents in the model, are grouped into four income level categories. Each income level category represents one or more deciles of Mexico's income distribution (See Table 2).

Table 2 Agents Classified by Income

Category	Income Decile
I	1st (lowest 10%)
II	2nd (next to lowest 10%)
III	3rd - 7th (the 'middle' 50%)
IV	8th - 10th (the highest 30%)

By analyzing data from the sources given below, we were able to calculate total expenditures of each category as well as the percentage that each category spends on each of the twelve consumer goods. There are four income categories so that each can have different demand function for the various final goods. The saving function represents the trade-off between present consumption and future consumption (which must be saved for). This trade-off between present and future consumption depends on the interest rate and the elasticity of substitution between consumption and savings. The elasticities of substitution between any two final goods are assumed to be equal and are fixed at one in the model. This allows the nested consumption function (nested to show the trade-offs between labor vs. leisure and consumption vs. savings) to take the form of a Cobb-Douglas utility function which is maximized subject to each agent's budget constraint. Each agent's spending on goods and services, plus savings (if any) must equal that agent's income, received as factor payments for labor and capital.

International trade is shown in the model by the use of a 'foreign' agent, who exports goods to and imports goods from Mexico. The model assumes that trade is balanced - that the value of Mexico's imports equal its exports. Supply (imports) and Demand (exports) elasticities of substitution are included as variables in the model, and are taken from the work of Stern *et al*. (1976). As stated earlier there are eleven internationally traded goods. All goods under production in Table 1 with the exception of electricity, tropical forest environment quality, and financial services are also traded goods. The real exchange rate is determined by the interactions of the foreign agents with the domestic economy. More specifically, if the price of exporting goods goes up relative to the price of nontradable goods then real rate of exchange is set to have increased. In the model the real exchange rate is measured by the variable FE defined as the endowment/demand sector of adjusted elasticity of export demand. This variable changes endogenously in the model (see Equation (14) in the appendix).

The final element of the model is the government, which is the combination of the

Mexican Federal government along with all state and local government. The government obtains its revenues through tariffs, a value-added tax on goods, an income tax, a social security tax on labor, and excise taxes on goods such as alcohol and tobacco. With this revenue the government subsidizes various industries, makes transfer payments, and purchases whatever labor, goods or services it needs.

The ‘general-equilibrium’ nature of the model involves the determination of a vector of prices for all goods and services (for both producer and consumer) such that all markets will clear, i.e., quantity supplied and quantity demanded will be equal. These prices determine the optimal allocation of resources. Once the model calculates this vector for the benchmark year, the model is solved again with exchange rate devaluations of by 35%, 45%, and 55% devaluations, respectively. We then examine the effects of these devaluation on production, consumption and welfare. A mathematical statement of the model is presented in the Appendix.

IV. Calibration and Data

The model is calibrated to a 1994 data set with these data coming from a variety of sources. Benchmark year (1994) data on the following were obtained; income and expenditure for each of the income categories; the amount of imports and exports in each of the traded sectors; use of labor and capital by each of the producing sectors as well as their level of output; coefficient for the transformation matrix between industrial output and consumer goods; investment by sector; government revenues and expenditure. In addition, we need to obtain estimates for the elasticity of substitution between labor and capital in all producing sectors as well as estimates on each sector’s import demand elasticity.

Data on consumer expenditures on final goods by income category are from the *Encuesta Nacional de Ingresos y Gastos de los Hogares*, 1996, published by the Instituto naciona de Estadística, Geografía e informática (INEGI). Data on imports and exports are from International Financial Statistics, various editions published by the IMF, *The Mexican Economy 1995*, published by the Banco de Mexico, and the *Anuarío Estadístico de los Estados Unidos Mexicanos*, 1996, published by INEGI. Data on inputs, outputs and use of labor and capital by production sector comes from data compiled by INEGI and supplied by the Secretaría de Media Ambiante, Resursos Naturales y Pesca (SEMARNAP). This same source along with the *Anuarío Estadística de los Estados Unidos Mexicanos* were used to calculate the transformation matrix as well as to find investment levels by sector. Tax levels and rates were calculated from the input output table as well as from data contained in *El Ingreso y el Gasto Público en México: Edición 1996* by INEGI. This later document along with *The Mexican Economy 1995* and *Encuesta Nacional de Ingresos y Gaslos de los Hogares 1996* was also used to obtain data on government expenditures and transfer payments. Finally, data on interest rates, capital earnings, and depreciation were obtained from *The Mexican Economy 1995 as well as Economic Growth* by Barro and Sala-i-Martin (1995). Substitution elasticity estimates for production came from Hueter (1997) and Skuta (1997)[4] and import demand elasticities were taken from Wylie (1995).[5]

4. In his work Hueter (1997) uses a translog cost function to estimate the elasticities of substitution between the various inputs to Mexican agricultures during the period from 1981 to 1993 (quarterly data). Skuta does essentially

A number of data adjustments are necessary to impose a general equilibrium structure on the economy. Basically this requires us to eliminate all inconsistencies in the social accounting matrix (SAM) and fit all production and utility parameters so that the model replicates the actual 1994 data (see Ballard *et al*. (1985)). Additionally, for a dynamic model, calibration requires that all quantity variables increase at the (steady state) rate of labor growth while all price variables decline at the rate of social preference. We run the model in benchmark using the MCP algorithm first developed by Rutherford (1994).

V. Simulation Results

Simulation Mexico's post-devaluation economy involves reducing the exchange rate from the model of the benchmark year. The year 1994 is used as the benchmark and the model is solved to make sure that the solution gives values identical to those which actually occurred in 1994. The model is then re-run under the assumption of 35%, 45%, and 55% devaluation and the results of each of these simulations are compared to the benchmark case. By so doing, we are able to observe the changes brought by such policies. To check the robustness of our results to parametric changes, a sensitivity analysis is carried out. Here, we assume a devaluation of 45%, but change certain key parameters to see how this affects our simulation results. It is important to note that the simulation results here assume that the full effects of devaluation are felt. This time period can be considered medium-term - one which shows full adjustment to the devaluation of peso, but one which is not long enough for technological advances to have any effect on the economy.

The results of these simulations, showing the impact of devaluation on industrial production, percentage changes in production, and relative prices, by sector, for all scenarios (i.e., 35%, 45%, and 55% devaluation) are listed in Table 3.

Examination of Table 3 shows that as the size of devaluation increases, all those industries that are positively (negatively) affected by devaluation will experience a greater positive (negative) effect. According to these findings, the industry that gains the most from currency devaluation is light manufacturing. This is not surprising in the light of the export driven nature of Mexico's high light manufacturing "Maquiladora industries". As the percentage of devaluation increases, this industry experiences a rapid growth in production. With a 35% devaluation, production in this sector increases by 45.22% (or 28.6 billion new pesos) from the benchmark year. When the pesos declines by 55%, the production of light manufacturing increases by 102.7% (or 64.9 billion new pesos) from the benchmark year. At the other end of the spectrum is the food and financial services sectors, where the losses resulting from the currency devaluation are the most, ranging from -4.62% (or -8.15 billion new pesos) and -4.63% (or -7.51 billion new pesos) for food and financial services, respectively to -10.33% (or -18.21 billion

the same thing for manufacturing. In both cases, the estimated elasticity of substitution between labor and capital turn out to be slightly less than one. Such estimates are in keeping with on earlier analysis by Sterner (1989).

5. Wylie's (1995) used SUR to obtain estimates on various imported items. His estimates varied from -0.2 on autos to almost -1.0 on data processing equipment.

new pesos) and -10.37% (or -16.83 billion new pesos) from the benchmark year.

Our simulation results also show that the output of the heavy manufacturing and mining sectors increase from the benchmark year. These increases range between 16.88 (or 3.5 billion new pesos) for other mining with a 35% devaluation and 57.62% (or 123.3 billion new pesos) for heavy manufacturing with a 55% devaluation. Table 3 also illustrates that the production of chemicals increases by 14.01% (or 9.2 billion new pesos) for a 35% devaluation and by 31.88% (or 21.02 billion new pesos) for a 55% devaluation. The production of wood products increases by 6.3% (or 1.99 billion new pesos) for a 35% devaluation to 14.27% (or 4.51 billion new pesos) for a 55% devaluation. Another industry experiencing a gain is refinery whose production increases between 6.21% and 14.13% (or between 1.5 and 3.4 billion new pesos) as the level of devaluation increases.

We now examine the effects of different devaluation rates on various consuming sectors. These results are shown in Table 4 and the percentage changes in this table are smaller than that in Table 3. Like the response of the production sectors to various devaluation rates, the percentage changes in consumption (either positively or negatively) increase as the rate of currency devaluation increases. Furthermore, all consumption sectors show a decline ranging between 6.1% to 9.3% for the 35% devaluation, 10.2% to 13.8% for the 45% devaluation, and 13.6% to 20.7% for the 55% devaluation. Although most of the production sectors, for the most part, experienced an increase in output as the exchange rate declined, consumption of all sectors fell because the increase in production was directed to exports. In fact, our model's results indicate that, following devaluation, exports increased by 54% to 100% (not shown in the table).

Of equal importance to our purpose here are the factor shares of labor, land, and capital given in Table5.[6] A knowledge of a change in relative capital shares combined with knowledge about the change in factor prices can give us important information on the migration of raw inputs following a shock to the economy. Hence, in Table 5 we give all relevant factor shares for the model's grains, livestock/tropical forest, heavy manufacturing, light manufacturing, and forestry.

As can be seen in Table 5, a devaluation of the Mexican peso leads to a fall in the labor share in grains, livestock, and forestry by about 0.1% to 0.2% depending on the severity of the peso devaluation. Following a devaluation then labor moves to manufacturing jobs in the cities putting upward pressure on the price of labor there. Land rents fall but the supply of labor and capital (whose share in grains, livestock, and forestry fell by 0.1 - 0.2%) tend to make agriculture practices more extensive rather than intensive. By and large, the same events occur in the other agriculture sectors and our numbers on factor shares in manufacturing suggest that indeed this influx of workers would go to factories in the cities. The peso devaluation also leads to a rise in the labor share in heavy manufacturing by 0.05% - 0.15% depending on the size of devaluation.

6. Relative factor share here is understood to be the return of to a particular raw factor of production (i.e., land, labor, or capital) in terms of the total value added in the sector by all factors of production. Hence, one or two relative factor share can rise if their contribution to total value added rises. If would, however, impossible for all factor shares to increase simultaneously.

One must always be careful in interpreting simulation results such as ours in the context of tropical deforestation. Nonetheless, less pressure on infra-marginal agricultural lands is *consistent with* a declining levels of shifting cultivation which has traditionally posed a threat to tropical forests. Nor does it appear that displaced workers will migrate to commercial forest. Mexico’s temperate commercial forest are chiefly located in isolated mountainous areas which are not conclusive to profitable cultivation of others crops. Although we see a moderate decrease in the share of labor in commercial forest activity (from 0.002% to 0.003%), this is offset by the decline in total output in the sector (from 2.17% to 5.03%). Hence, we see a little change in total employment in this sector.

In terms of payment received for factors of production (land, labor and capital), the simulation shows that devaluation makes everyone except the government worse off. The effects of the currency devaluation on total welfare of each income group and government are summarized in Table 6. In all cases, devaluation deteriorates the income of all groups except the government. However, the income group that is most hurt by devaluation is Agent 4 (the richest class). It is worth noting that we measure the income received as payment in exchange for factors of production and does not include any change in an agent’s utility as a result of transfer payments or government-provided public goods which could, of course, be used to offset these effects. As was the case with production and consumption, the negative income effect of devaluation increases with the size of devaluation. However, the largest benefit to the government accrues at the 35% devaluation.

The percentage change in the income of the first three groups ranges between -3.59% and -9.74% for a 35% devaluation; -5.37% and -14.57% for a 45% devaluation; and -8.01% and 21.77% for a 55% devaluation. The income effect of devaluation on the richest class (Agent 4) is -9.74 for a 35% devaluation, -14.57 for a 45% devaluation, and -21.77 for a 55% devaluation. The government experiences an its revenues; 1.26% for a 35% devaluation, 0.57% for a 45% devaluation, and 84%. A main reason for the increase in government revenues is that the petroleum industry is heavily taxed and devaluation leads to a large increase in the production of this industry. Another reason is the so called “inflation tax” meaning that as inflation increases with currency devaluation, so do government revenues.

VI. Sensitivity Analysis

The results discussed thus far are all from one set of simulations. These simulations employ certain values for various elasticities used in the model’s equations to find the market-clearing vector of prices and quantities. These values are the best estimates, but they are still estimates. One concern when using complex CGE models is whether the results obtained depend entirely on these chosen values. By changing these values (i.e., by varying the parameters) we see if the results change significantly from one set of parameters to another. Hence, this sensitivity test measures the robustness of the results to parametric changes.

One of the most important elasticities used in this CGE model is the elasticity of substitution between land, labor and capital in the production of agricultural goods in Mexico. This elasticity shows the ease of trade-offs between inputs given a constant amount of output. For all the results discussed thus far this elasticity, ε has been defined as 0.68. Another important

elasticity, relevant to our study in this CGE model, is the elasticity of transformation between livestock and tropical forests. This elasticity, α for all the results discussed up to this point has been defined as 0.30.[7] And finally, another important elasticity is import price elasticity.[8] This elasticity, m for all results presented above has been assumed to be 0.5.

We check the robustness of our results by varying the values of these elasticities and re-running the simulation for each different set of parameters. In the first round of simulations the elasticities of substitution and transformation are reduced by half (i.e., ε = 0.34 and α = 0.15) and in the second round, these elasticities are increased by 100% to ε = 1.36 and α = 0.60. In both cases we keep the import elasticity at m = 0.5. In the third round, we keep the elasticities of substitution and transformation at their original level (i.e., ε = 0.68 and α = 0.30) and change the import price elasticity to 0.5. In the interest of space, the following analysis concentrates on the 45% rate of currency devaluation. The simulation results of this sensitivity test are shown in Table 7. For the purpose of comparison we have repeated column 8 of Table 3, column 8 of Table 4, and column 6 of Table 6 in column 2 of Table 7. The percentage changes in this table represent changes from the benchmark values, given that the exchange rate declines by 45%. These findings support the initial results reported in the previous section and show that the model's results are quite robust with respect to these parametric changes.

More specifically, the figures in Table 7 show that for all chosen values of ε, α, and m the variations in production, consumption, income, and government revenues are quite small and all signs remain unchanged.

VII. Policy Implications

The numbers generated above have interesting implications for policy makers involved in balancing the concern of a developing country for continued economic growth with environmental concerns and the requirements of international lending agencies such as the IMF and the World Bank. We have seen that following a devaluation of the peso, more of Mexico's resources will be devoted to the production of exportables in the manufacturing sectors and that less will be used on services and agricultural products. Furthermore, such a shift leads to a decrease in overall domestic consumption which becomes increasingly more severe as the devaluation increases. This suggests that compliance with IMF requirements needs to be tempered with the overall well-being of domestic consumers. While, for example, a 35% devaluation creates 3% - 9% welfare declines, a 55% devaluation causes 8% - 22% declines and creates a severe hardship for the population at large. Hence, policymakers should aim to comply with international requirements only to a certain point and strive to pay back international debts in a more gradual fashion.

As noted above, one of the effects of currency devaluation is to slightly decrease the level of Mexican agricultural production. This, in turn, could act to ease the pressure on

7. This elasticities (i.e., $\varepsilon = 0.68$ and $\alpha = 0.30$) were obtained from Sobarzo (1992).
8. Although another important elasticity is the export price elasticity, reliable sources do not exit at this point. Thus we used the unitary elasticity. The import elasticity -0.5 was obtained from Wylie (1995).

marginal lands now supporting tropical forests in southern Mexico. The degree to which it does this, however, depends on the degree to which increased manufacturing activity in the cities makes use of any unemployed workers who may be predisposed to migrate to the countryside and practice shifting cultivation and destroying tropical vegetation.

Industrial policy alone, however, will not completely alleviate the problems of migration and shifting cultivation and must be used in conjunction with well thought-out rural development policies. First of all, effective planning requires that the government promote policies which encourage intensive rather than extensive agricultural practices. These could range anywhere from increased reliance on agricultural extension agents to research and development at agricultural experiment stations. Second, it is important to maintain and enforce a clear system of property rights. This would help to alleviate illegal shifting cultivation without the consent of indigenous peoples.

Although the distribution of income is not the main concern of this paper, it does play an important role in any policy, or set of policies, designed to enhance environmental protection. Furthermore, as in most developing countries, any environmental policy has to be made within the context of its effects on income distribution. From our model's results reported above, we have seen that peso devaluation's lead to a reduction on income among all income groups and especially the rich as the relative prices of land and labor decline. In fact, the income losses encountered in the 45% and 55% devaluation's are probably unacceptable in terms of long term economic and political stability. The losses suffered after a 35% devaluation, by contrast, are quite modest and suggest that the government needs to change currency prices only within some boundaries in spite of the pressure brought to bear by outside sources. Furthermore, policy makers must be careful to make modest changes since any drastic changes in currency prices can be expected to lead to some re-structuring and layoffs of wage-earners in the service sectors, and large labor dislocation might lead to migration to rural areas in the short to intermediate run.

VIII. Conclusion

The devaluation of the peso should have a positive impact on many manufacturing sectors of the Mexican Economy in the medium-run. Most urban manufacturing sectors will experience decreases in production while most land-based rural sectors will experience increases in production. This, in allow low skilled workers to leave the countryside thereby decreasing the pressure on most land-based industries and lowering the incentive to practice shifting cultivation. This should be somewhat helpful in decreasing the present rate of deforestation in Mexico's tropics.

The total impact of devaluation on Mexico's forests then is mixed: while traditional logging increases, deforestation should decrease. Hence, in the year to come there is likely to be a decrease in the standing stock of economically viable species. At the same time, however, we are likely to see decreased soil erosion as well as a rise in the amenity benefits most closely identified with tropical forests. Furthermore, such beneficial impacts are likely to intensify, the longer the present recession in Mexico continues.

In spite of such hopeful signs, policy makers will need to address a number of important issues. These include clearly defining property rights, encouraging the use of intensive agricultural practices, and the possible implementation of land-reform in rural areas. Equally important are extension programs which are targeted to recent migrants with little or no experience in environmentally sound cultivation practices.

Appendix

Mathematical Formulation of the Empirical Model

Definition of Variables of the Mathematical Model

Y_j -Total production in section j (j = 1, 2, ⋯, 17)
CD_j -Consumer demand for product j
GE_j -Government endowment product j
UM_k -Imports of product k (k = 1, 2, ⋯, 15)
$\sum_{i,j} RAS_{j,i}$ -RAS balanced input/output intermediate demands
GD_j -Government demand for product j
INV_j -Investment in sector j
UX_k -Exports of product k
SL_c -Supply of labor by household c (c = 1, 2, 3, 4)
SK_c -Supply of capital by household c
SD_c -Supply of land by household c
DL_j -Demand for labor in the industry
DK_j -Demand for capital in the industry j
DD_j -Demand for land in industry j
GDL_t -Government demand for labor
GDD_t -Government demand for land
TL_j -Tax on labor in industry j
TK_j -Tax on capital in industry j
TD_j -Tax on land in industry j
GCE_j -Consumer demand for consumer product i (i = 1, 2, ⋯, 12)
$Z_{j,i}$ -A 17 by 12 transformation matrix
$RCS_{i,c}$ -RAS balanced matrix of each household's demand for each consumer good i
TC_j -Excise tax on consumer good j
TRN_c -Transfer payment to household c
PIT_c -Personal income tax payment for household c
TAU_c -Marginal income tax rate for household c
SAV_c -Savings in household c
GC_c -Gross consumption of household c
ZTA_t -Consumption plus leisure coefficient
TE_t -Total government endowments

EM_k	-Demand elasticity of export demand
FE_k	-Endowment/demand sector of adjusted elasticity of export demand
GSK_j	-Government endowment of capital in industry j
GDK_j	-Government demand for capital in industry j
GTL_t	-Government wage taxes on its own employees
TXO_j	-Government output tax on industry j
TC_c	-Consumption taxes on household c
CG_c	-Total government consumption by household c
TC_j	-Total capital in sector j
TL_j	-Total labor in sector j

The Mathematical Model

I. *Overall Equilibrium by Sector*

(1) $Y_j + GE_j + UM_t = \sum_j RAS_{j,t} + GD_j + CD_j + UX_j + INV_j$

(2) $\sum_c SL_c = \sum_j DL_j + GDL_t$

(3) $\sum_c SK_c = \sum_j DK_j + GDK_t$

(4) $\sum_c SD_c = \sum_j DD_j + GDD_t$, where

(5) $GDL_t = \sum_j TL_j$

(6) $GDK_t = \sum_j TK_j$

(7) $GDD_t = \sum_j TD_j$

II. *Consumer Goods and Services*

(8) $CD_j = \sum_j Z_{j,t}[GCE_j - TC_j]_t$

(9) $\sum_c RCS_{t,c} = GCE_j$

(10) $\sum_j RCS_{kct} = SL_c + SK_c + SD_c + TRN_c - PIT_c$

(11) $GC_c = \sum_j RCS_{t,c} - SAV_c + (1 - TAU_c)(ZTA_c - 1)SL_c$

(12) $GC_c = SL_c + SK_c + SD_c + TRN_c - PIT_c + (1 - TAU_c)(ZTA_c - 1)SL_c$

(13) $TE_t = \sum_c (SL_c\ ZTA_c\ TAU_c + SK_c\ TAU_c - SD_c\ TAU_c - (\phi_c + TRN_t))$

where $\phi_c = SL_c\ TAU_c + SK_c\ TAU_c + SD_c\ TAU_c - PIT_c$

III. *Foreign Sector Balance*

(14) $\sum_k (UM_k(EM_k/(1+EM_k)) + UM_k/(1+EM_k)) = \sum_k (UX_k + FE_k)$

IV. *Consistency*

(15) $\sum_c (SL_c + SK_c + SD_c + TRN_c + PIT_c - TC_c) = \sum_c CG_c$

(Net household income equals household expenditures.)

(16) $\sum_j (GSK_j + GE_j + TL_j + TK_j + TD_j + TXO_j) + GTL_t$

$= \sum_c TRN_t + \sum_j (GDK_j + GD_j) + GD_c$

(Government income plus endowments equals government outlays.)

(17) $\sum_j (UM_j - UX_j) = 0$

(Net exports equal zero.)

(18) $\sum_j (CD_j + CD_j + UX_j - GE_j - UM_j) = \sum_j (DL_j + DK_j + TL_j + TK_j + TXO_j)$

(The value of demand equals value added plus taxes.)

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