Analysis of Policies Affecting Pesticide Use in Ecuador

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(Abstract)

Nominal Rates of Protection (NPR) were calculated to quantify the degree of pesticide subsidy in Ecuador from 1991 to 1996. Equilibrium exchange rates were computed first to determine the indirect and total NPR's in addition to the direct NPR's. The computed equilibrium exchange rates from 1987 to 1996 indicated a decreasing trend in Sucre overvaluation. The direct NPR's indicated a small tax on pesticides due to a tariff and customs tax, and the indirect NPR's indicated a decreasing trend of subsidization due to the reduction in Sucre overvaluation. In sum, total NPR's indicated that the subsidy on pesticides has decreased substantially.

A demand function for pesticides was estimated to quantify the effect of price distortions on pesticide demand. Due to the limited degrees of freedom, a statistically significant function was not obtained. However, pesticide price, agricultural credit, and overvaluation of the Sucre were statistically significant in influencing pesticide demand.

Policy implications were drawn based on empirical results and background information. Since the agricultural profitability of small farms producing outputs for domestic consumption is most affected by the current economic liberalization, the Ecuadoran government may need to find a means for supporting the profitability of these farms to protect national agricultural productivity. Policies that aid these farmers in the adoption of inexpensive integrated pest management (IPM) technologies would help achieve this end, while reducing the environmental and health problems caused by pesticide use.

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Chapter 1: Introduction

1.1 Problem Statement

The widespread presence and impact of pesticides in the ecosystem made shocking news in the United States in the 1960's. Three decades later, the pesticide problem is far from being solved. For example, until recently, a decline in the number of Swainson's hawk in Canada and in far western states was a mystery for biologists (Line, 1996). A biologist then found that the bird migrated to the pampas of Argentina during the Northern hemisphere winter months. He further found thousands of dead hawks around agricultural fields in that region. Forensic evidence related the deaths to a pesticide called monocrotophos. The effort put forth by the American Bird Conservancy to remove the pesticide from that market shows the level of concern that society places on protecting wildlife from the harmful effects of pesticides.

Another type of pesticide problem, pest resistance, can affect farmers' income. In 1994, cotton farmers in Rio Grande Valley, Texas, chose to adopt a government program that aimed to eradicate all boll weevil using malathion, a pesticide (Verhovek, 1996). However, the year after the first spraying was done, the cotton harvest was poor and growers lost $150 million compared to the previous year. Farmers said other pests damaged the crop, because spraying had killed beneficial organisms such as spiders and wasps. Even though officials stated that a series of climatic factors contributed to the devastation of cotton in the Valley, a study done by the United States Department of Agriculture, combined with the normal harvest just over the Rio Grande in Northern Mexico where there was no weevil eradication program, supported the farmers' claim.

In addition to those problems found in industrialized nations, the general lack of resources further complicates the use of pesticides in developing countries. In Ecuador, for example, the health concern applies not only to wildlife, but to human beings as well. Pesticides that have been banned or are used with restriction in other countries are still purchased at low cost and being used in Ecuador (IDEA, 1990; Lee and Espinosa, 1997). These chemicals have reached the top of the food chain, as a study in Ecuador found that human milk contained Aldrin, DDT, and other hazardous agricultural chemicals. Health concerns are also present on the farms where pesticides are applied. Farmers in Ecuador typically do not possess adequate protective equipment to protect themselves against direct exposure to pesticides when applying them manually (Crissman, Cole, and Carpio, 1994). As a result, many farmers suffer health problems caused by toxic pesticides.

An alternative to the sole use of pesticides to protect crops from pest damage is the Integrated Pest Management (IPM) approach. IPM emphasizes the use of increased information for making pest control decisions and various strategies to manage pests in an economically efficient and ecologically sound manner (Norton and Mullen, 1994). IPM uses pest suppression technologies such as biological control in which beneficial organisms attack pests, cultural control which uses rotations and cultivations, legal control which involves government regulations and their enforcement to prevent the spread of pest organisms, and chemical control in which pesticides and other chemicals are used with discretion. The adoption of IPM reduces the demand of pesticides and their accompanying problems.

When new technologies are developed, concern arises as to whether they are economically feasible to use or not. To answer this question, various studies have quantified the benefits and costs of IPM and, in many cases, have verified economic gains with IPM. In their literature review of economic evaluation of IPM programs, Norton and Mullen conclude that, in the United States, net returns at the farm level are generally higher, and production cost and risk are lower when IPM is adopted. They also verified that pesticide consumption is generally lower, as IPM attempts to decrease damage to the environment and health. Studies related to IPM are not as prevalent in developing countries as developed countries, but IPM is likely to be the most appropriate form of pest management in the tropics, where Ecuador lies (Mengech, Saxena, and Gopalan, 1995).

Although farmers in Latin America rely heavily on the use of pesticides, the Latin American share of the world market is low. It was estimated that, in 1990, Latin America used roughly eight percent of the world's pesticides (Lee and Espinosa, 1997). Ecuador's agriculture has historically relied on the international market for its supply of pesticides. Therefore, looking at import figures gives a general picture of the change in pesticide demand in the country. Throughout the 1980's and early 1990's, pesticide consumption measured by nominal import values fluctuated around an upward trend. Real import values changed little over the period of 1980 to 1994. However, increased pesticide consumption in Latin America in general is expected due to reasons such as population growth and increased food demand, a shift to large scale agriculture with mechanization, crop monocultures, and increased use of purchased off-farm inputs (Lee and Espinosa, 1997). Therefore, the occurrence of pesticide problems could be expected to increase, as well as the importance of the alternative IPM technologies.

One reason that pesticides appear to be overused, as measured by the external costs borne by the public, may be because the government of Ecuador subsidizes them through its policies. Several interpretations of the word subsidy are possible, but in this thesis, a subsidy is an assistance granted by a government for the consumption of pesticides. Therefore, a policy that lowers the price of pesticides is a subsidizing policy for the purposes of this research. It is also important to note that there are different views from which pesticide policies may be analyzed for their subsidizing or taxing effect. This happens because the subsidizing effect of policies on pesticide prices may be examined against different benchmark prices. Furthermore, these policies can influence pesticide demand in a price or non-price manner as defined by Weibel (Lee and Espinosa, 1997). The former includes trade policies such as tariffs and preferential access to foreign exchange; domestic policies such as exemptions or reductions from taxes; input policies such as subsidized agricultural credit; and government programs that support education and research on pest control. The latter includes support to education and research on agricultural chemical consumption, but not on alternative technologies such as IPM. Non-price policies are designed to reduce the risk of pesticides, but subsidize pesticides by neglecting alternative technologies.

Repetto (1985), and Lee and Espinosa (1997) studied the subsidies that pesticides received. Using the rationale that pesticides are inputs for a production process, these authors defined a subsidy by comparing the resulting pesticide consumption value of existing policies against the value that would result if pesticides were treated as any other input. Under that definition of a subsidy, one policy that effectively subsidized pesticide demand was government interference with the exchange rate. The exchange rate was overvalued from 1981 to 1983, from 1989 to 1991, and from 1993 to 1994, the time periods that the studies focused on. This overvaluation was an important factor, since most pesticides in Ecuador have historically been imported. Another trade policy that subsidized pesticides was tariff reductions and discounts compared to other imports. Domestic policies that subsidized pesticides relative to other goods included sales tax exemptions and a system of wholesale and retail price controls in the early 1980's. At the farm level, agricultural credit was available to encourage pesticide consumption, and agricultural associations could import pesticides directly to benefit the larger farm members. Lee and Espinosa found that the effective rate of subsidy decreased from estimated levels of 41-55 percent in the early 1980's to 10-25 percent in the late 1980's and early 1990's as a result of the government's attitude of less intervention and expanding intra-regional trade. These numbers show that, even though the magnitude of subsidy decreased, there is still a substantial amount of subsidy that encourages the consumption of pesticides and hinders the adoption of alternative technologies.

The heavy consumption of pesticides and the damage it causes imply that IPM may need to be encouraged more and pesticide consumption may need to be reduced. The government of Ecuador may, at the least, modify policies that inhibit adoption of IPM alternatives to encourage farmers to use less pesticides and thus adopt IPM. In fact, Ecuador's Ministry of Agriculture recognizes the problems caused by the heavy consumption of pesticides and proposes to solve the problem by "Promoting the efficient and safe use of agricultural chemicals, analyzing the different alternatives, for the integrated management of pests and diseases..." (DGA, p.16). Furthermore, in its strategies to achieve the goal, the ministry proposes to "improve and propose reforms at the actual legal and regulation level on the use and manipulation of agricultural chemicals" (DGA, p.16).

1.2 Objectives

The study has three primary objectives:

1) to document the current government policies that affect pesticide demand in Ecuador,
2) to quantify the degree of subsidy or tax due to those policies,
   and
3) to quantify the effect of those policies on pesticide demand and incentives to adopt IPM.

1.3 Hypotheses

1) Pesticide consumption is subsidized.
2) Pesticide demand is positively affected by the following variables: lower pesticide prices; higher banana and potato prices; higher banana and potato output quantities; larger amount of banana and potato credits; more overvalued exchange rate; and higher time trend variable.

1.4 Procedures and Data Sources

The set of policies affecting pesticide demand in Ecuador will be developed from interviews conducted with people who influence or are affected by pesticide policies in Ecuador. The relationship between pesticide policies and demand will be quantified in a two step process. The first step involves estimating the degree of distortion on pesticide prices that the policies create. In the second step, the demand for pesticides will be estimated to assess the effects of the distortions on pesticide use.

1.5 Organization of Thesis

This thesis is divided into five sections. Chapter 2 describes the current state of the Ecuadoran economy, agricultural sector, pesticide use, and IPM activities. Chapter 3 explains the methods that were used to accomplish the objectives of this thesis. Chapter 4 summarizes the results obtained about the current policies affecting pesticide demand, and the degree of impact of those policies on pesticide demand. Finally, Chapter 5 concludes with a summary of the results and implications for policy formulation.

Chapter 2: Background

2.1 Introduction

This chapter provides background information on the economic factors affecting pesticide demand. The first section depicts the Ecuadoran economic structure, policy, and performance. Next is an overview of the agricultural sector in recent years, followed by an assessment of current pesticide use in the country. Finally, the extent to which IPM education and activities have been implemented as alternatives to the sole use of pesticides is reported.

Ecuador is located along the northwestern shore of South America, with Colombia on its northern and Peru on its southern and southeastern borders (Figure 2.1). The country measures 276,840 square kilometers by area and had a population of 11.2 million in 1994 (EIU, 1996). The country is divided into three major climatic regions: the Coast, the Highlands, and the Amazon. Quito is the capital city located in the Andes with a population of almost 1.3 million in 1990. However, the largest city is Guayaquil on the Gulf of Guayaquil, with about 1.8 million people in 1990. The weather is tropical on the coast and eastern region, but temperate in the mountain zone. Spanish is the dominant language, but Indian languages, particularly Quechua, are also spoken.

2.2 The Ecuadoran Economy

The agricultural, forestry, and fishing sector is the most important contributor to the Gross Domestic Product (GDP) of Ecuador, generating 17.5 % over the period 1985 to 1995 (EIU, 1996). The principal agricultural crops for export are bananas, coffee, with cocoa, and Ecuador being the world's largest exporter of bananas. A growing sector is the oil sector, which began exploitation of the resource in 1972. Much long-term investment is attracted to that sector, and its growing contribution to Gross Domestic Product (GDP) reached 14.6% in 1995. The traditionally protected manufacturing industry has experienced difficult trading conditions,

(Source: http://geography.miningco.com/library/maps/blecuador.htm)

Figure 2.1 Map of Ecuador

due to high interest rates and scarce credit in the recent trade liberalization trend. Its contribution to GDP fell from 18.1% in 1987 to 15.5% in 1990 and since has held around 15.2%. The trade and tourism sector contributes about the same proportion to GDP as the other major sectors, providing 15% of GDP over the period from 1985 to 1995.

In the 1970's, GDP growth was high at 7.5% due in large part to the oil sector. However, the 1980's brought slow growth with periods of decline. Growth picked up in 1990, because of oil exports with high world prices. In 1991, GDP growth was helped by recovery of the agricultural sector's export-oriented activities such as bananas, and the mining sector. Growth slowed in 1992 and 1993, with the agricultural sector being particularly affected. Some reasons for the slow growth were "high interest rates, a tighter fiscal stance, a real appreciation in the Sucre, and slow growth in the world economy" (EIU, p.13). Ecuadoran government's tighter fiscal stance is explained by its concern over inflation problems since the early 1980's, due to "large public-sector deficits, currency devaluations, production problems in the agricultural sector and the gradual reduction of fuel and utilities subsidies" (EIU, p.14). Fiscal austerity and nominal exchange rate anchoring were measures taken to reduce the inflation rate from 54.6% in 1992 to 22.9% in 1995. Despite the poor performance by much of Ecuador's economy over the years of 1992 and 1993, Ecuador's withdrawal from OPEC in 1992 allowed the oil and mining sectors to boom because of its freedom to increase production. Furthermore, economic stabilization and deregulation made Ecuador more attractive for foreign investors, even though trade liberalization meant tougher competition for its domestic industries.

Despite the government's fiscal austerity, growth in the money supply initially increased as financial liberalization and short-term capital inflows induced lending. This created inflationary pressure and a credit boom in 1994 which, coupled with rising consumer demand and high consumer confidence, induced manufacturing growth. By the last quarter of that year, GDP growth had accelerated to 6.3%. However, the overvalued exchange rate had encouraged consumption of imports, including purchases of arms for the conflict with Peru, and the current account balance deteriorated. The conflict with Peru, together with political instability, also reduced short-term capital inflows towards the end of 1994, which caused the Banco Central de Ecuador to raise interest rates further. The conflict also forced the Ecuadoran government to cut its low public spending further, impose emergency war taxes, and make two minor devaluations. "This prevented large-scale capital flight and a major devaluation of the Sucre, but it also caused recession and uncertainty surrounding the sustainability of the system of exchange rate bands" (EIU, p.10). This recession in 1995 created a credit shortage for production and investment that hurt the poor sectors, such as the agricultural sector, due to decreased public spending. The export sector was not able to compensate for these difficulties, with its major products facing poor international conditions or domestic production problems.

In the beginning of 1996, "(t)he difficulties faced by producers and the financial sector (had) continued with high interest rates, illiquidity and investor uncertainty as to the outcome of elections and the future of economic policy" (EIU, p.13). In this environment, the government had to help some banks damaged by the reduced liquidity and high ratio of bad debts. Ecuador's over-dependency on oil, which represented 35% of exports in 1995, was a problem too. Oil accounted for 38.6% of the central government revenue in 1995. Other principal export commodities were agricultural products, which exposed the country to high risk due to fluctuations in prices and quantities demanded in international markets. The country had lost stability and it did not attract sufficient medium- and long- term investment. Ecuador's low domestic savings rate had left the country dependent on short-term investment to finance its current account deficit. On a somewhat positive note, the current account had improved, reflecting the drop in imports due to decreased domestic consumption and a one time purchase of arms for the military conflict.

Because a focus of this thesis is the impact of trade policies on imported pesticides, it is essential to understand the development of trade liberalization in Ecuador. As mentioned above, liberalization of the economy has been a notable trend in the recent years. However, the transition to a more liberalized economy has not been smooth. Liberalization started in the mid 1980's, involving elimination of trade barriers and reduction of state intervention. However, the traditionally protected domestic producers and powerful public-sector unions resisted, and the process stalled (EIU, 1996). Progress was made again in the early 1990's with events such as Ecuador's entry into the Andean Pact Free Trade Area and an announcement of a new foreign investment code. The Andean Pact also entered negotiations with MERCOSUR, which is a larger trade block consisting of Brazil, Argentina, Paraguay, and Uruguay. Furthermore, Ecuador joined the World Trade Organization (WTO) in January 1996, and must remove all of its non-tariff trading barriers, while a maximum of 10 percentage points above the Andean Pact Common External Tariff is allowed (EIU, 1996). These events clearly indicate that trade liberalization will continue for the country.

2.3 The Ecuadoran Agricultural Sector

Agriculture is an important sector in the Ecuadoran economy, with approximately one-third of the territory used for agricultural purposes (EIU, 1996). Production of export crops, such as bananas, is concentrated in the coastal region, while food for domestic consumption, such as potatoes, is produced in the highlands. Agriculture is the country's largest employer, but farmers generally have small acreages of land, and productivity and mechanization rates are low. Among factors that prevent investment and productivity increases in the agricultural sector are "insecurity of tenure, land shortages and overfarmed small-scale holdings" (EIU, p.27). To relieve the situation, the Instituto de Desarrollo Agrario is responsible for issuing land titles, but it has lacked financial and political autonomy and the technical resources necessary to carry out its functions to its full potential. Some farmers are able to adopt mechanization, but those who are able to afford it are usually medium and large farmers who produce export crops such as bananas, African Palm, and sugar cane (Fundacion Natura, 1994). Consequently, small farmers of crops such as cacao, coffee, rice, corn, and potatoes are less technologically advanced.

Another problem in the agricultural sector is the low quality of infrastructure and irrigation systems. This problem presents a barrier to development, especially for poorer highland farmers with limited education and resources (EIU, 1996). Since almost all areas of

Ecuador face a shortage of water during the summer, the problem of irrigation is of national concern. To solve this problem and to promote technical training and environmental awareness, "the government has embarked on a five-year project to decentralize the control and operation of irrigation facilities and hand them over to users" (EIU, p.27).

Much needed credit for farming creates yet another problem. Farmers may obtain credit from the government's Banco Nacional de Fomento (BNF). However, the high interest rates induced by a high inflation rate have made it difficult for farmers to pay back their debts. Consequently, the government has had to periodically write off bad debt or "restructure the BNF's agricultural loan portfolio" (EIU, p.27).

For the development of this impoverished sector, Ecuador depends on foreign aid that increases levels of productivity and mechanization. For example, "(i)n July 1996, 29 such projects with a total value of $172m were under way, with another five worth $49m in the pipeline" (EIU, p.27). Generally less welcomed than foreign aid by farmers in Ecuador is foreign competition which is expected to increase in the coming years. In the past, a system of price bands has protected national agricultural producers. However, this system is being phased out over seven years as a consequence of an agreement made when Ecuador joined the World Trade Organization at the beginning of 1996. As a result, farmers may feel increased competition for their products as foreign products pour into the country.

Farmers have changed their production decisions due to change in demand of crops and expectations of higher returns in the medium term (EIU, 1996). Rice is substituted for potato production to consume domestically, and African Palm is increasingly favored by farmers for export rather than the traditional crops of coffee and cocoa. Fundacion Natura also reports that farmers have converted farmland to pasture for decades as a result of greater profits they receive from milk and beef, and the relative ease to emigrate for temporary work out of the farm. As a result, in 1992, 63% of the agricultural land was covered by pasture, while 21% was devoted to crop production. By lowering their production, farmers are also responding to the disincentive created by politically set low agricultural output prices. Fundacion Natura suggests that the government set these prices low to gain popularity with urban consumers, and to keep salaries down for the urban population. They also report that a study by Vallejo establishes that the struggle against inflation had led the government to formulate that policy.

Other macroeconomic policies that have discouraged agricultural activities are based on the import substitution model adopted in the 1960's (Fundacion Natura, 1994). These policies include overvaluation of the Sucre, direct incentives for investment in industry, and controlled prices. By lowering the relative profitability of the agricultural sector, these policies reduced investment in this sector, concentrated entrepreneurial activities in higher-profit cattle and some crops related to the agricultural industry, and decreased the share of food output by small and medium farmers. However, policies based on the model of import substitution have been corrected recently as agricultural production has stagnated. Liberalization of the economy discussed earlier has been a measure taken to achieve this end. Export crops such as bananas have especially gained from the less overvalued Sucre. Also recently, flowers and green vegetables have become export products for highland agriculture in Ecuador (Fundacion Natura, 1994).

The rise in the prices of agricultural inputs, which are mostly imported, resulting from the less overvalued Sucre is also an important determinant affecting the profitability of agriculture. These input price increases have more severely affected the farmers producing fresh food in the highlands, and some producers of African Palm, sugar, and rice who had their output prices controlled by the government (Fundacion Natura, 1994). The aforementioned antecedent may explain the decrease in productivity of those crops.

In another attempt to promote agriculture, output prices that were set low by the government are now guaranteed a minimum profitability through minimum price control (Fundacion Natura, 1994). However, the benefits of this policy tend to be absorbed by the marketing chain instead of the small and medium farmers to whom the policy was directed.

2.4 Pesticide Use in Ecuador

Despite the high demand for pesticides in Ecuador, the amount used per farmer is low among the Latin American countries. According to a recent Panamerican Organization of Health data of pesticide consumption, Ecuadorans used 2.5 kg/farmer/year, while Costa Ricans were the most intensive users at 18.0 kg/farmer/year and Guatemalans were the least intensive users at 1.7 kg/farmer/year (Woolfson, 1996).

Woolfson writes that, according to a 1996 report by Mercedes Bolaños, the pesticide industry in Ecuador consisted of 146 companies that imported, distributed, formulated, and produced pesticides. Of those companies, 83 were importer-distributors, 51 were importers, 11 were formulators, and only one was a producer (Woolfson, 1996). In January 1996, this pesticide industry had 906 formulations of pesticides, corresponding to 327 generic products, registered through the Ecuadoran Service for Agricultural Sanitation (SESA) (Woolfson, 1996). These formulations were further broken down into 270 herbicides, 240 insecticides, 206 fungicides, 68 nematicides, and other products for non-agricultural use. Of these pesticides (which included some chemicals for home use), 3.6% were extremely dangerous, 8.9% were highly dangerous, 22.5% were moderately dangerous, 23.5% were lightly dangerous, 29.5% probably did not represent any risk, and 11.9% could not be toxicologically identified due to lack of information on their active ingredients (Woolfson, 1996).

Data on actual pesticide quantity used is not available publicly, but a close approximation of that quantity is import data, since pesticides are mostly imported in Ecuador. The source of actual import data is the customs of Ecuador, but obtaining data from that bureaucratic institution was reportedly a very difficult task and was not attempted given time and other constraints. Although the actual import data were not available, similar data were available in the form of import permit data for pesticides. These data were available, because permits are required to import pesticides, and the volume and price of pesticides are recorded when permits are issued.

Not all of the pesticides whose permits are issued are actually imported, but most of them are, according to information gathered from interviews with Ministry of Agriculture officials. These permit data were available from two sources: the Central Bank and SESA in the Ministry of Agriculture.

Table 4.2 shows these data for the years 1980 through 1994. The data show a decreasing trend until the late 1980's and no distinguishable trend after that period for insecticides, fungicides, and pesticides total quantities. The trend for herbicides quantity is less clear, fluctuating from year to year. Generally higher prices of pesticides are also noticeable beginning in 1987. Stressing an aforementioned point, when implications are drawn from these data it must be remembered that they do not represent actual pesticide demand, but rather permits granted for the import of pesticides.

The pesticides imported in Ecuador are used for different crops mentioned in the previous section, and the degree of pesticide use depends on various factors surrounding the production of crops. Cacao and coffee have been attacked by the "Broom of the Witch" and the "Rust", as called by farmers in Ecuador, for decades with little success in controling them (Fundacion Natura, 1994). These crops are mainly cultivated by small farmers who, for reasons explained in the previous section, do not have much capacity to invest in new technologies. Therefore, they depend on traditional technologies to grow their crops, and their demand for newer technologies such as pesticides fluctuates greatly with the world prices of these crops (Fundacion Natura, 1994).

The experience of bananas, grown by corporations, has been very different from that of cacao and coffee. Technology adoption has enabled the growers of this crop to overcome the diseases that this crop has had to face in the past, which in turn, has resulted in increases in productivity and profitability (Fundacion Natura, 1994). Ecuador is the world's largest exporter of bananas, and this crop is the second most important export good for the country. Investment in this crop is naturally high, which enables high level of technology adoption including pesticides. However, Fundacion Natura reports that pesticide residue restrictions imposed by the international market has forced Ecuadoran banana growers to control their pesticide use. In spite of the control on pesticide use, banana production has an adverse consequence to the environment from technology adoption, namely the aerial application of pesticides. This practice is not common in Ecuador, but where used, it contaminates a greater area than manual application.

Other than the aforementioned crops grown in the coastal region, other crops important to the agricultural industry include corn, sugar cane, African Palm, cotton, and various tropical fruits. Partly because these crops were introduced to the area only a few decades ago, their production has been coupled with the incorporation of new technologies, along with the intensive use of pesticides (Fundacion Natura, 1994). However, the degree of pesticide use depends on the crop, which depends on the size of farmers who cultivate them and the area in which they are cultivated.

Rice, plantain, and cassava are some crops produced in the coastal region for internal consumption. Rice particularly has experienced a significant increase in its production area and productivity, increasingly replacing potatoes as a staple food in the country (Fundacion Natura, 1994). The use of pesticides in rice production is significant, partly because of the government's policy to incorporate new technology for this crop. Pesticide damage to farmer's health becomes an important issue, especially when considering that farmers work submerged in water contaminated with pesticides.

In the highlands, new agricultural activity has contributed to the use of pesticides. This activity consists of the cultivation of flowers, fruits, and some green vegetables. Even though the area covered by these products is not extensive, their production significantly contributes to the national demand of pesticides, because the modern methods of production adopted by the growers of these products are based on the intensive use of pesticides (Fundacion Natura, 1994).

Fundacion Natura also reports that, although international standards limit the use of pesticides, the risks to the workers of these outputs are still high.

Among the more important crops for the daily national diet are corn and potatoes, grown in the highlands. These crops are mainly grown by small farmers, but the intensity of pesticide use varies by the crop. Growers of corn have been reluctant to take advantage of pesticides in their production process (Fundacion Natura, 1994). On the other hand, potato growers have adopted new technology such as new varieties of seeds produced by INIAP (Instituto Nacional de Investigacion Agropecuaria; National Agricultural Research Institute), together with the intensive use of pesticides. However, the productivity of this traditional crop seems to be decreasing, probably due to the degraded quality of soil caused by the intense use of pesticides itself (Fundacion Natura, 1994). Fundacion Natura asserts that, of the crops cultivated in the highlands, the use of pesticides for potato production poses the highest risk, due to the number of people involved in the production of potatoes, the generalized consumption of potatoes in Ecuador, and the use of some very dangerous pesticides for this crop.

Other small and medium farmers in the highlands also produce green vegetables and fruits intended for the domestic market. Although these crops only utilize 20% of the farmland in the highlands, pesticide use for these crops share similar characteristics to those of the potatoes. Furthermore, Fundacion Natura suggests that “the great geographical dispersion, the variety of producer type and the absence of organization among (the growers of fruits and vegetables) make it more difficult for the government and private organizations to impact over their conduct” (Fundacion Natura, p.222).

Finally, it must be mentioned that, while the area covered by pasture is greater than the rest of the agricultural land, pesticides are generally not applied to pasture (Fundacion Natura, 1994). Pesticide use in the eastern region of the country, where the Amazon jungle predominates, does not impact the environment greatly either due to the small extent of agricultural development in the region. Also, a final note to this series of descriptions of pesticide use by crop must be added: even though the use was generalized by each crop, a substantial difference in practices exists among producers of each crop. According to Fundacion Natura, these differences are caused by the following factors: the fluctuating output due to the shift in soil and weather conditions, and the change in temporary investment in the crops, reflecting price movements.

In its study, Fundacion Natura also identifies the major pesticides used in Ecuador from 1980 to 1991. Based on background information on these pesticides, they conclude that the pesticides that have experienced a great increase in import quantities are the ones applied to certain export crops, certain crops related to an agroindustrial nature, and potatoes (Fundacion Natura, 1994). Characterizing these crops, Fundacion Natura notes that their growers have expanded their area of cultivation, and they are capable of absorbing the increase in costs associated with rising pesticide prices. Given sufficient data, the conclusion made by Fundacion Natura relating pesticide quantity imported and crop type is verifiable with the econometric analysis conducted in this study. Another characteristic of the group of pesticides imported in great numbers is that the group consists of a small number of pesticides, reflecting a high proportion of imports represented by a few pesticides.

2.5 IPM Activities in Ecuador

Although the sole use of pesticides seems to be the single most popular method of pest control, in the recent years, some farmers have slowly started to adopt IPM practices (Fundacion Natura, 1994). However, the IPM adoption movement has not reached the mass of farmers. According to Fundacion Natura, of the few attempts made to utilize IPM, one of the most significant has been a sugar company's introduction of biological control of some pests that damage sugar cane. Another important effort to introduce IPM is the one conducted by INIAP which primarily seeks to find alternative pest control methods for large growers with a high level of specialization.

Part of the reason that farmers do not adopt IPM, but rather apply pesticides indiscriminately, is that IPM education is scarce. One of the IPM education programs that has existed was part of a program called PROTECA (Programa de Transferencia Tecnologica; Technological Transfer Program). This program emphasized less risky use of pesticides, and was offered to extension agents in various locations in the country (Fundacion Natura, 1994).

Even though programs that aim to educate farmers about IPM are few, there have been attempts to educate people in the general area of rational pesticide use and the environmental impact of pesticides. For example, the Programa Nacional de Sanidad Vegetal (PNSV; National Program of Vegetable Sanitation) in the Ministry of Agriculture has organized seminars directed at inspectors of the Program to inform them of the present situation of pesticide use (Fundacion Natura, 1994). Even the pesticide industry has taken action to diffuse the knowledge of pesticide use. As noted earlier, many of these educational activities may be directed to introduce a more rational use of the pesticides in Ecuador. However, it must be mentioned that some of these activities may only concentrate on the use of pesticides as a means of pest control. By not taking into account other measures of pest control, these activities may prevent the adoption of these alternative technologies.

Although farmers adopting the modern concept of IPM prevent some harmful consequences of pesticide use, there are other farmers who achieve the same end. These make up a significant proportion of the farmers in the highlands, and they are the ones who have not adopted the technology of pesticide application. Even though these farmers have been criticized for having low productivity levels, many scholars of Ecuadoran agriculture have pointed out that their activities are more suited to the local conditions (Fundacion Natura, 1994).

Chapter 3: The Theoretical Model and Methods

3.1 Introduction

This chapter presents the theoretical model and methods used in this study to approach the problem. The following section will first introduce the theoretical model as a framework for analysis. The next section will make a few comments on how information on current policies was obtained. The explanation of methods of calculating the equilibrium exchange rate will then follow. The fifth section then consists of a description of methods used to measure price policy distortions. Finally, the last section discusses the approach taken to estimate the input demand function for pesticides.

3.2 The Theoretical Model

3.2.1 Literature Review

The focus of this thesis is the analysis of policies affecting an agricultural input. Therefore, it is essential to understand the function of agricultural policies in order to evaluate their effectiveness. Monke and Pearson (1989) explain this point well. Policies are adopted to achieve two types of objectives, efficiency and nonefficiency ones. Efficiency objectives include acceleration of income growth, and correction of market failures and externalities. Nonefficiency objectives include income distribution concerns, and price stabilization. These are both important objectives in the development process, and the simultaneous attainment of both of them would be the best outcome. However, one objective is usually attained at the expense of one or more other objectives. It is important then to know which objective a set of policies is trying to achieve and others that are influenced by it, and to weigh the advantages and disadvantages that the policies cause. The analysis facilitates the development process by reducing waste caused by policies that do not contribute to achieving the objectives.

This thesis analyzes an efficiency loss that is apparently neglected or that is considered necessary for the attainment of important objectives. The partial equilibrium setting explained by Houck (1986) is useful in the efficiency loss analysis, because the loss is partly a result of trade policies. Houck summarizes the weakness and strength of the approach in the following manner:

> Partial equilibrium has its shortcomings. It short-circuits broad, economywide consideration of trade policy effects. However, partial equilibrium reasoning is relatively easy to grasp and provides an indispensable first step to understanding the operational vocabulary and major direct effects of various trade intervention schemes (1986, p. 3).

The relatively narrow scope of this research makes the partial equilibrium approach appropriate. Another important point to note about the analysis that will be carried out is that it will be static, which can be described as being "timeless" (Houck, 1986). Furthermore, the static demand and supply functions will be short-run relationships. These relationships will demonstrate how consumption and production quantities respond to price signals after sufficient time is allowed for adjustment, but before significant resource reallocation has taken place among economic agents. The static partial equilibrium analysis thus ignores outside forces, which may be very important, that influence consumption and production decisions to concentrate on the impacts of the policies.

Houck describes the initial setting for trade policy analysis in Chapter 4 of his book. Figure 3.1 summarizes that chapter. Fig. 3.1a by itself would depict the short-run supply and demand conditions of the country of interest for the analysis in autarky. It is assumed that these functions reflect numerous economic agents so that perfect competition can be assumed. If autarky was assumed, another assumption would be that all economic agents are included in the two functions. Then, p_{A1} and q_{A1} would be the isolation equilibrium.

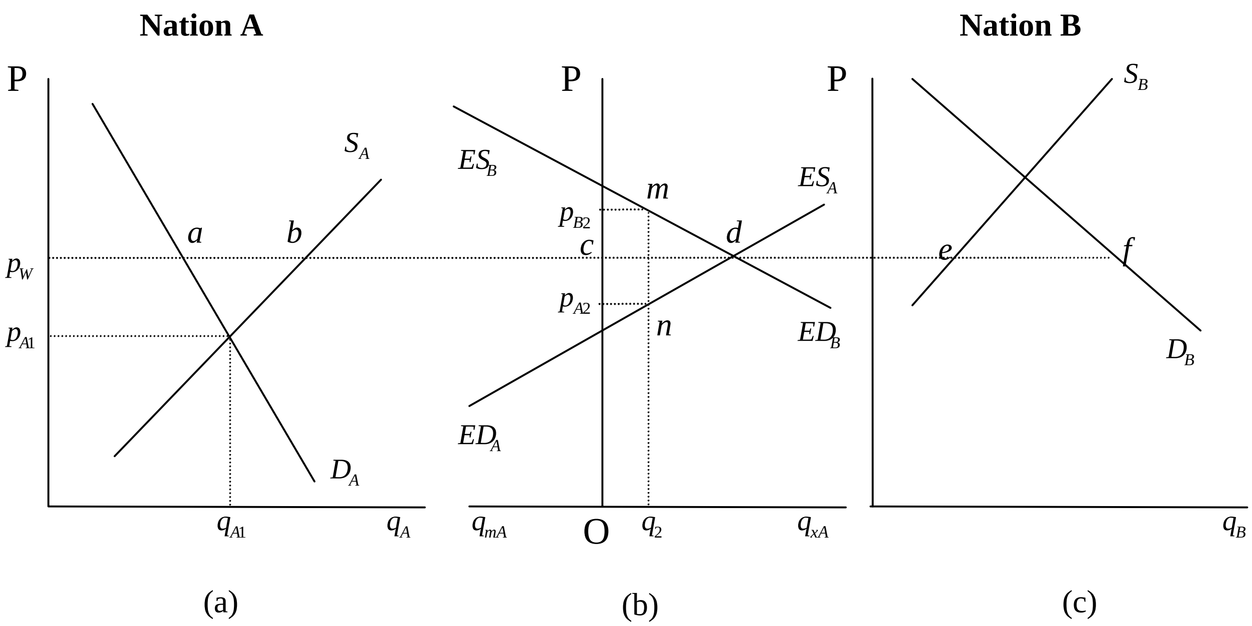

Figure 3.1 Two Nation Trading Regime (source: Houck (1986))

Relaxing the autarky condition would allow Nation A to export its commodity, assuming that the world price is higher than its domestic price. This happens because, at that price, more will be supplied than is demanded domestically. The function ES_A on Fig. 3.1b is the excess supply function of Nation A, which is the horizontal difference between its domestic supply and demand equations. That function is positive as long as the world price is above the isolation equilibrium price and Nation A exports its commodity. When the world price is less than that price, Nation A will import the commodity, so the function becomes the excess demand function, ED_A. Nation A will not import or export the commodity if the international price is equal to the isolation equilibrium price.

Supposing that, in this world, there are only Nations A and B, and Nation B's domestic supply and demand relation is as depicted on Fig. 3.1c, the countries will trade for the commodity because Nation A's isolation equilibrium price is lower than that of Nation B. Nation A will then export while B will import the commodity. The excess demand and supply curves for Nation B are derived in the same manner in Fig. 3.1b. For simplification, an exchange rate of one for one is used. Because of trade, Nation A will suffer from a shortage of supply, raising the price, and Nation B will experience excess supply, driving down price. As prices rise in A, less will be demanded and more will be supplied, moving up ES_A. The opposite will happen in Nation B. This trend continues until prices are equalized in both countries, ignoring transportation and other costs, because there will be no more advantage to trade. Then, p_W is the equilibrium price. At that price, A exports quantity of ab which is equal to cd and ef. Therefore, p_W happens at the intersection of ES_A and ED_B.

Now assume that there are transportation and other transfer costs of value mn. Then, the price in A will be lower than that of B by an amount mn. The trade amount will then be where the difference in the two nations' prices is equal to mn, at q_2 on Fig. 3.1b. It can be observed that the trade volume has decreased and the gains from trade for the producers in A and consumers in B have decreased, because the prices they face have fallen for the former and risen for the latter, relative to the hypothetical transportation cost free scenario.

Even though Nation B was the only trade partner in the above setup, B can be thought of as the rest of the world from A's point of view. Therefore, B's excess demand curve can be modified to be the net sum of excess supply and demand curves of all nations in the world, except A. All the analogy developed for B then can be applied to the rest of the world for A. An important distinction to make when trading with the rest of the world is whether the country of interest, A, is a "small" or "large" country. This depends on the volume of trade of the country relative to that of the rest of the world. If the volume of trade for that county is large, that country's decision to trade will affect the world price. A large export nation will face a negatively sloping excess demand function from the rest of the world, because changes in its exports will affect the world price. On the other hand, a small nation will face a horizontal excess demand function from the rest of the world, because change in its exports does not affect the international prices. The same analogy can be applied to determine the implications when a nation is an importer. Another point that is considered when analyzing trade is the substitutability of domestic and foreign goods. However, in this research, it is assumed that there is no domestic production of pesticides. Therefore, imports of pesticides are the only concern.

The efficiency loss is caused by subsidies of two types, direct and indirect subsidies. A direct subsidy is caused by policies such as import and sales subsidies. On the other hand, exchange rate distortion causes indirect subsidies to the consumer if overvalued. The opposite of the situations depicted above results in a tax. The mechanism explained by Houck (1986) through which policies create the efficiency loss is depicted in the next section, by applying it to the theoretical model constructed for the analysis.

3.2.2 The Adopted Model

Figure 3.2, which illustrates Ecuador's pesticide excess demand, explains the mechanics of the adopted theoretical model. Since Ecuador's production of pesticides is negligible as stated by Repetto and Lee and Espinosa, it is a net importer. That also means that the excess demand curve of Ecuador is identical to its domestic demand curve. Therefore, the analysis is simplified by not having to take into account the effects that policies have on domestic supply, which is assumed to be nonexistent. Furthermore, a small country assumption is applied to Ecuador in the world market, since its pesticide trade is not large. Consequently, it cannot affect the world price of pesticides, and it experiences a horizontal excess supply curve from the rest of the world.

In Figure 3.2, the undistorted excess supply is shown as ES_0, which is the same as the world price, P_W. Q_0 is then Ecuador's demand of pesticides without distorted policies. The price at which that quantity is sold in Ecuador under such ideal conditions is the same as the world price. However, when a subsidy, direct or indirect, is placed on the import or sales of pesticides, the excess supply curve shifts to ES_1. The new equilibrium point of domestic consumption becomes Q_1 at the price P'. As seen in Figure 3.2, consumption of pesticides has increased while its price decreased. To enable that move from the previous equilibrium point, the government had to pay an amount equal to P_WBCP'.

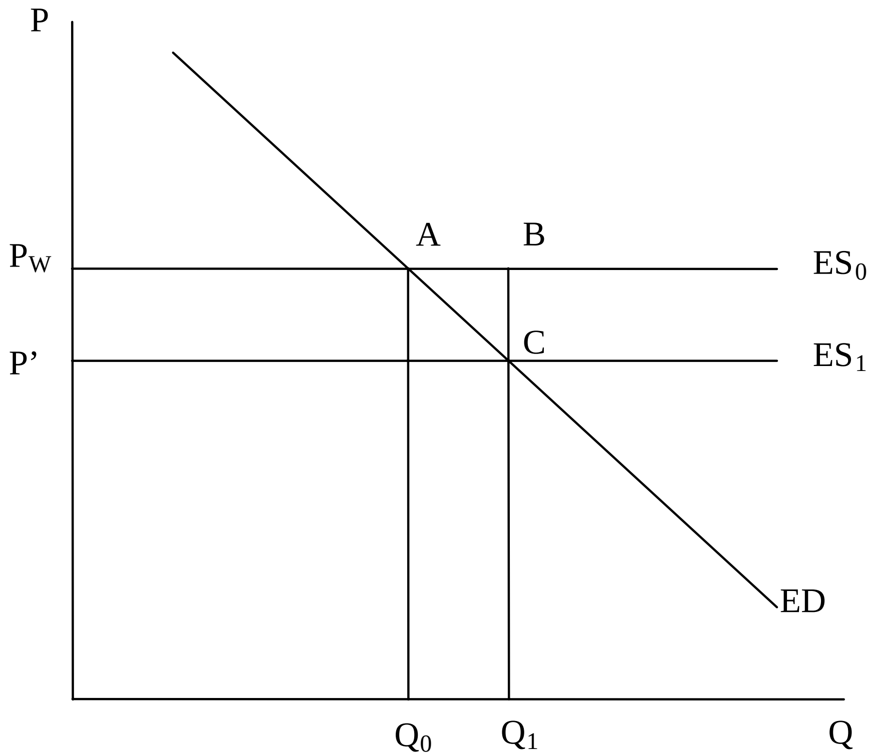

Figure 3.2 Ecuador's Pesticide Trade Model

An initial assumption of the pesticide market in Ecuador is that it is competitive and that no market failure or externality exists. Therefore, it is assumed that the policies that affect pesticide demand are not directed to correct these imperfections. That leads to the conclusion that the policies have created an efficiency loss. The efficiency loss may be interpreted to be the result of the difference between the opportunity cost of the change in quantity due to the policy distortion, and the total willingness to pay for that increase by the consumers (Monke and Pearson, 1989). The opportunity cost per unit of a tradable commodity is its world price, because it is a price determined by the world market which is the next best alternative for the use of a tradable commodity (Tsakok, 1990). That opportunity cost is also called a social cost or price, because it represents the foregone cost for society that could have been used elsewhere. On the other hand, the observed price in the domestic market, or the distorted price, is called the private cost or price, because that is the price that the private economic individual has to consider when maximizing profits. The relevance of the world price as the benchmark for efficiency is not dependent on the competitiveness of the international market, because that is the market that the country would have to trade with.

The total opportunity cost of the intervention is then Q_1Q_0AB in Fig. 3.2. The willingness to pay by the consumers of pesticides is the change in the area under the demand curve, Q_1Q_0AC. The difference between the two areas, ABC, is the efficiency loss which no one captures. The magnitude of the changes will depend on the elasticity of demand for pesticides.

Using this theoretical model, the research tried to identify the effect of policies on the demand for pesticides. To achieve that goal, the analysis was divided into two parts. The first one related the impact of policies directly to the change in prices they cause. The second technique determined the input demand function of pesticides in Ecuador to relate the change in prices to change in quantities demanded. The analysis was divided into two parts, because the estimation of the price that would have prevailed without the policy intervention first allowed the comparison of the social price of pesticide consumption to the private price. That implies finding the inefficiency in the pesticide market due to distorting policies. Prices allow such analysis of efficiency, because they contain information on relative scarcity and incentives to produce, market and consume different commodities (Tsakok, 1990). The second part of the analysis was conducted to estimate the level of impact of price distortion on the demand of pesticides, which is an objective of the thesis.

3.3 Documenting Current Policies

The documentation of current policies affecting the demand for pesticides was aided by interviews with representatives from entities interested in pesticide issues in Ecuador, and by literature gathered there. Representatives from the following entities related to the Ministry of Agriculture were interviewed: PRSA (Programa para la Reorientacion del Sector Agropecuario; Program for the Reorientation of the Agricultural Sector); IDEA (Instituto de Estrategias

Agropecuarias; Agricultural Strategy Institute); Direccion de Gestion Ambiental (Department of Environmental Issues); and SESA (Servicio Ecuatoriano de Sanidad Agropecuaria; Ecuadoran Service for Agricultural Sanitation). Aside from the entities related to the Ministry of Agriculture, AIFA (Asociacion de Importadores y Fabricantes de Agroquimicos; Association of Importers and Manufacturers of Agricultural Chemicals) and Fundacion Natura (an environmental non-governmental organization) provided information through interviews as well.

The first step in the interview process was to inform the representatives about the objectives of this study. Then, the function of the entity was asked, especially as related to the entity's interest in pesticides. The next question was about the knowledge of policies affecting pesticide use the representatives had. A detailed description of the policies was asked, including the applicability to different active ingredients, the effect on pesticide prices, the time period in which they were effective, their objectives, and their consequences on agricultural activity. If a representative did not mention policies that were known to exist, the representative's knowledge of those policies was asked to ensure that the representative provided all the information that he or she could. The information obtained in this way was compiled together with the one originating from literature gathered in Ecuador.

3.4 Calculating the Equilibrium Exchange Rate

3.4.1 Literature Review

It is probable that the Ecuadoran currency, the Sucre, has been overvalued even after the periods studied by Repetto (1985) and Lee and Espinosa (1997). As already discussed, the overvaluation of the Sucre through its manipulation by the Ecuadoran government creates an indirect subsidy for the import and consumption of pesticides. This subsidy is created because the overvalued Sucre enables importers of pesticides in Ecuador to obtain pesticides cheaper, and thus at a greater quantity than they should be able to. The importers can buy pesticides cheaper, because the importers can obtain more foreign currency for the Sucre than when the Ecuadoran government does not intervene in the foreign exchange market. It is therefore important to calculate the exchange rate that would have prevailed had the government not intervened in the foreign exchange market. That exchange rate is called the equilibrium exchange rate.

While the equilibrium exchange rate is defined as above, the nominal exchange rate is defined as “the number of units of foreign currency that can be purchased with one unit of the domestic currency” (Abel and Bernanke, p. 482) and is the exchange rate used in international transactions. A distinction between the two exchange rates is that, in the long run, the former tends to be a concept that may only exist under ideal economic conditions (such as perfect competition, zero transaction costs, no externalities, and so forth), whereas the latter is used for everyday transactions all over the world. Based on the definition of the equilibrium exchange rate, various methods, explained in Dough (1989) and Isard (1995), exist that try to calculate the equilibrium exchange rate using different approaches.

Purchasing Power Parity (PPP)

The first method explored here to calculate the equilibrium exchange rate is based on the purchasing power parity theory. This theory uses the notion that “at some point there is an equilibrium level of exchange rate which equates the price of externally traded goods in one country with the price of those goods in another country” (Dough, p. 3). Then, according to this theory, the exchange rate between two countries changes when the change in inflation rate in the countries differ.

The theory is not free of conceptual problems. One problem is that it assumes that commodities are price elastic, which is not the case with all commodities. Also, the exchange rate may be affected by outside shocks, overwhelming any price effects. It has also been found that the PPP theory does not explain much of the short term variation in exchange rate. However, the PPP theory predicts the exchange rate movement well in the long run, and it is, thus, used widely.

Balance of Payments (BOP) Approach

The notion behind the BOP approach is that foreign exchange is determined by the supply and demand for each currency in the world market. The balance of payments represents the flow of money between currencies, so it is a measure for the supply and demand of currencies. Hence the use of this approach to approximate the equilibrium exchange rate is explained. Specifically, the balance of trade, the current account, and the overall balance of payments, which includes the capital account, have been used to estimate the equilibrium exchange rate.

In spite of the approach's intuitiveness, it has been shown empirically that currencies appreciate even when the current account is in deficit. In the long run, however, such a current account deficit becomes unsustainable, and some adjustment has to be made if the market does not correct by itself.

3.4.2 The Adopted Procedure

The balance of payment approach applied by Krueger, Schiff, and Valdes (1991) will be used for the calculation of the equilibrium exchange rate. To derive the equation, Krueger, Schiff, and Valdes define the equilibrium exchange rate as "the exchange rate that equilibrates the current account (or leads to a current account deficit that is sustainable in the long run) in the absence of tariffs and quotas on imports ... and in the absence of export taxes and other export restrictions ... for a given price of non-tradables" (1991, p.265). The equation is as follows:

$$E^* = \left(\frac{\Delta Q_0 + \Delta Q_1}{\varepsilon_S Q_S + \eta_D Q_D} + 1 \right) E_0 ,$$

where: $E^* =$ equilibrium exchange rate (Sucres/US dollar),

$E_0 =$ nominal exchange rate (Sucres/US dollar),

$\Delta Q_0 =$ nonsustainable part of the current account deficit (US dollars),

$\Delta Q_1 =$ current account deficit that would result from removing trade taxes t_M and t_X at exchange rate E_0 (US dollars),

$$= \frac{t_M}{1+t_M} Q_D \eta_D - \frac{t_X}{1-t_X} Q_S \varepsilon_S$$

$t_X =$ export tax rate,

$t_M =$ import tariff rate,

$Q_S =$ supply of foreign exchange, assumed to be equal to total exports (US dollars),

$Q_D =$ demand for foreign exchange, assumed to be equal to total imports (US dollars),

$\varepsilon_S =$ elasticity of supply of foreign exchange, and

$\eta_D =$ elasticity of demand for foreign exchange.

It will be assumed that all of the current account deficit is unsustainable for Ecuador, implying that the exchange rate equilibrium occurs when the current account balance is zero. The assumption is a reasonable one for Ecuador, since borrowing could not take place indefinitely.

3.5 Measuring Price Distortions

3.5.1 Literature Review

Many studies have quantified the distortions of pesticide prices caused by policies (Repetto, 1985; Tjornhom, 1995; Lee and Espinosa, 1997), and there are a few techniques to evaluate the degree of protection or subsidy. Most of the techniques have used methods in which the distortion is observed by the comparison of world price, or border price, and the prevailing market price, which allows the use of the conceptual framework constructed. However, Repetto and Lee and Espinosa's studies compared the prices of pesticides versus those of other inputs. Because of the interest in using the conceptual framework introduced earlier, the former technique will be used in this study.

Subsidy on Pesticides vs. Other Inputs

The method used by Repetto (1995) and Lee and Espinosa (1997) compared the subsidy on pesticides against that on other inputs. Conceptually, their subsidized prices were the same as the private prices in most other analyses. However, a difference was that the subsidized prices were estimated by adding up costs of importation, transportation, and sale with current subsidies. The unsubsidized prices that they set as the benchmark prices were different from the social costs in other studies. These were calculated as if pesticides had been treated as any other production input. The difference between this type of benchmark and the border price is that the latter tends to be hypothetical, since its use assumes a pure free trade scenario. On the other hand, "(t)his approach ... compares the specific sources of pesticide subsidies (currency overvaluation, favorable tariff treatment, tax exemptions, etc.) against a counterfactual which measures the "standard" social costs of inputs and goods (particularly imported goods) in an economy..." (Lee and Espinosa, p.10).

Policy Analysis Matrix

The policy analysis matrix (PAM) is explained in detail in Monke and Pearson (1989). One of its uses is to assess the impact of policies on an agricultural system. PAM calculates the divergence between social and private profits to assess the efficiency of the system. To calculate these profits, PAM uses three rows and four columns in its basic structure. The columns are revenues, costs of tradable inputs, costs of domestic factors, and profits. Domestic factors are labor, capital, and land. Other nontradable inputs have to be disaggregated into domestic factors and tradable inputs. The row entries include private prices, social prices, and effects of divergences and efficient policies. The entries on the private prices row are the observable data. The revenues and costs of the system are calculated to come up with the private profits. The calculation of the social prices row is more complex. Social prices and costs have to be adjusted from the private ones based on the existence of market failure, externality, and policy diversions. Once these revenues and costs are calculated, social profits may be derived from their difference. The last row of PAM is the difference of each entry between the private and social counterparts.

The difference between the private and social profits is used to assess the divergence from efficiency of the system after the policies have been applied. That approach is similar to the partial equilibrium one and yields similar characterization of policy effects (Monke and Pearson, 1989). If that number is positive, then the policies have subsidized the system. A negative number implies a tax on the system. The nominal and effective coefficients of protection for tradable inputs, explained next, can be calculated using the entries in PAM. The former is the private tradable input costs divided by the social counterpart, and the latter is equivalent to the difference between the private revenues and tradable input costs divided by the social counterpart.

A strength of using PAM for policy analysis is that econometric techniques do not have to be used to estimate the demand and supply curves of the commodity of study. Those techniques often depend on unreliable data, which makes the analysis less realistic. Also, according to Monke and Pearson, the results of PAM are comprehensible to policy makers while the analysis is consistent with theory. Despite these and other advantages, the focus of PAM is on an agricultural system, and construction of PAM requires more effort than necessary to accomplish the task of this thesis.

Nominal Coefficient and Rate of Protection

The series of studies summarized by Krueger, Schiff, and Valdes (1991), and applied to a pesticide case by Tjornhom (1995), use the nominal and effective rates of protection for their analysis. The nominal protection coefficient (NPC) and the nominal protection rate (NPR) are measures of the protection of domestic producers or consumers from imports or exports. NPC is calculated as the ratio between the domestic price and the border price, and NPR is the percent difference between the domestic and border prices. A positive NPR represents a protection on the producer and disprotection on the consumer, while a negative one means disprotection of the producer and protection of the consumer.

A strength of these measures is that they may be applied to measure price distortion at any level in the production-consumption chain (Tsakok, 1990). However, the drawback of that strength is that these indexes only consider output or input prices, so their scope tends to be narrow when compared to the effective coefficient and rate of protection described next.

Effective Coefficient and Rate of Protection

The effective protection coefficient (EPC) and the effective protection rate (EPR) are different from their corresponding nominal measures, because they indicate the degree of protection on production structures. The EPC, for example, calculates the value added in domestic prices over the value added in border prices for a commodity. The value added is defined as the difference between the output value and the tradable input value. Because of that definition, the value added can also be interpreted as the return on non-tradable domestic factors of production such as land, labor and capital (Tsakok, 1990). The EPR is the percent difference between the value added in domestic prices and border prices.

An EPC greater than one means that producers receive greater return with the policy intervention. Any positive EPC implies incentive to producers, but Tsakok explains that the incentive is only potential and not actual. This happens because the difference in price levels does not result in concrete resource reallocation. A negative EPC indicates that there is a flaw in the decision to undergo the production process under existing productivity and cost conditions.

Of all the methods used to calculate the degree of subsidy granted by policies, the NPR will be applied to the analysis in this thesis. The method that Reppeto and Lee and Espinosa used will not be used, because it does not measure the subsidy but only the subsidy relative to other inputs. The EPR will not be used in this thesis either, because that measure can only be applied to analysis of production structures, which is not a focus of this thesis. In other words, EPR may only be measured when there is a domestic pesticide production industry, so that the measure indicates the degree of protection of that industry.

3.5.2 The Adopted Procedure

The NPR will be used to calculate the degree of subsidy for the sale of pesticides. The NPR will be obtained using the following equation:

$$NPR = \frac{P_W - P_B}{P_B},$$

where: P_W = wholesale price of pesticides (Sucres) net of marketing costs, and

P_B = border price of pesticides (Sucres),

= $P_{CIF} \times E$, where P_{CIF} is the CIF border price in dollars, and E is the nominal or equilibrium exchange rate in Sucres per dollar.

When the nominal exchange rate is used in the above equation, the calculated NPR is the direct NPR which reflects the degree of subsidy as a result of policies such as taxes and tariffs. On the other hand, when the equilibrium exchange rate is used in the equation, the NPR calculated is the total NPR which includes the subsidy due to exchange rate distortion. The indirect NPR, which represents the level of subsidy due to exchange rate distortions, is calculated by subtracting the direct NPR from the total NPR.

3.6 Estimating the Pesticide Demand Function

The demand for pesticides was estimated directly using multiple regression. That is, the quantities demanded of pesticides were regressed directly on pesticide prices, crop output quantities or prices, credit awarded to each crop, real exchange rate index, and a time trend variable. Theoretically, the explanatory variables for the estimation of the demand for pesticides should include input and output prices, and other factors that shift pesticide demand. The reason for including the output price variables is that pesticides are inputs into the production of crops, and, as explained in Beattie and Taylor (1985) and Binger and Hoffman (1988), input demand is "a derived demand since it depends upon the price of the product and is thus derived indirectly from the demand for the product" (Beattie and Taylor, p.94). However, it is a derived demand only under the strict assumptions of neoclassical theory, which deviate to some degree from the real world.

The use of pesticide prices as independent variables is due to the likelihood that pesticide prices are important for the decision of how much to consume pesticides. In other words, pesticide demand may be price elastic. Crop output quantities were also used as regressors since it may be hypothesized that the higher the crop output quantity, the higher the pesticide use. That reasoning may be drawn since higher crop output may result in higher profitability for the farmer, who may consume more pesticides if pesticides are normal goods. Agricultural credit given to farmers may affect their decision to purchase pesticides since more credit allows them to obtain more pesticides. The real exchange rate index was used as an independent variable since the index indicates the degree of the overvaluation of the Sucre. Since the overvaluation of the Sucre lowers pesticide border prices, it is possible that an overvalued Sucre leads farmers to purchase more pesticides. Finally, a time trend variable was included to observe if there was any time trend in the use of pesticides due to factors such as changing technology.

Ordinary least squares (OLS) method was used to estimate the input demand function for pesticides. This method is explained in Maddala (1992), including assumptions used when using this method. Ideally, at least 20 years of data is needed for implementation of this time series technique.

Chapter 4: Results and Discussion

4.1 Introduction

This chapter presents the results of the methods applied to this study. Section two presents the findings on the policies currently affecting pesticide demand in Ecuador. The next section is devoted to a discussion on data limitations, since this matter has significantly affected the analysis in this thesis. Following that discussion, the results of calculating the equilibrium exchange rate are reported. Section five contains the results of the price distortion calculations. In the last section, the outcome of pesticide demand estimation is presented.

4.2 Current Policies Affecting Pesticide Demand

To analyze the overall impact of policies on pesticide demand, it is important to identify the individual policies involved. This section provides information on current policies that affect pesticide demand to enrich the discussion on the conclusions drawn from the analyses in this thesis. Additionally, how each price policy fits in the framework for analysis introduced in the methods section is explained here. Only price policies are documented here since, using the model and methods introduced earlier, they can be quantitatively analyzed in the following sections.

A definition of price policies given by Farah (1994) describes these policies to be directly affecting the profitability of using pesticides. The change in the profitability of using pesticides is usually achieved by lowering the relative cost of using pesticides, therefore artificially shifting the pesticide supply curve down. This shift artificially raises the equilibrium pesticide quantity demanded, whose change depends on the elasticity of demand for pesticides.

It is essential to note that a general purpose of lowering the cost of agricultural inputs such as pesticides is to lower output prices for urban consumers (Fundacion Natura, 1994).

Although the principal concern in analyzing these policies in this thesis is effects on efficiency, the original objectives of the policies must also be taken into account in evaluating the policies.

Exchange Rate Policies

Historically, the Ecuadoran Sucre has been overvalued due to government's policies. For example, when Repetto analyzed the subsidy on pesticides from 1981 to 1983, importers of pesticides were allowed to use the official foreign exchange rate, which is lower than the market rate. In that time period, therefore, the Sucre was effectively overvalued. More recently, the Central Bank reports real effective exchange rates from 1993 through 1996 that still suggest general overvaluation. Repetto suggests that the Ecuadoran government keeps an overvalued exchange rate to correct the balance of payment disequilibrium. By doing so, Ecuador can import more than it exports.

The overvaluation of the Sucre for pesticide importers subsidizes the demand for pesticides because, given a certain amount of domestic currency, importers may obtain more foreign currency to purchase their goods. Therefore, importers have more purchasing power to import pesticides than otherwise. Consequently, they may buy more pesticides at a lower domestic price than they would at the undistorted equilibrium. These benefits are, in turn, passed down to pesticide buyers who see lower pesticide prices and respond by buying more than before the distortion took place.

Agricultural Credit Policies

Agricultural credit is important for farming. Credit is the purchase of inputs in excess of what the farmer might buy with his or her own limited financial resources. In Ecuador, agricultural credit has been subsidized for a long time. Artificially cheap credit allows farmers to purchase more pesticides than they would otherwise. Pesticide prices under such conditions are essentially lower because farmers obtain pesticides with subsidized money.

The existence of subsidized agricultural credit is documented by Fundacion Natura, and Lee and Espinosa. For example, Fundacion Natura explains that the traditional source of agricultural credit has been the National Bank of Promotion. In the 1980's, the Bank subsidized agricultural credit by charging an average interest rate 33.10% lower than that charged for similar credit in the national financial sector. However, agricultural credit is not equally distributed to all farmers. According to Fundacion Natura, credit granted to small farmers who produce for the domestic market has been limited. Another important trend to note about the agricultural credit subsidy is that its amount has decreased in the past few years, possibly due to reduced effective levels of subsidy (Fundacion Natura, 1994; Lee and Espinosa, 1998). These points are helpful when drawing conclusions about the quantitative results reported later in this chapter.

Tariff Policies

The tariff rate for pesticides has been lower than the average tariff on other goods in the last decades. Between 1981 and 1983, Repetto (1985) reports that even though the nominal tariff on pesticides was 5%, the effective tariff was 1.75% because of exemptions. A conversation with pesticide industry representatives revealed that in 1996, the nominal tariff was 2.5%, while the average nominal tariff on all imported goods was calculated to be 11.1% (Tamayo, 1997). The pesticide industry is given an incentive to import more when less than the average tariff is charged on pesticides.

Sales Tax Policies

Pesticides have been exempt from sales tax at least since the time of Repetto's analysis. From 1981 to 1983, Repetto found that despite the nominal sales tax of 5%, which translates to a 3% effective sales tax due to exemptions, pesticides were free of this tax. The difference in value that the tax adds between pesticides and other consumer goods has been even greater since December 1989, when the nominal sales tax became 10%, and pesticides were still exempt from this tax (Lee and Espinosa, 1998).

Other Policies

It was found through interviews with government officials and pesticide industry representatives that direct subsidies on the sales of pesticides and subsidies on domestic pesticide industries do not exist. Price and marketing margin controls do not presently exist either, but they did exist in 1991, which is the first year when the present analysis starts. Therefore, some information on this policy is essential. Lee and Espinosa say that the purpose of this policy was to " nominally (limit) pesticide price increases through a ceiling on production and marketing costs and wholesale/retail price margins" (p.8). In practice, the Ministry of Agriculture allowed a "30% mark-up over cif prices plus transport and administrative costs" (Repetto, p.25). The policy was never effective, however, due to lack of enforcement and competitive costs below the upper ceiling set (Repetto, 1985).

Also because of lax enforcement of price and marketing margin controls, small farmers who could not import pesticides directly had to pay higher prices than those paid by larger farmers and farmers' associations who could import directly (Repetto, 1985). In other words, small farmers, who had to buy pesticides from commercial dealers, paid higher retail prices to commercial dealers who effectively had control on the price they charged

4.3 Data Limitations

Before discussing the results of each analysis, the low quantity and poor quality of some of the data make it necessary to discuss data limitations. Types of data that were or could have been used for analysis in this thesis are presented in Table 4.1. The nature of the data limited the depth of analysis in several ways. First, the lack of dissagregated data limited the level of detail of the analysis. The level of dissagregation can be observed in the column labeled "Level" on Table 4.1. For example, some of the data, such as crop production data, exist at the regional level in addition to the national level. If all data existed at the regional level, the analyses in this thesis could have been performed with increased detail. Regional level analyses in this thesis may have given important results due to distinct regional characteristics of crop production.

Another example of the lack of dissagregation is in the pesticide data, which in most cases were not available at the active ingredient level. The lack of dissagregation of the pesticide data makes it impossible to observe the different effects of policies on specific pesticides that differ in toxicity level.

The second problem with the data can be seen under the column labeled “Period” in Table 4.1. Many of the data are only available beginning in 1980 or later. At least 20 years of observations are desirable for the time-series econometric analysis to have adequate degrees of freedom. Table 4.2 shows the data that were used in estimating pesticide demand. The table shows that only 15 years of data were available to carry out the basic regression for the demand for pesticides, and only 13 years of data were available once agricultural credit was introduced into the equation. The shortage of data reduced the statistical validity of the econometric analysis as will be discussed later.

The third problem with the data gathered in Ecuador is in their apparent lack of quality. For example, banana price is shown in 1980 Sucres in Table 4.2 after the original data were corrected for inflation in Ecuador and the United States. One would have expected price not to trend greatly over the period of 15 years, from 1980 to 1994. However, the price of banana increases by a factor of about 3.5. This increase in real price is not reasonable when the nominal world price was relatively stable over the same period of time (FAO, 1990). The dubious magnitudes of some of the data suggest low quality. The following report on the results of the analysis must be read with these data problems in mind.

4.4 The Equilibrium Exchange Rate

Most of the data to calculate the equilibrium exchange rate (EER) were obtained from the Central Bank (1997). The only exception to this statement is the nominal exchange rate data, which originated from the International Monetary Fund (1995). Furthermore, some of the variables needed in the equation for estimation of the EER had to be derived using data from the

Table 4.1 Characteristics of Data Gathered in Ecuador

Source	Data Type	Observations	Level	Period
Agricultural Compendium (from the Ministry of Agriculture)	Crops	Production quantities and areas	National, annual	Mostly 1965-1995
		Production quantities and areas	Regional, monthly	1990-1995
		Prices received by farmers	National, annual	1980-1995
	Pesticides	Some pesticide prices	National, monthly	1987-1995
	Agricultural Credit	# operations, values	By crop, annual	1982-1995
	Climate	Rainfall, max & min temp.	Regional, monthly	1990-1995
SESA*	Pesticide imports	Quantities by customs	By pesticide type, yearly	1980-1992
		Quantities and values by permits requested	By pesticide type, yearly	1992-1995
Central Bank	Pesticide imports	Quantities by permits sold	By pesticide type, yearly	1990-1996
		Values (cif and fob) by permits sold	By pesticide type, yearly	1980-1996
	Imports of principal goods by group	Quantities and values (cif and fob)	Yearly	1985-1996
	Exports of principal goods	Quantities and values (fob)	Yearly	1985-1996
	Current Account Balance		Yearly	1987-1996
	Government revenue	From tariff and export tax	Yearly	1987-1996
	Demand and supply of foreign exchange		Yearly	1987-1996
	Exchange rates		Yearly	1987-1996
	Real Exchange Rate Index		Yearly	1980-1996

*Ecuadoran Service for Agricultural Sanitation

Table 4.2 Data for Pesticide Demand Estimation

			1980	1981	1982	1983	1984	1985	1986	1987
Pesticide Permits	Insecticides	Quantity (kg)	940,312.00	742,907.00	705,051.00	648,661.00	889,445.00	587,645.00	383,347.00	456,240.00
		CIF/AI (1980 Su/kg)	446.60	375.54	510.43	415.48	434.43	456.62	564.22	654.70
	Fungicides	Quantity (kg)	1,276,028.00	834,695.00	1,135,040.00	1,315,967.00	2,069,235.00	972,587.00	843,397.00	876,601.00
		CIF/AI (1980 Su/kg)	124.96	111.70	130.18	118.87	118.20	105.17	158.36	165.37
	Herbicides	Quantity (kg)	1,474,326.00	2,314,228.00	1,581,914.00	806,321.00	3,464,695.00	1,946,948.00	872,753.00	1,058,830.00
		CIF/AI (1980 Su/kg)	174.50	161.31	191.48	190.56	196.93	160.36	238.13	272.29
	Total	Quantity (kg)	3,690,666.00	3,891,830.00	3,422,005.00	2,770,949.00	6,423,375.00	3,507,180.00	2,099,497.00	2,391,671.00
		CIF/AI (1980 Su/kg)	226.70	191.57	236.86	209.17	204.45	194.69	265.63	306.05
Crops	Bananas	Price (1980 Su/kg)	1.08	0.93	1.34	0.82	1.09	0.78	1.01	1.21
		Quantity (m. tons)	2,269,479.00	2,009,850.00	1,998,749.00	1,642,073.00	1,677,571.00	1,969,559.00	2,316,437.00	2,386,503.00
	Potatoes	Price (1980 Su/kg)	4.94	5.49	4.91	8.52	4.25	5.31	5.00	4.32
		Quantity (m. tons)	323,222.00	391,589.00	416,417.00	314,011.00	389,565.00	423,186.00	388,660.00	353,920.00
Agricultural Credit	Bananas	Initial Value (1980 '000 Su)	N/A	N/A	14,467.13	56,481.92	107,548.49	77,612.57	23,147.33	53,992.75
	Potatoes	Initial Value (1980 '000 Su)	N/A	N/A	101,247.05	100,028.57	131,998.99	131,348.19	2,262.99	101,078.00
Real Exchange Rate Index			51.11	46.03	48.97	53.16	61.93	63.05	69.62	89.63

			1988	1989	1990	1991	1992	1993	1994
Pesticide Permits	Insecticides	Quantity (kg)	285,555.00	112,284.00	332,347.00	192,681.00	340,422.00	187,313.00	590,728.00
		CIF/AI (1980 Su/kg)	688.42	1,170.05	672.93	814.10	617.30	571.82	549.12
	Fungicides	Quantity (kg)	394,456.00	510,772.00	1,161,406.00	837,146.00	1,006,094.00	992,925.00	1,216,811.00
		CIF/AI (1980 Su/kg)	216.47	243.26	221.62	323.50	549.04	506.24	375.77
	Herbicides	Quantity (kg)	395,292.00	215,803.00	961,075.00	519,311.00	637,600.00	640,461.00	844,656.00
		CIF/AI (1980 Su/kg)	542.31	403.48	314.31	377.68	328.28	293.04	225.83
	Total	Quantity (kg)	1,075,303.00	838,859.00	2,454,828.00	1,549,138.00	1,984,116.00	1,820,699.00	2,652,195.00
		CIF/AI (1980 Su/kg)	461.58	408.53	319.01	402.68	489.81	437.99	366.63
Crops	Bananas	Price (1980 Su/kg)	0.69	4.40	4.81	6.48	4.66	3.48	3.15
		Quantity (m. tons)	2,576,096.00	2,576,220.00	3,054,566.00	3,525,302.00	3,994,641.49	4,422,010.65	5,085,915.00
	Potatoes	Price (1980 Su/kg)	6.74	4.35	3.65	4.12	2.88	3.46	3.55
		Quantity (m. tons)	338,206.00	362,229.00	368,604.00	372,291.00	497,033.95	428,441.71	531,490.00
Agricultural Credit	Bananas	Initial Value (1980 '000 Su)	45,880.50	39,116.63	64,665.00	122,938.18	231,394.12	45,435.40	10,925.39
	Potatoes	Initial Value (1980 '000 Su)	149,686.57	197,172.48	166,185.00	160,534.61	172,570.59	120,018.03	111,744.70
Real Exchange Rate Index			102.26	98.80	108.13	104.39	104.68	91.05	86.03

previously mentioned sources. The import and export tax rates were such variables. The import tariff rate was calculated by dividing the government revenue from import tariff by the total CIF import value. On the other hand, the export tax rate was calculated by dividing the government revenue from export tax by the total FOB export value minus the export tax, since the FOB export value includes export tax. The original data used to calculate the EER are reported in Appendix A.

Other variables that required manipulation of original data to obtain values for were the elasticities of demand and supply of foreign exchange. Attempts were made first to derive these variables using econometric techniques. However, those attempts did not give reasonable or statistically significant results due to the small number of observations. Consequently, those estimates of elasticities were not used in this thesis and they are not reported here either. Since elasticity estimates could not be based on data, three hypothetical scenarios were constructed in which the elasticity values were varied to calculate the EER. The supply and demand elasticity values for the three scenarios were 1.0, -2.0; 1.5, -2.0; and 1.0, -3.0. These values were chosen because they are believed to represent the limits of typical values that demand and supply elasticities of foreign currency take. The combinations of the elasticity values were chosen so that typical and extreme EER values may be calculated.

The EER was calculated for the years 1987 through 1996. The results are reported on Table 4.3, along with the corresponding nominal exchange rates. It can be seen that for almost all the scenarios and years, the EER values were greater than the nominal exchange rate, suggesting overvaluation of the Sucre. The only case where this generalization does not hold is in 1990 for scenario 2. The EER is even negative in that case, which is not acceptable since exchange rates should be positive numbers. Consequently, it can be concluded that scenario 2 is not likely to be close to reality.

Table 4.3 Equilibrium Exchange Rates

Scenario	Elasticities	1987	1988	1989	1990	1991
1	e=1.0, n=-2.0	286.8	564.7	948.8	1,340.9	1,629.3
2	e=1.5, n=-2.0	365.8	2,677.5	3,733.8	-853.2	3,224.7
3	e=1.0, n=-3.0	239.8	431.9	735.2	1,020.7	1,352.7
Nominal Exchange Rate		170.5	301.6	526.3	767.8	1,046.2

Scenario	Elasticities	1992	1993	1994	1995	1996
1	e=1.0, n=-2.0	1,932.3	2,904.8	2,968.2	3,410.8	3,388.5
2	e=1.5, n=-2.0	4,884.4	5,778.1	3,969.9	4,515.7	7,697.6
3	e=1.0, n=-3.0	1,762.3	2,436.9	2,650.6	3,061.8	3,385.8
Nominal Exchange Rate		1,534.0	1,919.1	2,196.7	2,565.0	3,190.4

4.5 Price Distortions

To calculate the nominal rate of protection (NPR), it is ideal to have data on border and domestic prices of pesticides. FOB prices on disaggregated pesticides were available for one year from the Ministry of Agriculture, which could have been converted to CIF prices. Even though some data exists in the Agricultural Compendium from the Ministry of Agriculture, comprehensive data on domestic prices do not exist anywhere other than in the Association of Importers and Manufacturers of Agricultural Chemicals (AIFA), which was very reluctant to share that information. Without adequate domestic price data, aggregate border prices were manipulated to estimate domestic prices. To achieve this, all subsidies were subtracted from and all taxes were added to the border price of pesticides. The calculation then yielded the estimated domestic wholesale price of pesticides. Only the average for all pesticide border prices was used for analysis since, for a given year, the NPR will be the same for any type of pesticides. The former is true because the ratio of the border price and the estimated wholesale price is the same for all types of pesticides due to the estimation technique used for domestic prices.

Table 4.4 presents the estimated pesticide domestic prices and the intermediate data used to calculate the prices. The CIF average price of pesticides was derived using data from the Ecuadoran Service for Agricultural Sanitation (SESA). The second row on the table shows

Table 4.4 Wholesale Price Estimation

	1991	1992	1993	1994	1995	1996
CIF Price ($/kg)	3.96	1.65	3.55	5.43	5.54	5.91
CIF Price (Su./kg)	4,142.95	2,531.10	6,812.81	11,928.08	14,209.93	18,855.44
Import tariff	82.86	50.62	136.26	238.56	355.25	471.39
Estimated price (Su./kg)	4,225.81	2,581.72	6,949.06	12,166.64	14,565.18	19,326.83

dollar CIF prices converted to prices in Sucres using the nominal exchange rate from the International Monetary Fund's International Financial Statistics. Import tariffs were estimated using figures from Lee and Espinosa (1995) and an interview with a pesticide importing company executive, and were found to be 2% from 1991 to 1994 and 2.5% in the following years. The import tariff is the variable that restricted the observations to six because of lack of earlier data. As discussed earlier, the sales tax does not apply to pesticides, and even though marketing margin control existed in 1991, the measure did not effectively control the price of pesticides. The only tax that is not accounted for in this study due to the lack of specific information is the customs tax that Lee and Espinosa suggest existed. They estimate that tax and other "miscellaneous import fees" such as transportation and insurance to be at 5% of the total of import and tariff price.

Once pesticide domestic prices are estimated, the nominal rate of protection (NPR) can be calculated using the formula presented in the methods section. The results of the calculations are presented in Table 4.5. The scenarios in the first column refer to the scenarios set up for calculation of the equilibrium exchange rate with different elasticities of supply and demand of foreign exchange. The direct NPR's are the same for all three scenarios, since NPR is calculated using the border price obtained with the nominal exchange rate and not the equilibrium exchange rate which differs according to the scenario. Quite obviously, the nominal rate of protection is equal to the tariff rate and positive, since tariff is the only tax assumed to exist in this analysis.

Table 4.5 Nominal Rates of Protection

Scenario	NPR	1991	1992	1993	1994	1995	1996
1,2,3	**Direct**	0.020	0.020	0.020	0.020	0.025	0.025
1	**Indirect**	-0.365	-0.210	-0.346	-0.265	-0.254	-0.060
	Total	-0.345	-0.190	-0.326	-0.245	-0.229	-0.035
2	**Indirect**	-0.689	-0.700	-0.681	-0.456	-0.443	-0.600
	Total	-0.669	-0.680	-0.661	-0.436	-0.418	-0.575
3	**Indirect**	-0.231	-0.132	-0.217	-0.175	-0.166	-0.059
	Total	-0.211	-0.112	-0.197	-0.155	-0.141	-0.034

The total NPR's calculated by using the equilibrium exchange rate for each scenario are negative in all scenarios, indicating a total subsidy on the consumption of pesticides. In each year, total NPR's for scenario 2 are greater in magnitude than the corresponding ones in scenarios 1 and 3, which are relatively close. As established earlier, scenario 2 is not likely to be the prevalent case, so the real total NPR values for each year may be closer to the ones calculated in scenarios 1 and 3.

The indirect NPR's showing the price distortion due to exchange rate policies are all negative also. This result is intuitive since the calculated EER's are greater than the nominal exchange rates, implying overvaluation of the currency. Therefore, it is expected that the indirect NPR would be negative, showing a subsidy to the consumption of pesticides. Assuming that the real indirect NPR's lie somewhere near the values calculated for scenarios 1 and 3, it can be seen that the indirect NPR is higher in magnitude than the direct NPR, making the total NPR negative in all cases. However, the magnitude of indirect NPR is smaller in 1996 than in the previous years, making the total NPR still negative but of a smaller magnitude. Furthermore, there seems to be a slight downward trend in the magnitudes of indirect and total NPR's over the years. Consequently, the general conclusion from this analysis is that, although its magnitude is trending downward, the subsidization of pesticide consumption has been achieved through the overvalued exchange rates from 1991 to 1996, which surpassed the magnitudes of direct tax to the activity.

The aforementioned conclusion may generally be accepted, but it must be remembered that the customs tax, which is estimated to be less than five percent of the sum of the import price and tariff, is not included in this study. If incorporated in this study, that magnitude of tax could appreciably affect the direct NPR's in all years, but it would not affect greatly the indirect and total NPR's from 1991 to 1995 because their magnitudes are much greater than the direct NPR's. However, in 1996, the indirect NPR was only about 6% while the total NPR was only about 3.5% subsidy in scenarios 1 and 3. Given this small magnitude of the indirect NPR, the incorporation of the customs tax could even change the sign of the total NPR, suggesting a total tax on pesticide consumption.

4.6 Pesticide Demand Estimation

The data used for the estimation of pesticide demand, presented in Table 4.2, came from four sources. Pesticide permit data, which represent the use of pesticides in Ecuador, came from the Ecuadoran Service for Agricultural Sanitation (SESA). Data on crops and agricultural credit originated from various issues of the Agricultural Compendium published by the Ministry of Agriculture (MAG) of Ecuador. The real exchange rate index was found in the Central Bank's June 1997 issue of the Monthly Statistic Information. Finally, the Ecuadoran nominal exchange rates and the consumer price index were taken from the International Monetary Fund's International Financial Statistics.

It must be noted that in this national pesticide demand estimation, it was assumed that the imported pesticides data represented the country's demand for pesticides for agricultural crop production in the year that they were imported. This is a relatively reasonable assumption since Ecuador obtains almost all of its pesticides from abroad. It was also assumed that all agents in any stage of the pesticide marketing chain sell or use the pesticides as soon as they can in order to minimize the loss due to lost opportunity cost of the pesticides. Realistically, this assumption of immediate use has some drawbacks such as not taking into account the time it takes for the product to get from the importers to the farmers, and the fact that not all pesticides imported are actually consumed. Therefore, the use of actual pesticide consumption data, or at least data closely resembling consumption data such as pesticide sales data, would have given a closer representation of actual pesticide demand. The Association of Importers and Manufacturers of Agricultural Chemicals (AIFA) has national pesticide sales data for recent years, but it was not possible to obtain them due to their proprietary nature. Therefore, the closest approximation to national consumption of pesticides was the import data for pesticides.

There are three sources of pesticide import data, namely, the Ecuadoran Service for Agricultural Sanitation (SESA) in the Ministry of Agriculture, the Central Bank, and customs. These three sources have different administrative functions in the process of importing pesticides. Therefore, the data that each of these institutions collect are different. The customs data would be the best data, but it was found that obtaining any type of information from that institution was impossible. Due to the close link to the actual import data, the Central Bank data was the next best data, but some observations in the quantity imported were missing from their data. Therefore, the analysis relied on the SESA data, which was the most complete data obtained, even though this data only contains the permits issued for the imports of pesticides.

The SESA data included the imports of pesticides dissagregated to the level of each commercial product, which makes hundreds of pesticide products. Such a high number of variables is not appropriate for the analysis, so no attempt to analyze that dissagregated data was made. Consequently, the analysis was carried out using the aggregated data set from SESA, which groups pesticides by insecticides (including nematicides), fungicides, and herbicides.

From the pesticide permit data from SESA, the yearly quantity of pesticide active ingredients was used directly in the pesticide demand estimation, and the CIF data were used to obtain the average price of each pesticide type. Specifically, the price of each pesticide type was determined by dividing the CIF (cost, insurance, and freight) value by the quantity of each pesticide type. The CIF value was given in nominal dollars, so the price of pesticides had to be deflated to real terms; in this case, to 1980 Sucres. The first step in the price conversion process was to use the nominal exchange rate to change the pesticide prices in dollars to nominal Sucres. Then, the Ecuadoran consumer price index was used to convert the time series pesticide prices in nominal Sucres to 1980 Sucres. As with the case for the pesticide permit data, the crop production quantity data were used directly in the analysis, while the price data, which were in nominal Sucres, needed adjustment for inflation. The deflation process was performed once again, using the consumer price index. The agricultural credit given to producers of bananas and potatoes was also deflated using the same process. The real exchange rate index came directly from the Central Bank publication without any correction.

Because of the small number of observations, not all of the independent variables were initially included in the regression. Therefore, the pesticide demand regression was performed first on just five independent variables and divided into three general models: one containing the output prices, one with output quantities, and another with output credit. The general models can be depicted in the following manner:

$$Q_{Pest} = \beta_0 + \beta_1 P_{Pest} + \beta_2 P_{Banana} + \beta_3 P_{Potato} + \beta_4 RERI + \beta_5 Time$$
$$Q_{Pest} = \beta_6 + \beta_7 P_{Pest} + \beta_8 Q_{Banana} + \beta_9 Q_{Potato} + \beta_{10} RERI + \beta_{11} Time$$
$$Q_{Pest} = \beta_{12} + \beta_{13} P_{Pest} + \beta_{14} Credit_{Banana} + \beta_{15} Credit_{Potato} + \beta_{16} RERI + \beta_{17} Time$$

where Q = Quantity of pesticide,

P = Price,

Credit = Initial value of credit granted to a crop,

RERI = Real Exchange Rate Index,

Time = Time trend, and

Pest = Pesticides (Insecticides, fungicides, herbicides, or total pesticides).

The inclusion of each pesticide price in the models is logical and was discussed in the methods section. The hypothesis regarding the pesticide prices is that the higher the pesticide prices, the fewer pesticides are consumed. Banana and potato data were used in the models to represent outputs because these crops represent major outputs of Ecuadoran agriculture and they use significant amount of pesticides. The prices of these outputs were used in one set of regressions, and a second set was estimated which included quantities of these outputs. It was hypothesized that the higher the banana and potato prices and quantities are, the more pesticides are demanded. The third set of regressions included initial values of credit granted to farmers of each output. This third set of regressions was included with the hypothesis that the more credit a farmer is granted, the more pesticides demanded, since the farmer may use the credit to buy more pesticides. The real exchange rate index (RERI) and time trend variables were also used in each regression. It was hypothesized that the lower the value of the RERI (the more overvaluation there exists), the more pesticides will be demanded. Finally, pesticide demand was hypothesized to increase with the increase in time.

The results of the regressions are presented in Table 4.6. As predicted, the shortage of observations limited the statistical significance of the regressions. Only 15 observations were available for the first two sets of regressions, and only 13 for the last set due to shortage of the credit data. The low numbers of observations may explain the relatively low adjusted R squared values, with some regressions having even negative adjusted R squared values. The t-statistic values for most of the regressors are very low as well. Therefore, the regression results explain very little.

Although none of the variables are significant at even the 10% level, the signs of the regression coefficients having t-statistics greater than one, representing significance levels near 30%, may merit some discussion. The price coefficients for each pesticide type have t-statistic values greater than one in eight out of 12 regressions, with each of those coefficients being negative as expected. The potato quantity coefficients in two regressions have t-statistic values

Table 4.6 Regressions for Pesticide Demand Estimation

Output Regressors	Dependent Variable	Constant	Dep. Var. Price	Banana Price	Potato Price	Banana Quantity	Potato Quantity
Prices	Insecticide Quantity	-.136248E7 (-.037)	-404.846 (-1.306)	-14784.7 (-.403)	-33158.7 (-.850)	-	-
	Fungicide Quantity	-.450351E8 (-.383)	-430.444 (-.309)	22708.0 (.241)	-92657.7 (-.886)	-	-
	Herbicide Quantity	.269298E9 (1.841)	-1738.09 (-.509)	-120402 (-.854)	-356555 (-2.000)	-	-
	Pesticide Quantity	.620742E8 (.245)	-7889.51 (-1.449)	-1372263 (-.619)	-465633 (-1.846)	-	-
	(Variance Inflation Factors)	-	3.6308	1.9884	1.3978	-	-
Quantities	Insecticide Quantity	-.918072E8 (-1.431)	-525.202 (-1.829)	-	-	-.187501 (-1.423)	.885860 (.835)
	Fungicide Quantity	-.199186E9 (-1.087)	159.989 (.092)	-	-	-.363872 (-.898)	2.71338 (.881)
	Herbicide Quantity	-.268398E8 (-.083)	-3141.45 (-.892)	-	-	-.634246 (-.991)	6.46723 (1.159)
	Pesticide Quantity	-.303199E9 (-.648)	-9112.99 (-1.509)	-	-	-.765498 (-.769)	10.6557 (1.372)
	(Variance Inflation Factors)	-	3.9537	-	-	10.485	2.1133
Credit	Insecticide Quantity	.148846E8 (.409)	-633.268 (-1.960)	-	-	-	-
	Fungicide Quantity	-.254093E9 (-1.430)	-2091.06 (-1.104)	-	-	-	-
	Herbicide Quantity	.164076E9 (.730)	-4168.26 (-1.033)	-	-	-	-
	Pesticide Quantity	-.263700E9 (-.927)	-11118.8 (-1.868)	-	-	-	-
	(Variance Inflation Factors)	-	2.8180	-	-	-	-

Values in parentheses are t-statistics.

Table 4.6 (Continued)

Output Regressors	Dependent Variable	Banana Credit	Potato Credit	RERI	Time	Adjusted R^2	n	D-W Statistic
Prices	Insecticide Quantity	-	-	-7216.64 (-1.963)	1437.67 (.077)	0.67	15	2.1688
	Fungicide Quantity	-	-	-12785.8 (-1.543)	23927.3 (.403)	-0.06	15	1.6827
	Herbicide Quantity	-	-	-2532.69 (-.112)	-133561 (-1.809)	0.51	15	1.9691
	Pesticide Quantity	-	-	-11126.7 (-.435)	-26899.5 (-.211)	0.52	15	1.8719
	(Variance Inflation Factors)			3.8405	2.9131	-	-	-
Quantities	Insecticide Quantity	-	-	-7779.59 (-2.283)	46990.5 (1.450)	0.71	15	2.2193
	Fungicide Quantity	-	-	-12740.1 (-1.528)	101191 (1.093)	-0.07	15	1.9637
	Herbicide Quantity	-	-	599.897 (.027)	14107.5 (.087)	0.38	15	2.6865
	Pesticide Quantity	-	-	-9183.42 (-.327)	154675 (.655)	0.46	15	2.4776
	(Variance Inflation Factors)	-	-	4.0890	8.8417	-	-	-
Credit	Insecticide Quantity	-.117900 (-.136)	1.42989 (1.205)	-5592.13 (-1.241)	-6920.16 (-.376)	0.64	13	2.8492
	Fungicide Quantity	4.19323 (1.634)	1.21251 (.420)	-25428.5 (-2.368)	129433 (1.441)	0.20	13	2.8350
	Herbicide Quantity	2.31070 (.518)	3.77070 (.622)	-2736.64 (-.084)	-81596.8 (-.717)	0.21	13	2.7141
	Pesticide Quantity	7.97589 (1.379)	5.59363 (.679)	-31519.1 (-.995)	136461 (.948)	0.46	13	3.1203
	(Variance Inflation Factors)	0.85652	1.1736	3.3115	2.3150	-	-	-

Values in parentheses are t-statistics.

greater than one, and positive signs also as expected. Three of banana and potato credit coefficients out of eight have t-statistics greater than one, with all of them having positive signs as hypothesized. The real exchange rate index (RERI) coefficients include six coefficients with t-statistics greater than one, with all of them having negative signs also as hypothesized.

While the signs of the coefficients discussed in the previous paragraph were consistent with expectations, other ones were not. The time coefficients have t-statistic values greater than one in only four out of 12 regressions, and some of their signs were negative. The potato price coefficients in two regressions had t-statistics greater than one, but the signs of the coefficients were negative, contrary to expectations. The sign on banana quantity for the only coefficient with a t-statistic greater than one was also negative, contrary to expectations. A possible explanation for the unexpected signs (in addition to the low level of significance) is that these variables may be better represented as lagged variables in the pesticide demand equations because an increase in the demand and imports of pesticides in one year due to increased prices or quantities of outputs may only be realized in the following year. To test the possibility of this explanation, regressions were performed which included lagged variables. The results of these regressions are reported on Table 4.7.

Table 4.7 shows that the sign of the lagged potato price coefficient is positive and the t-statistics in the two regressions are greater than one. The signs of the coefficients for potato price, however, remain negative. Therefore, even though the hypothesis that the present year's increase in pesticide demand is positively related to the previous year's increase in potato price is supported, the present year's potato price may still be related to pesticide demand negatively in some manner. The relationship between the demand of insecticides in the present year and the potato quantity in the previous year was not found to be statistically significant.

It is possible that the low significance of regressors may be due to multicollinearity. Therefore, variance inflation factors (VIF) were calculated for each model. The only VIF's that indicated a possible problem with multicollinearity are the ones for banana quantity and time in the regression in which output quantities are included as independent variables. Those VIF values are both greater than five. A consequence of multicollinearity is that those variables may be picking up effects of other independent variables on the dependent variable. The best way to treat the problem of multicollinearity is to increase the number of observations, which is not possible in this case due to the lack of data. No further attempt to correct this problem was done.

The Durbin-Watson (D-W) statistic for each regression was used to detect autocorrelation. The herbicide and pesticide quantity regressions with output quantity variables, and all of the regressions with credit variables were found to have positive autocorrelation. The Cochrane-Orcutt iterative method was used in the attempt to correct autocorrelation. The results of the procedure are presented on Table 4.8. As a result of the procedure, the D-W statistic for most of the regressions decreased, although not to the point of eliminating the problem of autocorrelation. Furthermore, the D-W statistics for the insecticide and herbicide quantity models in Table 4.8 are higher than the corresponding ones in the initial regressions. This result may be caused again by the few number of observations. Since the small number of data seems to be a great impediment in the attempt to improve the demand model accuracy, no further modification of the model was made.

Table 4.7 Regressions with Lagged Potato Price and Banana Quantity

Output Regressors	Dependent Variable	Constant	Dep. Var. Price	Banana Price	Potato Price	Potato Price [-1]
Prices	Herbicide Quantity	.150372E9 (.704)	-2517.78 (-.657)	-112100 (-.758)	-265270 (-1.292)	178916 (1.088)
	Pesticide Quantity	-.192766E9 (-.560)	-7582.81 (-1.362)	-115336 (-.510)	-332417 (-1.205)	326690 (1.307)
Quantities	Insecticide Quantity	-.100173E8 (-.098)	-575.699 (-1.929)	-	-	-

Output Regressors	Dependent Variable	Banana Quantity	Banana Quantity [-1]	Potato Quantity	RERI	Time	Adjusted R^2	n
Prices	Herbicide Quantity	-	-	-	-2140.17 (-.077)	-74297.1 (-.077)	0.50	14
	Pesticide Quantity	-	-	-	-22262.9 (-.768)	100584 (.580)	0.52	14
Quantities	Insecticide Quantity	-.318125 (-.882)	.201496 (.702)	1.99340 (1.559)	-1078.22 (-.210)	5276.98 (.102)	0.68	14

Values in parentheses are t-statistics.

Table 4.8 Regressions to Correct Autocorrelation

Output Regressors	Dependent Variable	Constant	Dep. Var. Price	Banana Quantity	Potato Quantity	Banana Credit	Potato Credit
Quantities	Herbicide Quantity	-.243142E9 (-.477)	-3303.97 (-.917)	-.871888 (-1.264)	6.06268 (.986)	-	-
	Pesticide Quantity	-.232596E9 (-.279)	-9036.97 (-1.413)	-.643457 (-1.233)	10.8809 (1.186)	-	-
Credit	Insecticide Quantity	.301511E8 (1.098)	-759.980 (-2.155)	-	-	-.496143 (-.720)	1.60618 (1.802)
	Fungicide Quantity	-.307443E9 (-1.836)	-2375.04 (-1.364)	-	-	4.17418 (1.915)	3.03089 (1.336)
	Herbicide Quantity	.177859E9 (.926)	-5010.04 (-1.200)	-	-	1.68582 (.417)	4.86472 (.881)
	Pesticide Quantity	-.323690E9 (-1.640)	-11387.7 (-2.472)	-	-	7.02722 (1.722)	7.94397 (1.356)

Output Regressors	Dependent Variable	RERI	Time	n	D-W Statistic
Quantities	Herbicide Quantity	-8619.51 (-.271)	123743 (.479)	15	2.58601
	Pesticide Quantity	-8236.58 (-.168)	118880 (.281)	15	2.27268
Credit	Insecticide Quantity	-3784.68 (-.903)	-14635.4 (-1.053)	13	3.36420
	Fungicide Quantity	-31157.9 (-3.769)	156430 (1.848)	13	2.69123
	Herbicide Quantity	-2000.93 (-.066)	-88478.0 (-.909)	13	3.08728
	Pesticide Quantity	-39092.1 (-1.828)	166878 (1.671)	13	2.64373

Values in parentheses are t-statistics.

Chapter 5: Conclusions

5.1 Policy Implications

It was established in the previous chapter that the results of this study do not allow a precise analysis of policies affecting pesticide use. However, when combined with the background information from Chapter 2, the results bear some implications for policy formulation.

The most important form of subsidy related to the consumption of pesticides was found to be the overvaluation of the Sucre. To quantify the extent of overvaluation, the equilibrium exchange rate (EER) was calculated from 1987 to 1996. The calculation showed that, although the EER's were greater than the nominal exchange rates during the period of study, the magnitudes of the two are converging. In other words, even though the Sucre has remained overvalued in recent years, the degree of overvaluation has been diminishing. The impact of this reduction in overvaluation on pesticide prices in Ecuador has been substantial. Wholesale pesticide prices were 3.5% less on average than the real import prices in 1996 due to price distortion, while in 1991, they were 21 to 35% less (Table 4.5). The overvalued exchange rate was responsible for reducing wholesale pesticide prices by only 6% in 1996, while the corresponding number was 23 to 37% in 1991. The rates of the primary consumption taxes on pesticides, the tariff and the customs tax, are relatively low and stable, so it is evident that the substantial decrease in subsidy for consumption of pesticides is due to the decrease in Sucre overvaluation, which is part of the liberalization policy that the Ecuadoran government is undertaking.

The impact of the indirect subsidy provided by the overvalued Sucre to pesticide consumption is substantial, as evidenced by the many statistically significant real exchange rate index (RERI) variables at the 30% significance level in the pesticide demand regressions conducted in this study. Therefore, it may also be concluded that the decreased overvaluation of the Sucre is actually causing farmers to buy fewer pesticides. Another subsidy that encouraged the use of pesticides was subsidized agricultural credit. This form of subsidy did not change the price of pesticides, but made it cheaper for farmers to buy them because of an indirect subsidy resulting from lower interest rates than those available elsewhere. Some evidence supporting the increased use of pesticides as a result of increased credit was found in the regression analysis. However, credit may be becoming less important for the consumption of pesticides, since, as reported in Chapter 2, its effective level of subsidy is decreasing, and the amount of agricultural credit provided is decreasing.

In addition to the price increase for pesticides due to the liberalization policy of decreased Sucre overvaluation, the average CIF border price of pesticides is increasing, as seen in the first row of Table 4.4. The regression results in this study also showed some evidence of pesticide demand inversely depending on CIF pesticide prices, as expected. Therefore, the combination of decreased overvaluation of the Sucre and higher CIF pesticide prices seem to be making farmers use less pesticides. Policies that formerly greatly distorted pesticide prices are now vanishing, due to the government's liberalization policy, and the government seems to encourage less use of pesticides.

Even though the recommendation that the government may want to modify policies that encourage the use of pesticides seems to be largely fulfilled, many farmers now face the problem that they do not have access to inexpensive means of controlling pests. The problem may not be so great for large farmers who have sufficient resources to absorb the pesticide cost increases. In fact, large farmers who produce export crops may benefit from the less overvalued Sucre, as was reported in Chapter 2. However, small farmers, who may depend heavily on the income from farming for their livelihood, may not be able to buy even the minimum amount of pesticides to conduct subsistence farming. The inability of small farmers to farm profitably is a concern for the Ecuadoran government, because the welfare of those farmers is threatened, and because the level of agricultural activities may decrease. Consequently, the government may want to formulate policies that facilitate adoption of inexpensive IPM technologies for small farmers of domestically consumed outputs if high levels of pest loss are occurring on these crops.

As reported in Chapter 3, IPM activities in Ecuador have not been extensive. Consequently, policies that encourage the introduction of IPM must encompass many issues. First, IPM research may be addressed since IPM knowledge is scarce in Ecuador. It was reported earlier that INIAP (National Institute for Agricultural Research) is primarily responsible for the small amount of public IPM research that has been completed. A policy then may want to encourage INIAP to conduct IPM research for the crops for domestic consumption that small farmers grow. Needless to say, if growing conditions for some of these crops are similar to the ones for which IPM technologies exist in other countries, repetition of these research efforts is not necessary.

Far reaching IPM extension may become necessary once IPM technologies are available. Therefore, as the second part of IPM policies, the government may want to promote IPM extension to small farmers of domestically consumed outputs. It may be seen that the cost of IPM extension is high. However, by taking action now, the government could be saving financial resources to execute IPM adoption policies. The financial saving is due to the current lower cost to encourage farmers to adopt IPM. The current lower cost, in turn, is due to the high cost of using pesticides, which lowers the relative cost of adoption of alternative pest suppressing technologies such as IPM. Therefore, the present situation of high pesticide prices may be seen as a timely opportunity to pursue farmers to adopt IPM.

5.2 Future Improvements

The results of this study indicate a decreasing subsidy for consumption of pesticides in Ecuador. The study also partially supports the significance of exchange rate and credit policies in affecting the demand for pesticides. Although the need for additional research to quantify the subsidy to pesticide consumption is not great due to the decreasing importance of subsidies in the prices of pesticides, an improved pesticide demand estimation could give insights for facilitating the adoption of IPM.

To improve the pesticide demand estimation, the dependent variables should be disaggregated by formulations. This disagregation would allow the creation of more specific policies aimed at different pesticides. However, as reported in Chapter 2, there are hundreds of formulations of pesticides used in Ecuador. Therefore, only the important ones in terms of toxicity level and quantity used can be accounted for in such a study. The previous statement gives another clue as to how to treat the overwhelming number of pesticide data for regression purposes. That is, another way to study these pesticides effectively is to aggregate them in terms of toxicity level. This type of aggregation could be helpful since implications about pesticide demand may be drawn depending on toxicity level. This approach to the analysis of pesticide use is logical since the toxicity of pesticides is the most significant characteristic of concern.

Another important improvement that could be made in the estimation of pesticide demand is the incorporation of independent variables that would indicate the significance of pesticide usage according to farm size. One variable could be the number of farmers according to each farm size. The successful incorporation of this variable into the pesticide demand regression could also indicate the difference in pesticide use among farmers of different sizes, as a result of the reduction in pesticide subsidy.

The improvements mentioned above cannot be made without the suggested data. The lack of available data for Ecuador was a serious problem for the present study as was the low quality of data. Data improvement should be addressed.

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Appendix A: Data to Calculate Equilibrium Exchange Rate

		1987	1988	1989	1990	1991
Nominal exchange rate	**(Su./$)**	170.5	301.6	526.3	767.8	1,046.2
Total export value	**(Thousand $ FOB)**	1,929,194.00	2,193,501.00	2,353,883.00	2,724,133.00	2,851,013.00
	(Million Su. FOB)	328,927.58	661,559.90	1,238,848.62	2,091,589.32	2,982,729.80
Export tax revenue	**(Million Su.)**	309.00	875.00	1,018.00	879.00	1,583.00
Total import value	**(Thousand $ CIF)**	2,158,137.00	1,713,525.00	1,854,781.00	1,865,126.00	2,399,040.00
	(Million Su. CIF)	367,962.36	516,799.14	976,171.24	1,432,043.74	2,509,875.65
Import tariff revenue	**(Million Su.)**	41X,714.00	66,996.00	108,612.00	167,098.00	213,254.00
Current account balance	**(Million $)**	-1,187.00	-680.00	-715.00	-360.00	-708.00

		1992	1993	1994	1995	1996
Nominal exchange rate	**(Su./$)**	1,534.0	1,919.1	2,196.7	2,565.0	3,190.4
Total export value	**(Thousand $ FOB)**	3,101,527.00	3,065,615.00	3,842,683.00	4,411,224.00	4,889,834.00
	(Million Su. FOB)	4,757,742.42	5,883,221.75	8,441,221.75	11,314,657.22	15,600,673.09
Export tax revenue	**(Million Su.)**	2,734.00	1,235.00	766.00	0.00	0.00
Total import value	**(Thousand $ CIF)**	2,430,978.00	2,562,223.00	3,622,019.00	4,152,635.00	3,723,570.00
	(Million Su. CIF)	3,729,120.25	4,917,162.16	7,956,489.14	10,651,384.20	11,879,789.44
Import tariff revenue	**(Million Su.)**	274,413.00	392,470.00	606,631.00	754,050.00	767,220.00
Current account balance	**(Million $)**	-122.00	-678.00	-681.00	-735.00	293.00

Vita

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Takayoshi José Yamagiwa was born in Yokohama, Japan in 1973. He grew up in El Salvador (his mother's home country), Bolivia, California, and Guatemala. Takayoshi was an honors student when he received his bachelors in Biological Systems Engineering in 1996, also from Virginia Tech. Takayoshi's living experiences did not only allow him to speak Spanish, Japanese, and English, but they also made him interested in issues of developing countries and international relations. His interests in world cultures made him an active member of the international community at Virginia Tech, and he was the founder and president of the Japanese club and the public relations person for the Council of International Student Organization for a few years during his undergraduate years. As a masters student, he received the Kline fellowship, awarded to a person with a potential and willingness to help the international community. He also recently won the third place in a global education essay contest, sponsored by Virginia Tech's Office of International Programs. After completion of his masters, Takayoshi will start working for FONAES, the Salvadoran government's institution funding environmental projects, evaluating the projects and their impact to the nation.