Risky Business:
An Analysis of Price and Small Landholder Returns In the Pedro Peixoto Settlement Project In the Western Brazilian Amazon

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RISKY BUSINESS: AN ANALYSIS OF PRICE AND SMALL LANDHOLDER RETURNS IN THE PEDRO PEIXOTO SETTLEMENT PROJECT IN THE WESTERN BRAZILIAN AMAZON

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A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirements of the degree

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Abstract

This research focuses on agriculture production of small landholders (100 hectares or less) in the government settlement project of Pedro Peixoto, in the state of Acre in the western Brazilian Amazon. Monte Carlo simulations show that returns from agriculture production for small holders in the Pedro Peixoto project are well above the Brazilian poverty line, and significantly exceed the annual minimum wage.

The level of price risk faced by small landholders in the Pedro Peixoto project is examined. It is shown that the level of price risk in the settlement project is higher than price risk in the south of Brazil as well as external markets. The high degree of price risk faced by small landholders in the Pedro Peixoto project may be a barrier to alternative agriculture practices that require increased intensification, such as agroforestry. However, it is also demonstrated that price variation is falling after July 1994. Due to the declining price variation alternative production practices that currently are too risky may become more attractive in the future.

The expected return from many of the commodities typically produced by small landholders is shown to be falling after July 1994. This decrease in expected return may be due to a reduction in transaction costs that, in turn, reduce the price of commodities deficit in the project. Conversely, the expected returns of some commodities (coffee and banana) that are surplus in the project are rising after July 1994. This is also consistent with falling transaction costs.

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This document is dedicated to my parents Melita and John Dahl, who have always provided support and understanding in whatever I have attempted. They have also provided a family that I am very proud to be part of, and a home in which I am always welcome. For this I owe you a debt that I can not even begin to repay.

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1.0 Introduction

Much has been written about the economics of agricultural development in the Amazon. Often attention has focussed on cattle production, principally when done by large ranchers (Fearnside, 1987a). The focus on large ranchers misses a significant portion of agricultural activity in the region. In 1997 it was estimated that small landholders (farm size less than 100 ha) make up 56% of registered farmland in Rondônia and 30% of registered farmland in Acre, two states in the western Brazilian Amazon (Vosti et al., 1998b). Not only do small landholders account for a significant proportion of farmland, due to their numbers (48,000 small landholder households in Acre and Rondônia in 1997, Vosti et al., 1998b) they also account for a significant proportion of deforestation.

Thus, this research focuses on small landholders to gain a better understanding of economic forces driving agricultural production for this important group of Amazonians, and to gain a better appreciation of the driving forces behind continued deforestation. Small landholders in the Pedro Peixoto government settlement project in the Brazilian state of Acre were chosen as the focus of this research to coordinate efforts with researchers from the International Food Policy Research Institute (IFPRI), Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), and the Alternative to Slash and Burn (ASB) project.

1.1 Pedro Peixoto Settlement Project - An Overview

Official settlement projects in the Brazilian Amazon have been facilitated by government policies designed to populate the Amazon region and attempts to address significant poverty concerns. Faminow (1998) notes that the Amazon development projects provided land for the landless poor of the Brazilian northeast and for displaced agricultural labourers from the south of Brazil. The migration to the agricultural frontier in the Amazon also involved spontaneous settlement, both within and outside of official settlement projects.

The Pedro Peixoto government settlement project is found in the state of Acre in the western Brazilian Amazon region (Figure 1.1). Settlement in the Pedro Peixoto project is a relatively recent occurrence. While the Pedro Peixoto government settlement project was opened in 1972, the majority of settlers in the project (two-thirds of them) arrived during the 1980s (Fujisaka et al., 1996). Settlement in the Pedro Peixoto project was aided in the late 1980s when the section of highway BR 364 that runs from Porto Velho (capital of Rondônia) to Rio Branco (capital of Acre), was paved (Fearnside, 1987 a) (BR 364 begins in Cuiabá in Mato Grosso).

Originally the settlement was on 370,000 hectares of land, divided between 3,200 families. Land plots for the settlement are located 50 to 100 kilometres from the capital of Acre, Rio Branco (Fujisaka et al., 1996). In 1994 the average small landholder held approximately 80 hectares of land with approximately 20 hectares cleared of forest (Witcover et al., 1996).

1.2 Production on the Frontier

Small landholders in the Pedro Peixoto settlement project practice a form of slash-and-burn agriculture. Generally, land near the road is first cleared. Over time clearing continues away from the road so that swaths of land are gradually opened on either side of the road (Fujisaka et al., 1996). Many small landholders (66%) do not return the cleared land into fallow after yields of annual crops begin to decline. Rather, the land is converted to pasture for dairy and beef cattle (Witcover et al., 1996).

Cattle production comprises a large portion of the annual value of agricultural production. Many writers (Fearnside 1987a, Fearnside 1988, Hecht 1985, Ledec 1992, and Serrão and Toledo 1992 for example) have claimed that cattle production in the Amazon is uneconomic, and has occurred because of government subsides and inflation driven land speculation. However, as outlined by Mattos and Uhl (1994) Amazon producers have adapted their production practices to match their environment. Other authors (for example, Faminow 1998, Loker, 1993, Mattos and Uhl, 1994) who have revisited the economics of agricultural production in the Amazon have discovered that agricultural producers in the region may be making rational economic decisions when they choose to convert forest to cropland and eventually pasture. This is in spite of declining (or non-existence of) government subsidies and with little opportunity for speculative gains in land values (Faminow 1998).

This research contributes to this debate using the case of small landholders in Pedro Peixoto. It is demonstrated that gross returns from agricultural production places small landholders in the Pedro Peixoto settlement project well above the Brazilian poverty line, and well above the annual minimum wage rate. That is, this study shows that small landholders do receive economic benefit from agricultural production that may be greater than the return from alternative uses for their labour. If this is the case, it can be expected that small landholders will continue production and expansion of production irrespective of land value speculation and the existence / nonexistence of government subsidies.

1.3 Price Risk and Intensification

Intensification, often requiring increased specialization, of agricultural production has been proposed by some as a means of increasing economic returns from agricultural production in the Amazon, while decreasing the pressures for deforestation. Toniolo and Uhl (1995) indicate that the major impediments to intensification in the Amazon region are restricted access to credit, restricted access to technical assistance, and precarious frontier markets.

The settlement project in Pedro Peixoto displays characteristics of precarious frontier markets. Isolation from other markets in the region is one characteristic of frontier markets. For example, Witcover et al. (1996) found that small landholders in the Pedro Peixoto settlement project have fewer connections with market infrastructure than the settlement project of Theobroma in the neighbouring state of Rondônia. One result of market isolation explored in this research is a high degree of commodity price variation or price risk. The high degree of price risk faced by small landholders in Pedro Peixoto is highlighted when price variation in Pedro Peixoto is compared with other regions of Brazil as well as markets outside Brazil.

High price risk can be offset by small landholders through the adoption of diversified production practices. Therefore, the presence of high price variation may present a barrier to specialization in the region. Risk-averse small landholders will likely continue to produce a diversified portfolio of agricultural products as long as they are faced with highly variable product prices. It is also demonstrated that the price risks inherent in pasture products (beef and milk) are the lowest of all the commodities produced by small landholders. This fact provides another reason why pasture products have become the largest contributors to farm household revenue from agricultural production.

1.4 The Policy Environment

This study also examines the combined impact on commodity prices of a suite of recent policy changes and market liberalization initiatives. These policy changes were introduced along with the Plano Real in July of 1994. The Plano Real devalued the past currency (the New Cruzado) by 2,750 times to form the current Brazilian currency, the Real, in an attempt to curb rampant inflation. At the same time government subsidies and tax incentives were reduced and barriers to trade were lowered (e.g., the Mercosul free trade pact).

July of 1994 will be used in this study to divide commodity prices into "before" and "after" periods to determine if any trends in expected price and price variability are evident. Prices from the Pedro Peixoto project are also examined to determine if the observed trends can be explained. This is done in an attempt to determine if the trends in expected returns and price variation will likely continue or if they are a temporary impact.

1.5 Research Objectives

The intent of this research is to begin the process of analysing prices received by small landholders in the Amazon. To date, little published research has analysed price structure in the area. Few authors have made an attempt to analyse price risk or determine the direction of commodity price tends. Therefore, little is known about the impact of price risk or price trends on production decisions of small landholders. It is hoped that beginning the analysis of producer prices in the Pedro Peixoto settlement project will be an important contribution to the understanding of agricultural production in the Amazon region.

This research will attempt to answer three basic questions. First, are expected prices for the commodities commonly produced by small landholders sufficient to support small landholders, and are these returns higher or lower than alternative forms of income? Second, is the degree of price risk faced by small landholders in Pedro Peixoto greater than price risk in other agricultural markets and if so, what impact does the higher degree of risk have on small holder production decisions? Finally, are any trends in prices and/or price variation evident after July 1994?

Answering the first question will shed some light on the economic viability of small landholder production in Pedro Peixoto and allow one assessment of the success of the settlement project. An answer to the second question may help explain the production decisions of small landholders and provide insight into the viability of alternative production practices, many of which require increased intensification and specialization. The third question begins to look towards the future of agricultural production in the region. Evidence of price trends that are likely to continue into the future may point to the need for adaptation to preserve small landholders' income level.

1.6 Structure of the Thesis

The analysis in this study is divided into three sections. Chapter Two outlines the procedures used throughout the analysis. The research relies on a combination of statistical tests, Monte Carlo simulations, and stochastic dominance analysis. Chapter Three outlines the production environment found in the Pedro Peixoto project. This chapter describes a typical production basket for small landholders in the Pedro Peixoto project, based upon survey research conducted by IFPRI and EMBRAPA during 1994. Chapter Three also examines prices from January 1992 through July 1994. The expected return from agricultural production is compared with a World Bank estimate of Brazilian poverty and the minimum wage rate to derive measures of the relative level of small landholders' income.

In Chapter Four the price series are divided into two groups, before July 1994 and after July 1994. The expected return and the degree of variation from the expected return in the two periods are examined to discover if any trends are evident after July 1994. Expected returns are compared by using stochastic dominance techniques to determine if small landholders' welfare is falling or rising after July 1994. This chapter also repeats this analysis for two commodities, coffee and banana, that were not typically produced by small landholders in 1994. Finally, two causes of the observed trends, inflation and decreasing transaction costs, are presented and analysed. This analysis provides some insight as to whether the trends in expected return and price variability are likely to continue in the future.

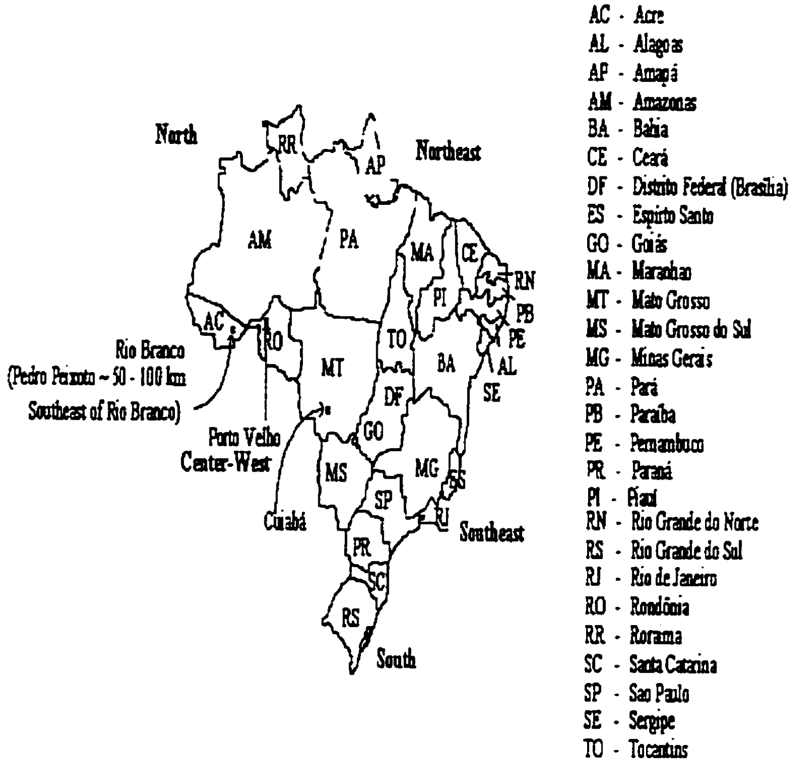
1.7 Syntheses of the Results

This research will show that the degree of price risk faced by small landholders in the Pedro Peixoto project is higher than the price risk faced by producers in the south of Brazil and external markets. By choosing to produce a diversified portfolio of commodities, small landholders have been able to reduce their risk exposure. This research will also show that the degree of price risk is lowest for pasture products, beef and milk. This observation provides one reason why cattle production has become so important to producers in the Amazon. The high degree of price risk may form a barrier to the adoption of alternative commodities (coffee or banana for example) or alternative production practices (for example improved pasture management) that require increased intensification.

It will be demonstrated that the return small landholders receive from agricultural production in the Pedro Peixoto project is well above the Brazilian poverty line, and well above the minimum wage rate. This lends support to the argument that agricultural production in the Amazon is economic and does not require large government subsidies or windfall gains from land speculation.

Finally this research will demonstrate a need for small landholders to change their production practices and/or begin production of new commodities. This is due to falling expected prices that may be a result of falling transaction costs between Acre and external markets. Fortunately, this study also shows that price variation may also be falling, leading to a reduction in price risk, which may decrease the barrier to intensified production practices.

Figure 1.1: Map of Brazil



Adapted from Faminow, 1998

2.0 Methods

This chapter will briefly outline the methods of analysis and the tools used to conduct this study. The chapter begins with an overview of the principles of risk and risk management. This is followed by a discussion of the methods used to construct stochastic spreadsheet simulation models. The third part of this chapter outlines the stochastic dominance techniques used to analyse the results of the simulations. The final section of this chapter is a brief review of the statistical tests used throughout this work.

2.1 Principles of Risk and Risk Management

This study focuses on price risk faced by small landholders in the Pedro Peixoto government settlement project, both in terms of the level of price risk and how price risk may be changing over time. It is therefore useful to review the sources of price risk and actions producers may take to reduce price risk.

2.1.1 Measurement of Price Risk

Robison and Barry (1987) define risky circumstances as "uncertain events whose outcomes alter a decision makers well-being" (Robison and Barry, p.13, 1987). This definition unquestionably applies to agricultural commodity prices.

Price uncertainty, or price risk, has been measured a number of different ways in this study. The simplest measurement is price variance. The level of price variation is examined in two periods, before July 1994 and after July 1994, to determine if the level of price uncertainty is changing over time.

The second measure of price uncertainty used in this work is the coefficient of variation, the standard deviation divided by the mean price. As the coefficient of variation is a unitless measure of price variation, it allows for the comparison of price uncertainty between commodities and across time periods. This measurement of price uncertainty is commonly applied when comparing the degree of risk inherent in the production of different commodities, for example in Sonka and Patrick (1984), or Walker and Helmers (1984).

As discussed by Cabuszewski and Sinquefield (1985), the time period in which prices are measured (e.g., daily, weekly, monthly, etc.) will have an impact upon price variation measurements. Therefore the coefficient of variation for a price series measured monthly is not comparable to the coefficient of variation of a price series measured daily.

A third measure of price variation, price volatility, is employed to account for differences in time periods. Price volatility (equation 2.1) (Cabuszewski and Sinquefield, 1985) is the standard deviation of the percentage price changes, adjusted for the deviations caused by different measures in time. Like the coefficient of variation, price volatility is independent of units.

$$\text{volatility} = \sqrt{\frac{a}{(n-1)}\sum_{t=1}^{n}(r_t - \bar{r})^2}$$

$$r_t = \frac{x_t}{x_{t-1}}$$

$$\bar{r} = \frac{\sum_{t=1}^{n} r_t}{n} \qquad (2.1)$$

a = annualized time unit (e.g.,12 for monthly data or 365 for daily data)

x_t = price at time t

n = number of observations

The degree to which a price uncertainty alters production decisions depends upon each individual producer's state of knowledge which is directly related to their ability to predict future price changes (Robison and Barry, 1987). Price trends may represent a predictable source of price risk, and as such do not contribute to price risk. The random variability remaining after the predictable variation has been removed might better represent the price risk faced by producers (Young, 1984). Following procedures outlined by Judge et al. (1985) the first difference of each price series was calculated. This isolates the random variation in prices from one month to the next. The three measures of price uncertainty discussed above, variance, coefficient of variation, and price volatility, have been calculated and compared for the first-differenced price data.

2.1.2 Response to Price Risk

Sonka and Patrick (1984) outline a number of means by which producers can reduce their exposure to risk. Some of the methods for risk reduction are intuitive, such as choosing to produce commodities with a low degree of price risk. One theme common to many of the proposals for risk reduction is diversification. Producers may diversify their operations in a number of ways. Alternative production enterprises can be undertaken, annual cropping with cattle production for example. Production may be diversified through the selection of crops and / or seeds that are not susceptible to the same causes of production failure (e.g., crops which are not susceptible to the same pest problems). Intercropping in the region of study is a production practice used by small landholders which may reduce production risk. Finally marketing may be diversified through time, that is the selling of products may be spread through the year.

Equation 2.2 (Sonka and Patrick ,1984) outlines how diversification reduces risk. The contribution to the total variance of an enterprise from a particular operation equals square of the proportion of resources dedicated to an operation (p_a and p_b) multiplied by the variance of the operation (σ^2_a and σ^2_b). The partial variances of the various operations are added together and added to an additional term that accounts for the correlation between the operations (c in equation 2.2).

$$\sigma_t^2 = p_a^2\sigma_a^2 + p_b^2\sigma_b^2 + 2p_a p_b c\sigma_a\sigma_b \tag{2.2}$$

The impact of diversification is perhaps best illustrated through the use of an example. For the sake of the example σ^2_a and σ^2_b are both equal to ten units. If a producer chose to specialize in either operation a or b, the variance of the enterprise would be ten units. If however (assuming for the moment that the correlation between the two operations is -1) the producer chooses to dedicate 50% of their resources to each of the two operations the variance of the enterprise would be zero.

Sonka and Patrick (1984) and Levy and Sarnat (1984) also note that the benefit of diversification is reduced if the expected values of the operations have highly positive correlation coefficients. Carrying through with the example, if the correlation between the two operations was 1 the variance of the enterprise would be 10 units. In this case the benefit of diversification has been eliminated due to the correlation between the two operations. However, as long as the correlation between the different operations is not perfect, there is potential for risk reduction through diversification.

The level of risk reduction is also partially dependant upon the degree of diversification. In the previous example, in which 50% of resources are dedicated to each operation, variance can be reduced from ten units (correlation coefficient equal to 1) to zero units (correlation coefficient equal to -1). However, if 75% of resources were dedicated to operation (a) and 25% of resources were dedicated to operation (b) the variance of the enterprise could be reduced from 10 units (correlation coefficient equal to 1) to 2.5 units (correlation coefficient equal to -1).

2.2 Simulation

The simulation procedures in this analysis use Monte Carlo sampling techniques. Monte Carlo sampling techniques involve randomly selecting an estimated value for a stochastic variable from a probability distribution (Law and Kelton, 1991). In this study, price distributions are randomly sampled and the sampled values are combined with estimated production to derive multiple (e.g., 1,000) random estimates of gross income from agricultural production. The relative frequencies of the multiple random estimates are used to estimate income probability distributions. In large samples, the relative frequency of occurrence of estimated values can be used as approximations for probabilities. Because income from agricultural production is a continuous function, the relative frequencies of intervals, not discrete points, will be used to approximate probabilities (Kementa, 1986).

If the sample size is large enough, the estimated probability of any interval will become stable. That is, after the price distributions have been sampled many times, the relative frequency of any income interval estimated through the simulation process will change little after additional samplings (Kementa, 1986). The stability of the simulation model will be measured by monitoring the percentage change in each fifth percentile of the output distributions, the percentage change in the mean of the output distributions, and the percentage change in the standard deviation of the output distributions. Simulations can be considered stable when the percentage change of all three of these measures are less than 1.5% (Pallisade, 1997).

Variables estimated by the simulation process are not fixed numbers. Rather, they are defined by a probability distribution that can be described by statistics of central tendency and dispersion, such as the mean, and standard deviation respectively. The simulation models in this study have been constructed using the Microsoft Excel spreadsheet program, combined with the @RISK software.

2.2.1 Price Distributions

The first step in the simulation process is defining a probability distribution for each price series. Following procedures outlined in Law and Kelton (1991), three different possible price distributions were specified and tested for "goodness-of-fit". For each price series a triangular distribution (defined by its minimum and maximum), a lognormal distribution (defined by its mean and standard deviation), and a normal distribution, truncated at zero (defined its mean and standard deviation) were specified. How well each distribution fit the data was then tested using the Chi-Square test statistic, as described by Walpole and Myers (1972). If the calculated χ^2 statistic, as given by equation 2.3, is greater than the critical χ^2 value, the null hypothesis, that the theoretical distribution adequately describes the observed data is rejected. In equation 2.3, o_i are equal to the observed frequencies, e_i equal the expected frequencies, and k is the number of intervals in the price series.

$$\chi^2 = \sum_{i=1}^{k} (o_i - e_i)^2 / e_i \qquad (2.3)$$

The "goodness-of-fit" for the theoretical distributions of all of the commodities used in this study were examined using this method. The frequencies between each tenth percentile (k = 9) in the series were compared with the expected frequencies generated by the different distributions. Using the Chi-Square test it was found that, of the distributions tested, the truncated-normal distribution best fit the sample data for all prices but Brazil-nut, which can be best described by a lognormal distribution (Table 2.1).

Through this study all prices will be represented by a truncated-normal distribution except Brazil-nut which will be represented by a lognormal distribution. It is recognized that the theoretical distributions tested may not be the best distributions to use when describing the various prices. For example, Law and Kelton (1991) point out that many distributions are skewed to the right, but not enough observations in the right-hand tail of the distribution are available to define the skewness from the observed sample. Given that the theoretical distribution may not be the "best", the sensitivity of results to a change in distributions will be tested. Analysis will be repeated using alternative distributions, to detect if results are dependant upon the choice of distribution.

2.2.2 Definition of Simulation Variables

The final step in the simulation process is the conversion of the static estimates of annual gross returns from agricultural production to stochastic estimates of annual gross returns. This is accomplished using the Monte Carlo simulation procedures previously described.

The International Food Policy Research Institute (IFPRI) and Empressa Brasileira de Pesquisa Agropecuária (EMBRAPA) conducted a survey of small landholders in the Pedro Peixoto project. This survey revealed that small landholders in the Pedro Peixoto project use a minimum of purchased inputs, including hired labour. Surveys of the small landholders in the Pedro Peixoto project in 1996 found that less than 2% made use of chemical fertilizers, approximately 12% made use of insecticides, and approximately 13% made use of herbicides (Carpentier, forthcoming). Other studies conducted in the Amazon region, Browder (1994) and Jones et al. (1995) for example, have also discovered that small landholders rely on few purchased inputs. This finding is consistent with the assertion that the region is poor in capital and labour, and small landholders tend to adopt systems that minimize capital and labour requirements (Cunha and Sawyer, 1997).

Data regarding actual production expenses are not readily available. Given the current minimal use of purchased inputs in the Pedro Peixoto project, and given the lack of reliable cost data, gross returns from agricultural production are used in place of net income from agricultural production. This assumption, used throughout the remainder of this work, is consistent with Jones et al. (1995) who also found cost data difficult to obtain and proxied net annual income with gross returns.

2.3 Comparison of Different Combinations of Expected Price and Price Variation

Simulation results will be used to create cumulative probability distribution functions (CPDF) for the gross returns of each agronomic system (Levy and Sarnat, 1984). The CPDFs are used to compare the combination of gross return and variability found in each system to identify the system that leads to the highest producer welfare.

2.3.1 First Degree Stochastic Dominance

Results of the simulations can be ranked according to desirability. The first step in this ranking procedure removes all "undesirable" alternatives with no assumptions regarding the risk preferences of the producers. That is, are any production systems less desirable regardless of whether the producer is risk averse, risk neutral, or risk loving? This is accomplished by using First Degree Stochastic Dominance (FSD). Stochastic dominance is a powerful evaluation tool because it evaluates returns over the entire range of outcomes. Other systems of preference ranking, such as mean variance analysis, only evaluate the systems at the means and therefore ignore some valuable information (Parsch, 1997).

Using FSD, production system A will be dominated by system B if, for any value along the X axis, the probability of receiving a higher return in system B is greater than or equal to the probability of receiving a higher return in system A (adapted from Levy and Sarnat, 1984). Graphically, if A is dominated by B the CPDF of option A always lies below (or to the left of) the CPDF of B (Figure 2.1).

FSD is demonstrated by a hypothetical example in Figure 2.1. The two systems in the example, system A and system B, are normally distributed. System A is defined by a mean of 10 and a standard deviation of 3. System B is defined by a mean of 15 and a standard deviation of 4. Using the Monte Carlo techniques described in the previous section, CPDFs have been constructed for systems A and B. From observing Figure 2.1 it can be easily seen that the probability of receiving a higher return is always greater in system B. Therefore, all producers would prefer system B to system A (i.e., B dominates A).

Because no assumptions have been made regarding risk preferences, a FSD result is not influanced by different levels of variation within the systems. FSD is only influenced by the expected values (Levy and Sarnat, 1984). Following the previous example, all producers would prefer system B to system A because the higher returns in B overshadow any increase in variation.

2.3.2 Second Degree Stochastic Dominance

FSD may not be 'efficient' enough to identify the most desirable production system. At some point the CPDF of the two systems may cross. That is, for some level of returns the probability of achieving a higher return may be greater under system A, but at a different level of return the probability of achieving a higher rate of return may be greater under system B. In this case the variation between the two systems will play a stronger role in the preference ordering of producers. If FSD is not sufficient to differentiate between two production systems, Second Degree Stochastic Dominance (SSD) will be used to identify the more desirable systems. The use of SSD requires the assumption that producers are risk averse (Levy and Sarnat, 1984).

System A is dominated by system B using SSD if the area under the CPDF of B is always greater than, or equal to, the area under the CPDF of A, for all values along the X axis (equation 2.4). Alternatively, system A is dominated by system B if the area between the two probability distributions (i.e., area B - area A) is greater than or equal to zero for all values along the X axis. (equation 2.5) (adapted from King and Robison, 1984). In equations 2.4 and 2.5, A(x) and B(x) represent the CPDF of systems A and B.

$$\int_{-\infty}^{x} A(x)dx \leq \int_{-\infty}^{x} B(x)dx \qquad (2.4)$$

$$\int_{-\infty}^{x} [A(x) - B(x)]dx \geq 0 \qquad (2.5)$$

SSD is graphically demonstrated through a hypothetical example in which both system A and system B are defined by a normal probability distribution. In the SSD example, system A is defined by a mean of 10 and a standard deviation of 5 and system B is defined by a mean of 10 and a standard deviation of 1. Using the Monte Carlo techniques previously described, the CPDF for each of these systems have been calculated and graphed in Figure 2.2. From Figure 2.2 it can be seen that neither system is dominant under FSD because the two distributions cross. However, as seen in Figure 2.3, the area under the CPDF of B is always greater than or equal to the area under the CPDF of A (i.e., the difference between the area under B and the area under A is always equal to or greater than zero). Therefore, system A is dominated by system B following the rules of SSD.

In the preceding example, variation does play a role in determining if one system is preferred to another. A risk averse producer prefers the combination of expected return and variation found in system B over the combination of expected return and variation found in system A. Usually risk averse producers will prefer lower variation to higher variation (Parsch 1997). However, Levy and Sarnat (1984) point out that it can not be stated that the risk averse producer will always prefer lower variation. The degree to which a producer will prefer a system with lower variation will also depend upon the difference in expected values. That is, a producer may prefer a system with higher variation, if the system with the higher variation also has a sufficiently higher expected return.

Figure 2.2 also shows the requirement for the "risk aversion" assumption when using SSD. Both systems have the same expected value. Therefore, the risk neutral producer would be indifferent between them (Levy and Sarnat, 1984). The risk loving producer may prefer the higher possible returns of system A. Only the risk averse producer would definitively prefer system B to system A.

Further information regarding the desirability of various systems can be obtained through the application of generalized stochastic dominance. However these techniques require more rigorous assumptions regarding the risk preferences of producers (Parsch et al., 1997). At this time this type of detailed information regarding the risk preferences of small landholders in the western Amazon region is not available.

2.3.3 Applications of Stochastic Dominance

Stochastic dominance criteria have been developed in the field of financial analysis. As discussed by Porter (1978) the technique has been applied to the analysis of different portfolios to determine the strategies that will lead to efficient investments. That is, investment strategies that optimize combinations of variability and expected return, given investors' risk preferences. Different production decisions are analogous to different portfolio decisions. Different production decisions can be analysed using stochastic dominance to learn which combination of variability and expected return are optimal for a given set of risk preferences. Salin and Dobbins (1994) applied this technique to analyse the risk and benefits of low input farming in Indiana.

Bey and Porter (1978) show that stochastic dominance techniques can be applied to capital investment decisions. Stochastic dominance criteria have been applied to agricultural investment decisions in the presence of uncertainty by Parsh et al. (1997). Novak and Jeffery (1997) have used this approach to analyse the benefit of investing in insurance programs relative to the benefit of government agricultural policies.

This study will combine and adapt some elements of the previous applications of stochastic dominance techniques. Like Novak and Jeffery (1997) stochastic dominance will be used to analyse government policy. Stochastic dominance techniques are used to determine if producers' welfare is increasing or decreasing because of changes in government policy.

2.4 Additional Statistical Tests

A number of statistical hypothesis tests (in addition to the test described in section 2.1.1) are used. These tests are commonly applied in statistical analysis and are briefly summarized below.

2.4.1 Test for Significant Correlations

In Chapters Three and Four, each price series is examined for significant correlation with other prices. Significant correlations are incorporated into simulation models. Tests for significant correlations are conducted following the Z-test, as outlined by Walpole and Myers (1972). The null hypothesis that there is no significant linear relationship, is rejected if the Z-statistic, as given in equation 2.6, falls outside the critical region. At a confidence level of 95% confidence the critical region for the Z-test lies between -1.96 and 1.96. In equation 2.6, r equals the correlation coefficient between the two prices, and n represents the number of paired observations from the two price series.

$$z = \frac{\sqrt{n-3}}{2} \ln\left[\frac{1+r}{1-r}\right] \tag{2.6}$$

2.4.2 T-Test for Differences in Mean

The T-test for difference in means is applied in Chapter Four to determine if mean prices from two different time periods differ statistically. From visual observations of price graphs, some knowledge is gained of the direction of price changes so a one tailed test for difference in mean is used. The null hypothesis is that there is no difference between means. As described by Walpole and Myers (1972) the null hypothesis is not rejected if the inequality in equation 2.7 holds. In equation 2.7, x_1 and x_2 are observed means from the first and second series, s^2_1 and s^2_2 are the standard deviations from the two series, and n_1 and n_2 are the number of observations in each series. The test outlined in equation 2.7 assumes that s^2_1 and s^2_2 are different. Therefore, the degrees of freedom used to define the critical region of the T-test is defined by equation 2.8. All T-tests used throughout this work have been conducted at a confidence level of 95% (α=0.05).

$$\frac{x_1 - x_2}{\sqrt{(s_1^2/n_1)+(s_2^2/n_2)}} \leq t_{v,a} \tag{2.7}$$

$$v = \frac{(s_1^2 / n_1 + s_2^2 / n_2)^2}{\frac{(s_1^2 / n_1)^2}{n_1 - 1} + \frac{(s_2^2 / n_2)^2}{n_2 - 1}} \tag{2.8}$$

An alternative to equation 2.7 substitutes a pooled variance in the denominator (equation 2.9). The alternative calculation for the test statistic is appropriate in cases of small sample sizes ($n<30$) (Kenny and Keeping, 1951). In equation 2.9 the degrees of freedom of the test, v, is given by equation 2.8 (i.e., the degrees of freedom are the same as for equation 2.7).

$$\frac{x_1 - x_2}{\sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}} \times \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \leq t_{v,a} \tag{2.9}$$

2.4.3 Test for Significant Difference in Variance

In Chapter Four, the variance from two different periods is tested to determine if variation in prices is changing over time. The hypothesis that the variation from the two periods is the same is tested using the F-test, as outlined by Walpole and Myers (1972). From observing price graphs, some information can be gained about the possible direction in the change of price variation. Therefore a one-tailed F-test is applied. The alternative hypothesis, that the variance in one period is greater than the variance in a second period, is accepted if the calculated F-statistic, as given by equation 2.10, is greater than the critical region for the F-distribution. In equation 2.10, s_1^2 and s_2^2 are the sample variances calculated from the data. The critical region for all F-tests conducted are defined by a 95% confidence level (α=0.05) and degrees of freedom given by v_1 and v_2.

$$f = \frac{s_1^2}{s_2^2}$$

$$v_1 = n_1 - 1 \qquad (2.10)$$

$$v_2 = n_2 - 1$$

2.4.4 Akaike Information Criterion

To conduct the statistical tests in sections 2.4.5 and 2.4.6, the appropriate number of lag periods must be determined. That is, are current prices influenced by past prices and, if so, how far back in time does this influence extend?

Following Mohanty et al. (1996) the appropriate lag term for each price series has been determined using the Akaike information criterion (AIC). The optimal number of lags will be indicated by the lowest AIC value. AIC values are directly related to the sum of squared errors from regression analysis. That is (all other things being equal) a lower error sum of squares will lead to a lower AIC value. However, the AIC imposes a "penalty" for additional lags, to account for the additional explanatory power due simply to the introduction of additional endogenous variables. That is, (all other things being equal) the introduction of additional lags will lead to a higher AIC value (Rahman, 1987).

To determine the AIC, the commodity prices were regressed against commodity prices lagged i periods (equation 2.11). Equation 2.11 assumes that additional lag periods are sequential. That is, if a lag period of three is identified, it is assumed that lag periods one and two also play a significant role. This may not be the case, as prices from more distant lag periods may have an influence on current prices while nearby lags are less important. This factor is a weakness of the AIC.

The linear regression was carried out for five commodities (rice, corn, beans, beef and coffee) and six different lag periods (one through six). The time series from January 1992 through July 1997 was divided into two different periods, from January 1, 1992 through July 1994, and for August 1994 through July 1997. AIC values were calculated for the five commodities and two time periods for the states of Acre and Paraná. The variance of the error term from each of the regressions was used to calculate the AIC, as given by equation 2.12. In equation 2.12, i is equal to the number of lags used in the linear regression, n is the number of data points, and σ^2 is equal to the variance of the error term from the linear regression (equation 2.11):

$$P_t = \beta_0 + \beta_1 P_{t-1} + \ldots + \beta_i P_{t-i} + \varepsilon \tag{2.11}$$

$$AIC = \frac{2i}{n} + \ln \sigma^2. \tag{2.12}$$

Paraná was chosen for comparison purposes as it is a large agricultural region in the south of Brazil with well developed agricultural markets. Prices for agricultural products in Paraná should be highly integrated with prices in other southern states. Therefore prices from Paraná can be viewed as representative of prices from the agricultural markets in the south of Brazil.

Table 2.2 gives the calculated AIC values for the period from January 1992 through July 1994. As can be seen from Table 2.2, in this period optimal number of lags for rice, corn, beans, and beef prices in Acre is three and the optimal number of lags for coffee prices in Acre is two periods . For Paraná the optimal number of lags for rice, corn, and beef prices is three periods, the same as Acre. The optimal number of lags for bean prices in Paraná is two periods and while the optimal number of lags for coffee prices is one period.

For the period from August 1994 through July 1997 the optimal number of lag periods is four for rice, corn beef and coffee prices, both in Acre and Paraná. The optimal number of lags is also four for bean prices in Paraná but the optimal lag for bean prices in Acre is one (Table 2.3).

2.4.5 Dicky-Fuller Test for Stationarity

The market integration test outlined in section 2.4.6 assumes that the first differences of prices are stationary. If a series is stationary it will always return to an equilibrium expected value after a shock. That is, a stationary series does not follow a random walk (Pindyck and Rubinfeld, 1991).

The assumption that the first differences of the various price series are stationary has been tested using the augmented Dicky-Fuller test, as given by equation 2.13 (Mohanty et al., 1996) . Following Mohanty et al. (1996), the number of lag periods included in equation 2.13 (m+1) is determined by the AIC, as given by Tables 2.2 and 2.3. The null hypothesises (β=0) of non-stationarity is rejected if the absolute value of the calculated test statistic is significantly large. From Table 2.4 it can be seen that in all cases the null hypothesis is rejected. That is, all the first differenced series examined are stationary.

$$\Delta P_t = \alpha + \beta P_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta P_{t-i} + \varepsilon_t \tag{2.13}$$

2.4.6 Johansen Co-integration Test

As discussed by Vosti et al. (1998a) changes in the structure of agricultural markets in the Amazon region may be leading to increased integration with markets outside of the region.

Prices in two states are co-integrated if a stationary linear relationship between them can be defined (equation 2.14). Equation 2.14 is commonly referred to as the co-integrating equation and λ is commonly referred to as the co-integrating parameter (Pindyck and Rubinfeld, 1991). Another way of expressing the concept of co-integration is in terms of common trends. Different prices can be viewed as co-integrated if it is found that they follow common trend(s) (Benson et al., 1994). By way of a simple example, if two series are separated by ten units and both show an increase of one each period, the two series can be said to follow a common trend and are co-integrated. In this example there is one unique co-integrating parameter (λ from equation 2.14), and the two series share a common trend ($x_{t+1} = x_t+1$ and $y_{t+1} = y_t+1$).

$$z = x + \lambda y \tag{2.14}$$

As discussed by Benson et al. (1994), if the number of common trends between the series being examined is equal to the number of prices being examined, there is no limit to the number of ways the two series can diverge from each other. That is, there is no evidence that the series are moving together and the hypothesis that the series are co-integrated is rejected. To carry on with the simple example, if it has been found that $x_{t+1} = x_t+1$ but $y_{t+1} = y_t+100$, the series have two trends and there is no λ that will satisfy equation 2.14.

The number of common trends between the series is determined by subtracting the number of co-integrating equations (r, or the rank of $\Theta(r)$ in equation 2.15) from the number of series being examined (Benson et al. 1994). In equation 2.15, Z_t is a vector of co-integrating equations. The rank of Z_t is equal to the number of price series being examined for co-integration. For this study, two price series are examined in each Johansen test being conducted, therefore Z_t is a 2 X 1 vector in each case. In equation 2.15, k is equal to the number of lag periods included in the analysis (Mohanty et al., 1996):

$$\Delta Z_t = \sum_{j=1}^{k} \alpha_j \Delta Z_{t-j} + \Theta(r) Z_{t-1} + \varepsilon_t. \tag{2.15}$$

Following through on the discussion by Benson et al. (1994), rejection of the hypothesis of r equal to zero would imply fewer common trends than the number of series being examined, and would provide some evidence of co-integration. Mohanty et al. (1996) also note that the hypothesis of co-integration would also be rejected if r was equal to the rank of Z_t (this would imply no common trends between the series being examined). As the rank of Z_t is 2 for all co-integration tests conducted in this study, these test will provide evidence of co-integration between prices in Acre and prices in Paraná if r is found to be greater than zero but less than two.

Table 2.1: Chi-Square Goodness-Of-Fit Tests For Prices Distributions In Pedro Peixoto

Commodity	Theoretical Distribution	Calculated χ^2 Statistic
Rice*	Truncated Normal	8.3
Rice*	Lognormal	14.3
Rice	Triangular	21.4
Corn*	Truncated Normal	6.8
Corn	Lognormal	18.9
Corn	Triangular	27.6
Beans*	Truncated Normal	7.6
Beans	Lognormal	24.9
Beans	Triangular	31.2
Milk*	Truncated Normal	12.2
Milk	Lognormal	25.7
Milk	Triangular	19.8
Beef*	Truncated Normal	10.8
Beef*	Lognormal	14.3
Beef	Triangular	17.8
Brazil-nut	Truncated Normal	35.6
Brazil-nut*	Lognormal	12.6
Brazil-nut	Triangular	21.3
Coffee*	Truncated Normal	8.2
Coffee	Lognormal	27.6
Coffee	Triangular	35.4
Banana*	Truncated Normal	6.0
Banana*	Lognormal	13.4
Banana	Triangular	16.8

*Significant at a 95% confidence level. The critical χ^2 value is 15.5 at a confidence level of 95%
Source: Calculated from EMATAR (unpublished)

Table 2.2: Calculated AIC Values January 1992 Through July 1994

Commodity	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6
Rice Acre**	2.17	2.26	2.01*	2.29	2.34	2.21
Corn Acre**	1.61	1.71	1.48*	1.51	1.63	1.73
Beans Acre**	5.19	5.28	5.04*	5.08	5.16	5.29
Beef Acre**	2.46	2.52	2.42*	2.53	2.60	2.72
Coffee Acre**	-3.27	-4.15*	-4.09	-4.12	-4.01	-3.89
Rice Paraná***	0.30	0.20	0.19*	0.20	0.31	0.41
Corn Paraná***	-1.00	-1.27	-1.32*	-1.28	-1.27	-1.30
Beans Paraná***	2.38	2.45*	2.51	2.46	2.56	2.70
Beef Paraná***	1.51	1.42	1.35*	1.39	1.51	1.54
Coffee Paraná***	-2.83*	-2.75	-2.77	-2.73	-2.69	-2.56

* Indicates minimum AIC value and optimal number of lag periods

** Calculated from EMATAR (unpublished)

***Calculated from Secretaria da Agricultura (various)

Table 2.3: Calculated AIC Values August 1994 Through July 1997

Commodity	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6
Rice Acre**	0.63	0.54	0.43	0.35*	0.48	0.53
Corn Acre**	-0.01	-0.02	-0.02	-0.21*	-0.03	-0.09
Beans Acre**	2.77*	2.87	2.98	2.95	3.06	3.19
Beef Acre**	-0.03	-0.02	-0.14	-0.28*	-0.22	-0.12
Coffee Acre**	-2.03	-2.16	-2.41	-2.71*	-1.76	-1.70
Rice Paraná***	-1.28	-1.31	-1.24	-1.52*	-1.40	-1.04
Corn Paraná***	-1.34	-1.45	-1.56	-1.57*	-1.48	-1.35
Beans Paraná***	2.47	2.52	1.92	1.78*	1.91	2.04
Beef Paraná***	1.36	0.66	0.56	0.52*	0.66	1.42
Coffee Paraná***	-3.00	-3.04	-3.05	-3.12*	-3.05	-2.99

* Indicates minimum AIC value and optimal number of lag periods

** Calculated from EMATAR (unpublished)

***Calculated from Secretaria da Agricultura (various)

Table 2.4: Dicky-Fuller Test Results, First Differenced Prices January 1992 through July 1997

Commodity	Dicky-Fuller Test Statistic
Acre Rice**	-4.5*
Acre Corn**	-5.7*
Acre Beans**	-4.3*
Acre Beef**	-4.2*
Acre Coffee**	-3.5*
Paraná Rice***	-4.5*
Paraná Corn***	-4.3*
Paraná Beans***	-4.3*
Paraná Beef***	-4.5*
Paraná Coffee***	-3.3*

* Significant at a 95% Confidence Level. At a 95% Confidence Level the Critical Value is -2.9

** Calculated from EMATAR (unpublished)

***Calculated from Secretaria da Agricultura (various)

Figure 2.1: First Degree Stochastic Dominance Hypothetical Example

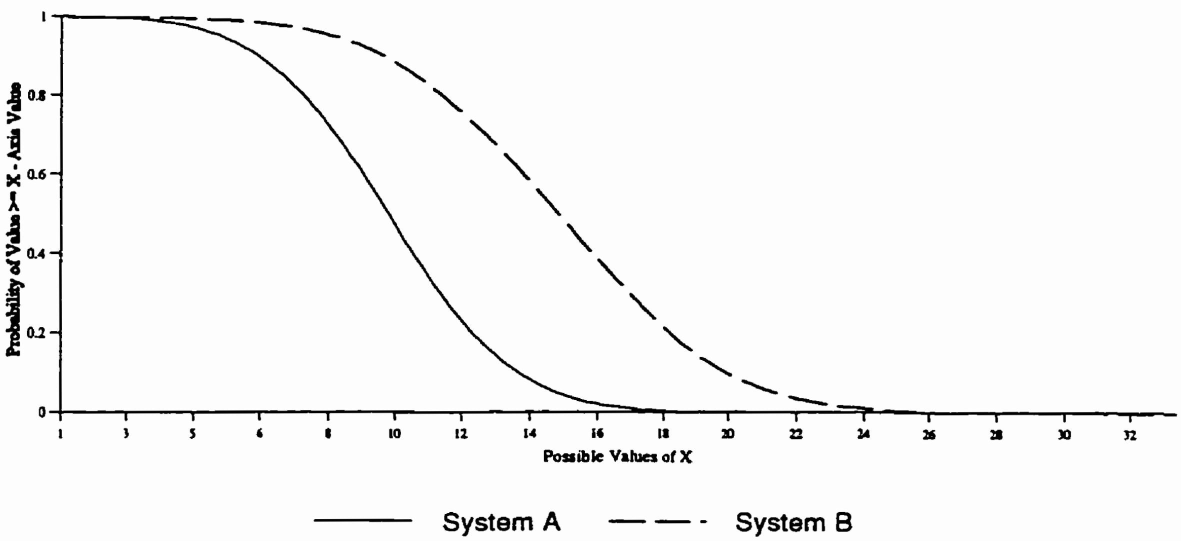


Figure 2.2: Second Degree Stochastic Dominance Hypothetical Example

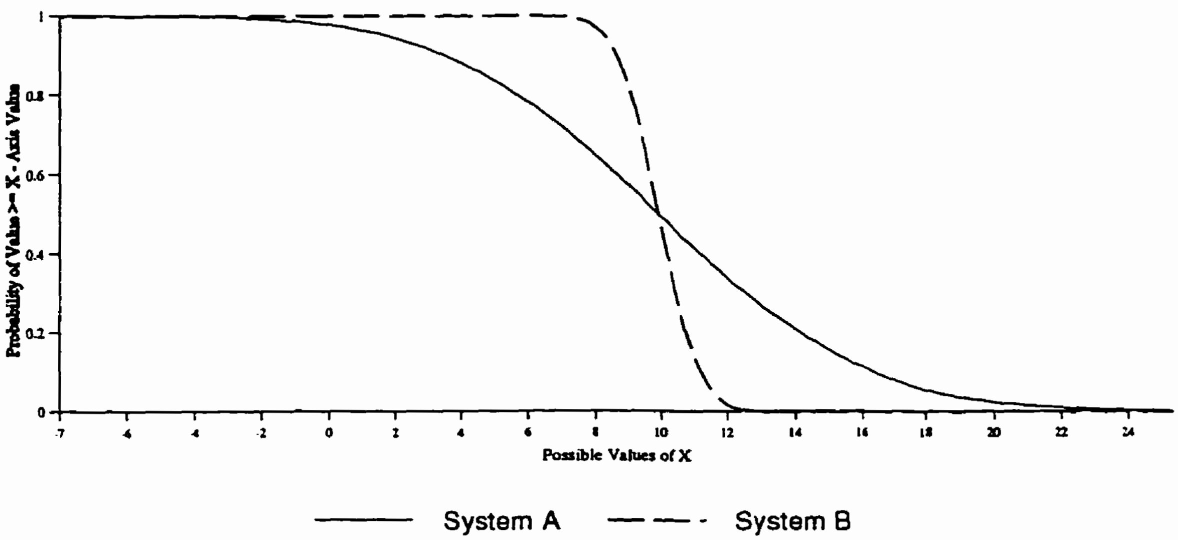
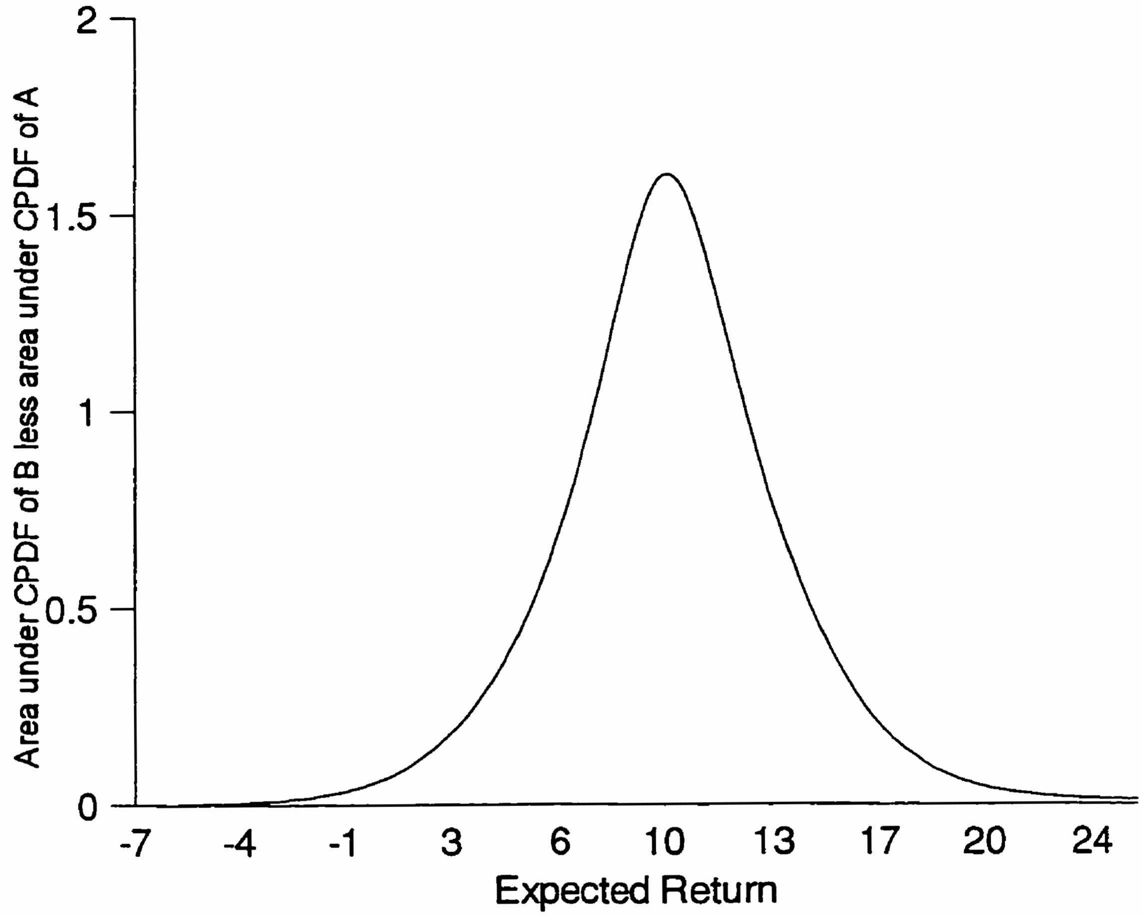


Figure 2.3: Difference in Areas Under CPDF Curves, SSD Example



3.0 Annual Small Landholder Production and Its Value

This chapter introduces the physical environment found in the Pedro Peixoto project. This is followed by a review of the production practices of small landholders in the region, and a description of their typical annual agricultural production. The estimate of annual production is combined with price distributions through simulation analysis (as outlined in the previous chapter) to derive a stochastic estimate of the value of annual agricultural production. This estimate is then compared to the annual minimum wage, and the World Bank's poverty line estimate.

3.1 Production Environment

This section gives the reader a brief overview of the production environment for small landholders in the Pedro Peixoto project in order to provide context to discussions that will follow in later sections.

3.1.1 Soil Environment - General

Seventy-five percent of the soils in the Amazon region are classified as Oxisols and Ultisols. Both Oxisols and Ultisols tend to be acidic. Oxisols can be described as deep, well-drained red or yellow soils, low in natural fertility, with a high clay content. These soils usually have a highly stable granular structure, which facilitates the working of the soil (Sanchez, 1976). The granular nature of these soils also allows for adequate development of the plant root systems. The structure of Oxisols is stable, and does not quickly deteriorate under cultivation or due to heavy rains. Oxisols drain well, and allow for easy penetration of rainfall. However, due to the granular nature of the soil structure, they also are susceptible to drought (Greenland, 1979). Oxisols are generally located in areas with little slope, but not subject to flooding (Sanchez, 1976).

Ultisols have been described as deep well drained red or yellow soils, low native fertility, with fewer desirable physical properties than Oxisols. Like Oxisols, these soils tend to be acidic. The difference in soil structure is due to a lower clay content (Sanchez, 1976). Because of the less desirable soil structure, these soils are often more difficult to cultivate. The lower clay content of these soils also means that their ability to hold water is lower than Oxisols, and they are more susceptible to drought (Greenland, 1979). Ultisols often have course topsoil, which increases the risk of erosion. These soils are also more prone to compaction problems than Oxisols. Ultisols are often found on the edge of gentle slopes, and are frequently next to Oxisols (Sanchez, 1976).

3.1.2 Soil Production Constraints - General

Nitrogen is the nutrient that most commonly limits yield potential (Sanchez, 1976). Because nitrogen is a highly soluble compound, it is susceptible to leaching caused by the high amounts of rainfall found in the Amazon region (de Boot et al., 1979). The vast majority of soils in the Amazon region (90%) also suffer from a deficiency in phosphorous. Aluminium toxicity is the next most common constraint to plant growth. This constraint occurs in the acidic soils (73% of Amazon soils) (Sanchez et al., 1982).

Cation exchange capacity is another important measure of soil quality. Cations refer to positively charged plant nutrients such as, calcium, magnesium, or potassium.

Cation exchange capacity is a measure of a soil's ability to absorb and hold essential plant nutrients. A soil with a low cation exchange capacity will have fewer available nutrients than a similar soil with a higher cation exchange capacity (Brady, 1984). As previously mentioned, most soils in the Amazon region tend to be acidic. This is an important factor when cation exchange capacity is considered. Cation exchange capacity decreases as soil pH declines. That is, the ability of a soil to hold available nutrients declines with pH levels (Brady, 1984). This has important implications for the native fertility of the soil and the effectiveness of supplemental fertilizers. If supplemental fertilizers are added to soils with low cation exchange capacity, a large portion of the added nutrients will not be absorbed by the soil and will not be available for plant growth. Beyond being unavailable for plant growth, the unabsorbed portion of the supplemental fertilizer will be subject to leaching (Brady, 1984). Given the high volume of rainfall in the Amazon region, this has significant implications for the effectiveness of supplemental fertilizers. According to Sanchez et al. (1982), approximately 15% of soils in the Amazon region suffer from a low effective cation exchange capacity. The addition of limestone, or another basic compound, can increase the effective cation exchange capacity of soils (Brady 1984). However, Sanchez et al. (1982) suggest that the addition of limestone to Amazon soils with low cation exchange capacity may negatively affect other soil properties.

Historically, laterite formation or the development of a hard impermeable layer of soil has been cited as one of the major constraints to agriculture in the Amazon region (Sanchez, 1976). However, only about 4 percent of the soils in the Amazon region are subject to laterite formation (Sanchez et al. 1982).

The productivity of tropical soils may decline under continuous production, even if supplementary fertilizers are available (Lal, 1979). This is due, in part, to a deterioration of soil physical properties under cultivation (Lal, 1979, Sanchez, 1976). Because of cultivation, the soil particles break down into smaller particles. This decreases the rate at which water can flow through the soil, which in turn reduces plants' ability to retrieve nutrients, and increases the susceptibility of the soil to erosion. The rate of deterioration in soil structure is dependant (among other factors) on the type of soil. For example, the aggregate particles found in Oxisols are more stable than the aggregate particles found in Ultisols (Sanchez, 1976). Therefore, continuous cultivation will have a greater impact on Ultisols than Oxisols. Management practices that reduce tillage can reduce the rate of degradation of soil physical properties, and improve on the soil's fertility (Lal, 1979). The use of agricultural systems, such as intercropping, that protect the soil from the impact of falling rain can also reduce the rate of soil structure decomposition (Sanchez, 1976).

3.1.3 Soil Production Constraints - Pedro Peixoto

The International Food Policy Research Institute (IFPRI) and Empressa Brasileira de Pesquisa Agropecuária (EMBRAPA) conducted socioeconomic surveys in the government directed settlement project of Pedro Peixoto during 1994 and 1996. The location of each agricultural lot included in the survey was plotted on soil survey maps of the Pedro Peixoto project to classify the soil types found in the survey sample. It was found that Oxisols are the soils most commonly found in the project.

The soil types found in the project were also grouped into classes, based on the primary constraint to agricultural production. It was found that 35% of the soils in the survey region have a single constraint to agricultural production, fertility. Fifty-one percent of the soils in the Pedro Peixoto survey region have fertility and slope as the primary soil constraints to production. Nine percent of the soils in the survey region have poor drainage as the primary soil constraint to production and 5 percent of the soils in the survey region have a severe slope, usually combined with fertility, as the primary soils constraint to agricultural production.

3.1.4 Production Practices

Fujisaka et al. (1995) have also used the results of the survey of the Pedro Peixoto settlement project. A summary of the findings by Fujisaka et al. (1995) provide an overview of the farming practices in the area. The government settlement project of Pedro Peixoto covers 370,000 ha. The land was divided into approximately 3,700 parcels of land and distributed to about 3,200 families. The climate in the Pedro Peixoto can be classed as warm and humid, with an average temperature of about 24 C, and annual rainfall of approximately 2,000 mm.

The majority of small landholders in the Pedro Peixoto project practice a form of slash-and-burn agriculture. Sanchez (1976) gives a detailed description of the shifting cultivation (or slash-and-burn) cycle. Traditionally producers that practice slash-and-burn agriculture clear a small area of forest, burn the residue, and simultaneously plant several crops. Often higher nutrient demanding crops, such as rice, are planted immediately after clearing, followed by less demanding crops such as cassava. Crops are typically grown in a sequence that mimics forest regrowth, with each crop becoming successively taller (e.g., cassava followed by plantains). Plots are abandoned when yields decline below acceptable levels (due to weed infestations or declining fertility for example). This typically occurs two to three years after the plot has been cleared. The plot is then left fallow and returns to native vegetation.

The slash-and-burn production system depends upon the forest as a source of nutrients for crops. Nutrients bound in organic matter are released and made available for crop production in the ash when the forest is cleared and burned. During the fallow periods the forest is allowed to regenerate, restoring the stock of nutrients available for crop production. In studies conducted in Africa it was found that forest growing on an Ultisol base will restore the depleted nutrients in about eight years (as noted by Sanchez (1976) this schedule may differ slightly under different growing conditions). Similarly, in work conducted in the eastern Brazilian Amazon, near Paragominas in the state of Pará, Buschbacher and Uhl (1988) discovered that the majority of nutrients had been restored after eight years.

Sanchez (1976) notes that this cycle is sustainable as long as the fallow period is sufficiently long enough to allow nutrient regeneration. However, productivity usually falls rapidly, with most plots no longer producing annual crops one to three years after clearing. Therefore, this type of production system requires continual clearing to maintain production levels. If small holders attempt to extend the cropping period, the rate of forest regrowth upon abandonment will be slower and the required fallow period will be longer. Shortening the fallow period will release fewer nutrients upon reclearing and may result in slower forest regrowth in subsequent fallow periods.

Small landholders in the Pedro Peixoto cultivate lands cleared of primary forest for approximately two years. Rice is the annual crop planted most frequently in the first year after clearing. Rice is generally not grown following this first planting. Other annual crops, such as corn, are sown after the rice has been planted (Fujisaka et al., 1995) (often in conjunction with the rice crop). Intercropping, or the practice of simultaneously growing more than one crop in the same area, is a practice frequently used in the Amazon region (Sanchez, 1976). The 1994 survey does not estimate the degree to which intercropping is used in the Pedro Peixoto project, however, preliminary results from a similar survey conducted in the region in 1996 show 58% of respondents practised intercropping.

After annual crop production, a majority (approximately 66%) of the small landholders in the survey convert the land into pasture. Small landholders in Pedro Peixoto most commonly planted three species of Brachiaria, *Brachiaria brizanta*, *Brachiaria decumbens*, and *Brachiaria humilicola*, in land converted to pasture. Most small landholders in the settlement project burned their pastures annually. The average stocking rate in 1994 was 1.2 head per ha (Witcover et al., 1996). As will be discussed in later sections of this chapter, pasture products (milk and beef) compose a large portion of the value of small landholders agriculture production.

Approximately 1/3 of the land (that area not converted to pasture) is converted to fallow after annual crop production. Small landholders in the Pedro Peixoto project generally leave the land fallow for approximately 2 ½ years. Then fallow land is recleared and used for annual crop production, following a production pattern similar to newly cleared land (Fujisaka et al., 1995). The fallow period is less than optimal. Survey respondents indicated that they would prefer to leave their land fallow from four to six years (Witcover, 1996). This period is much closer to the optimal time frame of approximately eight years identified by Sanchez (1976).

3.2 Sample Production Basket

This work uses primary production data gathered by IFPRI / EMBRAPA during 1994. A review of these data can be found in Witcover et al. (1996). The data were gathered through surveys of small landholders in the Pedro Peixoto government-directed settlement project in the state of Acre, Brazil. An overview of the survey methodology and a sample of the survey has been published as a working paper by Witcover and Vosti (1996). The survey was given to approximately 90 households in the Pedro Peixoto project, from August 29, 1994 through September 3, 1994 (Witcover and Vosti, 1996). Besides the published data, this study will also use survey data that have not yet been published.

Price variation will be examined in commodities that have a median production greater than zero in 1994 (rice, corn, beans, milk, beef, and Brazil-nut). Median area in production (Table 3.1) has been multiplied by median yield (Table 3.2) to derive production estimates (Table 3.3).

For each commodity, yield and area estimates have been derived from sub-samples of the 1994 survey. For a given commodity, all producers in the Pedro Peixoto survey that had area dedicated to that particular commodity are included in the sub-sample. This includes producers that reported land area in that crop but did not report production. Producers with zero production were included in the sub-sample to take into account the possibility of production failure. Producers in the Pedro Peixoto sample that did not have land area dedicated to a particular commodity were not included in the sub-sample. For example, if a producer reported having land planted in rice and corn, but not beans, their survey responses would be included in the sub-sample for rice and corn, but not beans. If the same producer reported that no rice was harvested (due to insect infestation for example), their survey responses would still be included in the sub-sample used to generate the estimate of rice yield.

The distributions for area and production per area are skewed to the right (Table 3.1 and 3.2). Consequently, median yields and areas are used as the indicator of central tendency to reduce the impact of unusual producers found in the right-hand tail of the area and production distributions.

Median yields for rice, corn, and beans, are similar but below other estimates for the state of Acre. For example, IBGE-DIPEQ-Acre (1996) has estimated the following median state yields (per hectare) for 1996: 1,210 kg of rice, 1,261, of corn, and 581 kg beans. In quoting official statistics, Cunha and Sawyer (1997) give the following yields (per hectare) for 1995 in the north of Brazil: 900 kg of rice, 900 kg, of corn and 700 kg of beans. This is compared with survey estimates of median yields: 900 kg of rice, 737 kg of corn, and 361 kg of beans. The difference between the median yield estimates in Table 3.2 and the other yield estimates may be due to the inclusion of larger farms in the official results. These farms have greater access to credit and improved technology than small landholders in Pedro Peixoto. As a result, larger farms may have a higher yield potential. No comparable alternative statistics were found for the number of kg of Brazil-nuts extracted annually from forest reserves.

Estimates of annual milk production have been derived from the survey in a slightly different manner. Reliable estimates of the number of lactation days are not available from the survey results. The average number of lactation days would be required to estimate milk production from dairy herd size. Estimates of median milk production (Table 3.4) in the rainy and dry season are derived from small landholders' estimates of daily production. As with the annual crops, the production distribution for milk is skewed to the right (Table 3.4). Again, median production is used as the estimate of central tendency to reduce the influence of production in the right-hand tail of the distribution.

From the 1994 survey, median production in the dry season was 2 litres/lactating cow per day. Median production in the wet season was 3 litres/lactating cow per day. Dividing the daily median production in Table 3.4 by the litres per cow per day yields an estimate of 2.5 lactating cows in the dry season and 3.3 lactating cows during the wet season (or an average of three lactating cows for the entire year).

Again estimates of daily production are similar but below other estimates of milk production in the region. For example, EMATER / EMBRAPA (1980) estimate that average regional production from unimproved pasture is approximately 4 litres per lactating cow / day. For milk production there is another reason, beyond the potential difference between small and large farmers previously mentioned, for the difference between milk production as estimated in Table 3.4 and other estimates in the region. Some small landholders will not have access to dairy processors (Faminow and Vosti, 1998). This is especially true during the rainy season when road infrastructure deteriorates. During times when access to markets is restricted, it is likely that these farmers will only harvest enough milk to supply their family needs (or perhaps their neighbours), and allow the remainder to be consumed by calves. This will reduce both the harvest period, and the average production during this period.

Estimates of beef production are also extracted from the survey differently than the annual crops. For beef production, estimating the annual increase in animal size is important. This method was chosen over estimating the number of animals sold in each year to account for small landholders who are increasing their herd size. Other studies in the Amazon region have shown that the small landholders generally avoid selling female calves that are kept to replenish and increase the herd (Faminow et al., 1998). The belief that some producers may be increasing their herd size is also consistent with the large increases in the size of the Amazon herd experienced over recent history (Faminow, 1997).

From the 1994 survey, it has been estimated that the median herd size in Pedro Peixoto is 13 animals. Determining the age composition of the herd accurately from the survey is not possible. However, Faminow et al. (1998) found that approximately 50 percent of the emerging cattle herd was composed of animals in growth stages. It should be noted that this work was conducted in a different region of the Amazon and may be viewed as an approximation for Pedro Peixoto herd. Based on this approximation, 6.5 animals of the median herd in Pedro Peixoto are in the growth phase. According to Valentim (1989) these animals gain at an average rate of 90 kg per year on unimproved pasture. Based on these estimates, a herd of 13 animals will gain 585 kg per year. The common measurement unit of dressed meat in the region is an arroba. One arroba is equal to 30 kg of live weight. Therefore, based on the above assumptions, a herd of 13 animals will gain 20 arroba per year.

The estimate of annual beef production is similar to other estimates of production from unimproved pastures in the Amazon. Faminow (1998) presents an average annual herd growth of 24 to 27 kg/ha from natural grasses in the state of Pará. From the 1994 survey small landholders in the Pedro Peixoto project have an average of 18 ha of pasture (Witcover et al., 1996). Using the statistics from Pará, this translates into an annual gain of 440 to 490 kg (live weight per year). The estimates of herd growth from unimproved pastures are well below the estimates of herd growth from improved pastures. For example, statistics from experimental farms in Pará place annual gains between 161 and 181 kg per animal, and estimates from planted pastures in Pará place annual gains between 52 and 68 kg/ha (this translates into a growth rate between 950 kg and 1,240 kg per animal per year on 18 hectares of pasture) (Faminow, 1998).

In summary, the example 1994 production basket for small farmers in Pedro Peixoto is: 2,180 kg of rice, 1,780 kg of corn, 720 kg of beans, 798-kg of Brazil-nuts, 2,900 litres of milk, and 600 kg (live weight) of beef (20 arroba). To give an indication of how well this production basket represents small landholders in Pedro Peixoto, 40% of small landholders in the survey produced all six commodities in the sample production basket during 1994 and more than 80% of small landholders in survey produced between four and six of the commodities found in the sample production basket.

3.3 Price Variability

Robison and Barry (1987) define risky circumstances as "uncertain events whose outcomes alter a decision makers well-being" (Robison and Barry, 1987). This definition unquestionably applies to commodity prices.

Price uncertainty may alter a producer's production decisions. The degree to which price uncertainty affects production decisions is directly related to producer's ability to predict future price changes (Robison and Barry, 1987). Therefore, differences in price uncertainty may help explain small landholders' production decisions.

3.3.1 Prices - Collection

Prices for the various commodities examined have been collected from the Brazilian extension agency (Empresa de Assistência Técnica e Extensão Rural or EMATER) in the state of Acre. Prices were collected for all commodities included in the 1994 sample production basket. The price series for each commodity begins in 1992 and carries through to July 1997 (Table 3.5).

Some caution is required when using the EMATER price series (Faminow et al., 1998). The sampling methods used by EMATER may not always be scientific and the data collection is not continuous. However, the EMATER price series is the most comprehensive price series available for these commodities in this region.

All prices have been deflated using an internal general price index collected from the Fundação Getúlio Vargas. The deflator is a national weighted index of wholesale prices (60%), consumer prices (30%), and construction prices (10%) (Fundação Getúlio Vargas, 1994).

EMATER collects the price information on a local level. The price series presented are averages of the local districts that make up the municipalities of Plácido de Castro and Rio Branco (Table 3.5). These are the markets that small landholders in Pedro Peixoto will be most likely to deliver their commodities.

The price series for Brazil-nut is an exception. Averaging the prices for the local districts did not yield an adequate number of observations. More than half of the observations from 1992 through July 1997 were missing for the two-municipality average. Consequently the Brazil-nut price series is based on an average for the state of Acre. However, based on the limited data for the municipalities of Pedro Peixoto and Plácido de Castro, and on conversations with EMBRAPA / IFPRI, and EMATER researchers, it is believed that the statewide average prices for Brazil-nut normally exceed the Pedro Peixoto price. One explanation given for this price difference is the existence of producer cooperatives in other regions in the state. These cooperatives may increase the market power of producers when dealing with the single purchaser of Brazil-nuts in the region.

To more accurately reflect the price received by the small landholder in Pedro Peixoto, the state average price for Brazil-nut has been multiplied by a factor of 0.65 (Table 3.5). The adjustment factor was determined through a simple linear regression comparison of the two price series (r-square of 0.37) and discussions with EMATER and EMBRAPA researchers. Sensitivity analysis has been conducted using different adjustment factors. The results of the sensitivity analysis are displayed following the simulation of expected returns.

3.3.2 Prices - General Description

From the coefficients of variation (Table 3.5) it can be seen that small landholders in Pedro Peixoto face a high degree of price variation. The degree of price variation for the commodities in the typical production basket is higher than for other regions of Brazil. For example, for all prices that were available for comparison, the coefficient of variation is lower in the southern state of Paraná. In Paraná during the same period (January 1992 through July 1997) the coefficient of variation for rice was 12%, 21% for beans, 15% for corn, and 15% for beef (Secretaria da Agricultura, monthly). The coefficients of variation in the Pedro Peixoto project are similar to other findings in rural states outside of the southern region. For example, Araujo (1995) found coefficients of variation of 25% for rice and corn in the north east of Brazil.

The coefficient of variation also is useful in comparing price variation (the source of price risk) inherent in prices of different commodities. The degree of price variation is lowest for beef and milk, followed by rice, corn, beans, and Brazil-nut respectively (Table 3.5). As price variation is the source of price risk (Young, 1984), by this measure beef and milk have the lowest degree of price risk, while Brazil-nut has the highest degree of price risk.

However, as discussed in Chapter Two, price trends may represent a predictable source of price variation. Trends have been removed from the price series through first differencing. This isolates the random variation in prices from one month to the next. The coefficient of variation from the de-trended price series shows the same ranking as the original data. That is, the lowest degree of price risk is found in beef, followed by milk, corn, rice, beans, and Brazil-nut respectively (Table 3.5). However, removing the trends increases the differences between commodities. If the commodities are grouped by land use, it can be seen that the degree of random price variation is lowest for commodities derived from pasture, followed by annual crops, and is highest for the commodity extracted from forest reserves.

Price variation is higher than variation generally found on North American commodity exchanges. Table 3.6 compares price volatility for three different cases: the Chicago Board of trade, Paraná and the municipalities of Plácido de Castro and Pedro Peixoto. On January 30, 1998, the Chicago Board of trade listed the volatility for March wheat at 22%, March oats at 27%, March soybeans at 18% and March Soybean meal at 20% (www.cbot.com). The price volatility for the commodities in the typical production basket is: 83% for rice, 65% for corn, 99% for beans, 68% for milk, 49% for beef and 700% for Brazil-nut. Similar to the case of the coefficient of variation, price volatility is much higher for prices in the Pedro Peixoto project than for the same commodities in the state of Paraná.

Given the high degree of price variability, a discussion of returns from agricultural production can not only focus on the mean returns, or expected value. Variation around the mean must also be considered. If a range of probable outcomes is considered, and not just the most probable outcome (i.e., the expected value) farmers can make better planing decisions, and allocate their resources more efficiently (Sonka and Patrick, 1984). In this study, price variation is incorporated into estimates of gross return from the sample production basket through the use of spreadsheet simulation models.

3.4 Simulation - Prices from 1992 through 1997

A simulation model for annual small landholder gross returns has been constructed using the sample production basket and prices from 1992 through 1997, following the procedures outlined in Chapter Two.

As outlined in Chapter Two, correlations between the various prices may impact the simulation results. The various price series were tested for correlations. The significance of the correlations was tested using a Z test, as outlined in Walpole and Mayers (1972). At a 95% significance level the critical region for the Z test is -1.96 through 1.96. If the calculated Z statistic falls outside this region the hypothesis that there is significant correlation between two prices (Walpole and Myers, 1972). It was found, that from January 1992 through July 1997 the price of rice was significantly correlated with the price of corn and Brazil-nut, and the price of milk was correlated with the price of beans and negatively correlated with the price of corn (Table 3.7). The correlations between rice and corn and between rice and beef have been integrated into the simulation model to yield realistic results (Walker and Helmers, 1984).

As described in Chapter two, the stability (or convergence) of the simulation model was monitored. As the percentage change (between iterations) in every fifth percentile, the percentage change in the mean, and the percentage change in the standard deviation were below 1.5%, the simulation model can be considered stable (Pallisade, 1997).

3.4.1 Simulation Results

Annual value of agricultural production, as estimated through the simulation process, is given in Table 3.8. Two standard deviations below and above the mean gives a range for gross returns from the sample production basket of R$ 2,208 to R$ 3,824 annually. In 1995 the World Bank estimated (World Bank, 1997) the Brazilian poverty line to be 1,104 1996 Reais for the average household of 4.5 individuals. The estimated value of the sample production basket falls above the World Bank's poverty line estimate. The estimated value of annual production is also above the minimum wage, which in 1994 averaged approximately $R 1,200 (Fundação Getúlio Vargas, 1994, unpublished). Note that the estimated annual return is above the annual income from off farm labour even if it is assumed that the average family earns two minimum wages per year. This does not infer that small landholders that produce these commodities are not poor. It simply shows that they are better off than the poorest residents of Brazil. Evidence exists of a downward trend in prices, which may move producers of the sample production basket closer to the poverty line. This issue will be addressed in the next chapter.

The coefficient of variation for gross returns is below the coefficient of variation for any single price series (Table 3.5 and 3.8). Increasing the number of commodities in the production basket decreases the risk associated with the variability in the price of any one commodity. This is the same effect as a diversified investment portfolio. Producers of a number of different commodities face lower price risk than a producer who chose to specialize in the production of only one commodity (Robison and Barry, 1987).

3.4.2 Relative Commodity Importance

Evaluated at mean levels, milk and beef form a large portion of small farmers gross return from agricultural production (Table 3.9) at 35 percent and 16 percent respectively. Combining the percentage of revenue from milk and beef show that pasture products contribute 51 percent of the value of the sample production basket. This finding is consistent with Araujo (1995) who discovered a negative relationship between price variation and the quantity produced in the northeast of Brazil.

Beans are the next most important commodity, generating 17 percent of the value of the sample production basket. Beans are followed in importance by, rice at 16 percent of value and corn at 10 percent of value. Annual crop production accounts for 43 percent of the value of the sample production basket. The remaining 5 percent of the sample production basket's value is derived from the extraction of Brazil-nuts from forest reserves.

Several different ongoing factors, market integration for example, may be affecting commodity prices. Evidence of changes occurring in commodity prices may be seen by viewing graphs of the different price series such as presented in Chapter Four where a more in-depth look at commodity prices is taken, in order to learn if prices are changing over time and to detect if these changes have had a positive or negative impact on the value of the sample commodity basket.

3.4.3 Sensitivity Analysis

Brazil-nut prices used in the simulations have been adjusted to reflect perceived differences between the average state price and the price received by Pedro Peixoto producers. The sensitivity of simulated expected returns to changes in the adjustment factor has been tested by changing the adjustment factor and repeating the simulation of expected returns. Three alternative adjustment factors were tested: 0.45, 0.85, and no adjustment (i.e., and adjustment factor of 1)

The results of the simulations using the different adjustment factors for Brazil-nut are similar to the simulated expected return using the adjustment factor of 0.65. Using an adjustment of 0.45 the mean expected gross return was R$ 2,960 with a standard deviation of R$ 389. Using an adjustment factor of 0.85 the mean expected gross return was R$ 3,039 with a standard deviation of R$ 400. Using no adjustment factor yields a mean expected gross return of R$ 3,063 with a standard deviation of $R 410.

The expected gross returns using the alternative adjustment factors for Brazil-nut all lead to expected returns that are within one standard deviation of the expected return using an adjustment factor of 0.65. That is, simulated expected returns are not sensitive to the tested changes in the adjustment factor for Brazil-nut prices.

3.4 Seasonality

Some of the commodity prices may have seasonal variations. These seasonal variations may affect the value of production for some small holders in the Pedro Peixoto settlement project. Some small holders may, for cash flow reasons, be forced to sell their surplus commodities immediately after harvest, when prices may be depressed. Some small land holders, especially producers near the end of developed roads, may have restricted marketing opportunities due to road conditions during the rainy season. Other small landholders may have the opportunity to store their surplus production in order to capture prices during high price seasons. The following sections examine prices for the commodities in the typical production basket for evidence of seasonality, and simulate the impacts of marketing production during low and high price seasons.

3.4.1 Evidence of Seasonality

Following procedures outlined by Schwager (1995) a price seasonality index was constructed for each of the commodity found in the typical production basket. The seasonal index is calculated as follows: (1) an average price is calculated for each year, (2) each monthly price is expressed as a percentage of the average yearly price (i.e., actual monthly price divided by yearly average price), (3) the seasonal index for each month is calculated as the mean (from January 1992 through July 1997) of the monthly percentages calculated in step two.

For annual crops (rice, corn, and beans) the price index peaks in the periods prior to the harvest season and troughs in the periods following the harvest period (Figures 3.1 through 3.3). Generally, the low price months also correspond with the dry season (May through September) and the high price months correspond with the rainy season (October through April). These results are not surprising, as prices are expected to fall as additional product becomes available after harvest, and expected to rise as the quantity supplied declines due to reduced available stocks as well as reduced access to market (market access will be reduced for some small landholders during the rainy season due to road deterioration). Confirmation that seasonal price trends for the annual crops follow economic theory verifies, at least to some degree, the reliability of the price data. If, for example, it was found that prices peaked just after harvest with no accompanying market explanation (e.g., a peak in the quantity demanded during the same period) the reliability of the data could be brought into question.

Monthly price indices for milk and beef (Figures 3.4 and 3.5) also display results that are consistent with economic theory. Unlike the annual crops, milk and beef do not have a distinctive harvest season. As expected milk and beef prices do not show the same degree of seasonality as annual crops (Figures 3.4 and 3.5). However, milk and beef do show some seasonality, with prices increasing during the rainy season and decreasing during the dry season. Again, this result is expected as market access declines during the rainy season due to declining road conditions.

Brazil-nut prices peak during September and October (Figure 3.6). Based on discussions with EMBRAPA researchers, almost all of the Brazil-nuts marketed in Acre are exported outside of Brazil, and the price of Brazil-nuts in the state is dependant upon world demand for nuts and world price cycles. This is consistent with Richardson (1995) who indicates that only 5% of the annual Brazil-nut harvest remains in Brazil. Richardson (1995) also discovered similar seasonal prices, with peaks occurring during the October - November period which he attributes to seasonal peaks in the quantity of nuts demanded on the world market due to holiday nut demand.

Figures 3.1 through 3.6 demonstrate that prices for annual crops included in the typical production basket (rice, corn, and beans) as well as prices for Brazil-nut show the greatest degree of seasonality. The following two sections will simulate the impacts of marketing these products during the peak prices periods as well as the impact of marketing these products during the low price periods.

3.4.2 Simulation Results - Impact of Marketings During Peak Price Periods

Some producers in the Pedro Peixoto settlement project may be able to take advantage of the high portion of the seasonal price cycle for annual crops and Brazil-nuts. In order to simulate this possibility, the simulations conducted in section 3.4 have been repeated, using average prices and standard deviations (across all years of data) (Table 3.11) from the three months showing the highest seasonal index for rice, corn, beans, and Brazil-nut. From Table 3.10 it can be seen that the months of November, December, and January are the peak months for rice and corn, while the peak months for beans are

March, April and May. For Brazil-nut the peak months are August, September, and October.

Comparing the simulation results using peak prices periods (Table 3.12) with the simulation results using all prices (Table 3.8) shows that the expected income increases by 7% if small landholder can capture peak price periods. However, from observing Table 3.8 and 3.12, it can be seen that the expected returns generated using prices throughout the entire year are within one standard deviation of the expected returns generated using peak price periods. This implies that small landholders who are able to capture peak price periods will not receive a significantly different expected return from producers that market their products evenly through the entire year.

3.4.3 Simulation Results - Impact of Marketings During Low Price Periods

Due to cash flow requirements and due to road deterioration during the rainy season, some producers in the Pedro Peixoto settlement project may be forced to market their surplus production during low price periods. Similar to section 3.5.2, expected returns have been simulated using low price periods. From Table 3.10 it can be seen that the lowest three-month period for rice is March through May, May through July for corn, August through October for Beans, and November through January for Brazil-nut.

Expected returns have been simulated using the average prices and standard deviations for these periods (Table 3.13). The results (Table 3.14) show a 9% decline in expected return from the simulations conducted in section 3.4 (Table 3.8). However, as with the simulations using peak price periods, expected returns from the low prices periods are within one standard deviation of expected returns generated using the compete time series. This implies that small landholders who are forced to market their products during low price periods will not receive a significantly different return from producers that market their product evenly through the entire year.

3.5 Summary of Results - Chapter Three

The following is a brief summary of the research findings presented in Chapter Three.

- Typical annual production for small landholders in the Pedro Peixoto project is approximately: 2,180 kg of rice, 1,780 kg of corn, 720 kg, of beans, 2,900 litres of milk, 300 kg dressed beef (600 kg live weight), and 800 kg of Brazil-nut.

- Price risk is lowest for pasture products, (beef and milk), followed by the annual crops (corn, rice, and beans respectively), and is highest for the extracted product, Brazil-nut.

- Estimated expected return from the typical production basket is 3,000 Reais per year. This is almost three times the World Bank's estimate of the poverty line (1,100 Reais per year) and two and ½ times greater than the annual minimum wage (1,200 Reais per year)

- Pasture products (beef and milk) contribute the largest percentage of income (54%) to total small landholder gross annual return. Pasture products are followed in importance by beans, rice, and corn respectively. Of the commodities in the typical production basket, Brazil-nut contributes the least to annual gross return (5%).

- Evidence of price seasonality was presented. It was discovered that the seasonal patterns in the annual crops and the pasture products follow expected patterns. That is, prices tend to decrease after harvest (for annual crops) and during the times of increased market access (for annual crops and pasture products). Brazil-nut prices appear to be influenced by holiday peaks in the quantity demanded.

Table 3.1: Area (ha) in Production - Pedro Peixoto 1994

Commodity	Mean	Median	Standard Deviation	Skewness	Units
Rice	2.81	2.42	2.29	1.89	ha
Corn	2.90	2.42	2.27	1.87	ha
Beans	2.41	2.00	2.32	2.39	ha
Brazil-nut	61.49	55.0	31.21	2.36	ha of forest

Source: IFPRI / EMBRAPA 1994 Survey

Table 3.2: Annual Crop Yields - Pedro Peixoto 1994

Commodity	Mean	Median	Standard Deviation	Skewness	Units
Rice	968	900	718	0.651	kg/ha
Corn	1,042	737	971	1.00	kg/ha
Beans	470	361	412	1.14	kg/ha
Brazil-nut	20.9	14.5	24.2	2.99	kg/ha of forest

Source: IFPRI / EMBRAPA 1994 Survey

Table 3.3: Estimated Annual Crop Production for Pedro Peixoto - 1994

Commodity	Estimated Production	Unit
Rice	2,180	kg
Corn	1,780	kg
Beans	720	kg
Brazil-nut	798	kg

Calculated from Table 3.1 and 3.2

Table 3.4: Estimated Pedro Peixoto Annual Milk Production

Litres/Day/Farm

	Mean Production/Day	Median Production/Day	Skewness	Total Median Production
Dry Season (150 days)	7.02	5.00	2.32	750
Wet Season (215 Days)	11.26	10.00	2.23	2,150
Annual				2,900

Source: IFPRI / EMBRAPA 1994 Survey

Table 3.5: Selected Price Data, January 1992 through July 1997, December 1996 Reais

Commodity	Number of Obs.	Min.	Max.	Mean	Std. Dev.	Coefficient of Variation	First Difference Coefficient of Variation	Unit
Rice	50	6.38	23.61	13.70	3.56	26%	31%	60 kg sack
Corn	60	6.42	17.89	10.58	2.45	23%	21%	60 kg sack
Beans	59	24.46	99.76	40.74	13.25	33%	33%	60 kg sack
Milk	58	0.18	0.51	0.36	0.08	23%	20%	Litre
Beef	58	16.68	38.14	24.48	4.07	17%	11%	Arroba
Brazil-nut (adjusted)	62	0.05	0.45	0.16	0.07	47%	55%	kg

Source: EMATER (unpublished)

Table 3.6: Comparison of Price Volatility

Commodity	Chicago Board of Trade*	Plácido de Castro and Rio Branco**	Paraná***
Rice	---	81%	24%
Beans	---	99%	34%
Corn	---	65%	25%
Milk	---	68%	---
Beef	---	49%	25%
Brazil-nut	---	700%	---
Wheat	22%	---	---
Oats	27%	---	---
Soybean	17%	---	---
Soybean Meal	20%	---	---

*Volatility of the March 1998 futures contract, January 30, 1998 from the Chicago Board of Trade Webpage (HTTP:/WWW.CBOT.COM)
** Calculated from EMATER (unpublished)
*** Calculated from Secretaria da Agricultura (various)

Table 3.7: Correlations Between Pedro Peixoto Prices: January 1992 - June 1997

	Rice	Corn	Beans	Milk	Beef
Corn	0.28*	-----			
Beans	-0.15	-0.24	-----		
Milk	0.04	-0.27*	0.37*	-----	
Beef	0.02	-0.04	0.26	0.05	-----
Brazil-nut	0.29*	-0.06	-0.17	0.22	-0.08

* Significant at a 95% confidence interval.
Calculated from EMATER (unpublished)

Table 3.8: Simulation Results, Production Basket Valued Using 1992 Through 1997 Prices

Minimum	Maximum	Mean	Standard Deviation	+/- 2 Standard Deviations	Coefficient of Variation
1,704	4,628	3,016	404	2,208-3,824	13%

Table 3.9: Percentage of Small Landholders Simulated Annual Gross Income By Commodity

Commodity	Percentage of Gross Income
Rice	16%
Corn	10%
Beans	17%
Milk	35%
Beef	16%
Brazil-Nut	5%

Table 3.10: Seasonal Price Indices
(Standard deviation in () below index)

Month	Rice	Corn	Beans	Milk	Beef	Brazil-nut
October	107 (13.77)	105 (13.21)	84 (15.910	93 (8.61)	97 (7.14)	111 (77.22)
November	112 (19.09)	120 (17.03)	94 (31.96)	89 (3.51)	97 (13.15)	82 (43.58)
December	114 (5.34)	123 (16.50)	92 (19.110	95 (10.41)	92 (10.49)	83 (56.74)
January	111 (12.45)	125 (14.41)	99 (8.68)	94 (18.93)	103 (11.12)	94 (34.25)
February	108 (26.58)	102 (16.43)	104 (11.52)	100 (8.59)	107 (14.90)	83 (27.90)
March	88 (14.54)	94 (13.92)	121 (27.69)	107 (5.17)	106 (6.45)	92 (26.36)
April	88 (13.92)	87 (14.73)	116 (22.06)	111 (6.16)	107 (8.22)	77 (18.49)
May	80 (18.51)	82 (13.50)	118 (22.15)	105 (11.40)	101 (4.25)	94 (30.63)
June	98 (9.94)	82 (10.10)	104 (14.35)	106 (14.33)	98 (2.57)	94 (31.17)
July	97 (6.71)	87 (7.22)	94 (11.74)	99 (7.02)	96 (10.92)	99 (39.88)
August	100 (9.76)	97 (5.30)	82 (8.31)	101 (6.12)	95 (10.03)	86 (42.35)
September	103 (11.18)	105 (15.41)	80 (13.85)	99 (4.19)	96 (7.19)	130 (40.87)

Calculated from EMATER (unpublished)

Table 3.11: Average Prices During Peak Price Periods - December 1996 Reais

Commodity	Average Price	Standard Deviation	Period
Rice (per 60 kg)	16.20	3.99	November-January
Corn (per 60 kg)	12.87	2.28	November-January
Bean (per 60 kg)	45.66	20.40	March - May
Brazil-nut (per kg)	0.22	0.11	August-October

Source: EMATER (unpublished)

Table 3.12: Simulation Results Production Basket Valued At Peak Price Periods - December 1996 Reais

Minimum	Maximum	Mean	Standard Deviation	+/- 2 Standard Deviations	Coefficient of Variation
1,866	4,826	3,236	378	2,480-3,992	12%

Table 3.13: Average Prices During Low Price Periods - December 1996 Reais

Commodity	Average Price	Standard Deviation	Period
Rice (per 60 kg)	11.79	2.61	March- May
Corn (per 60 kg)	9.25	1.74	May - July
Bean (per 60 kg)	34.58	7.11	August - October
Brazil-nut (per kg)	0.12	0.054	November - January

Source: EMATER (unpublished)

Table 3.14: Simulation Results, Production Basket Valued At Low Price Periods - December 1996 Reais

Minimum	Maximum	Mean	Standard Deviation	+/- 2 Standard Deviations	Coefficient of Variation
1,828	3,624	2,747	329	2,089-3,405	12%

Figure 3.1: Monthly Price Index for Rice
(100 = mean period price)

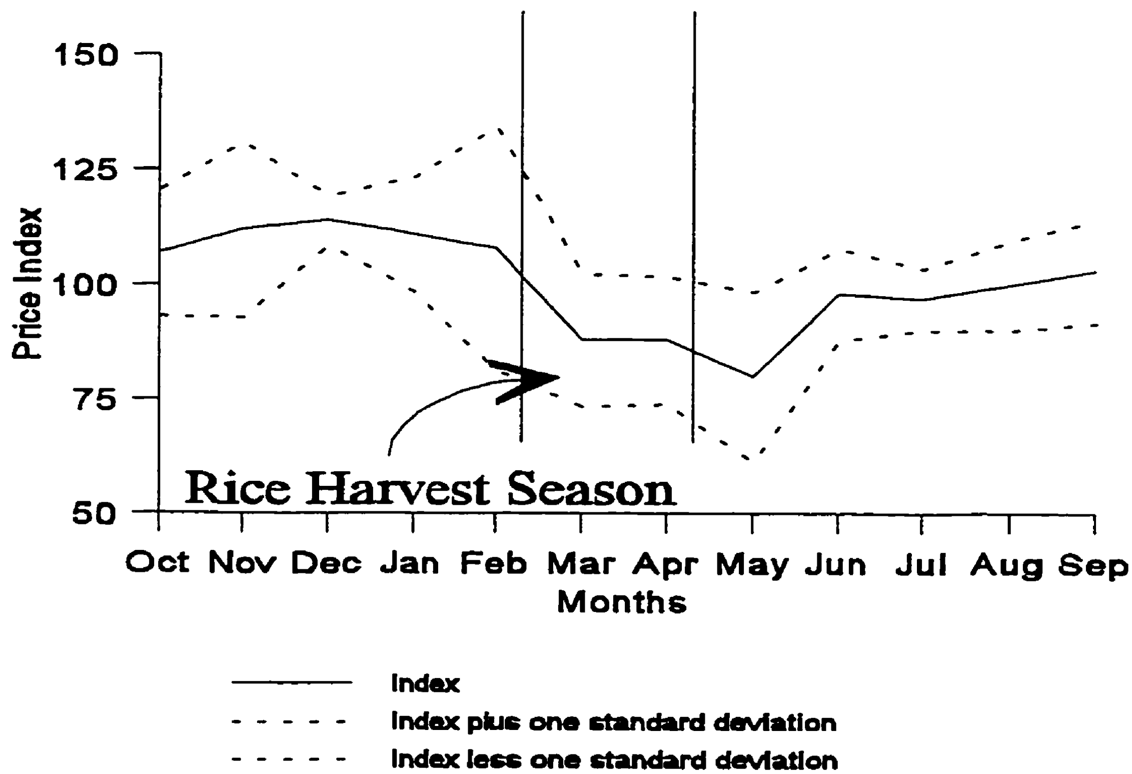


Figure 3.2: Monthly Price Index for Corn
(100 = mean period price)

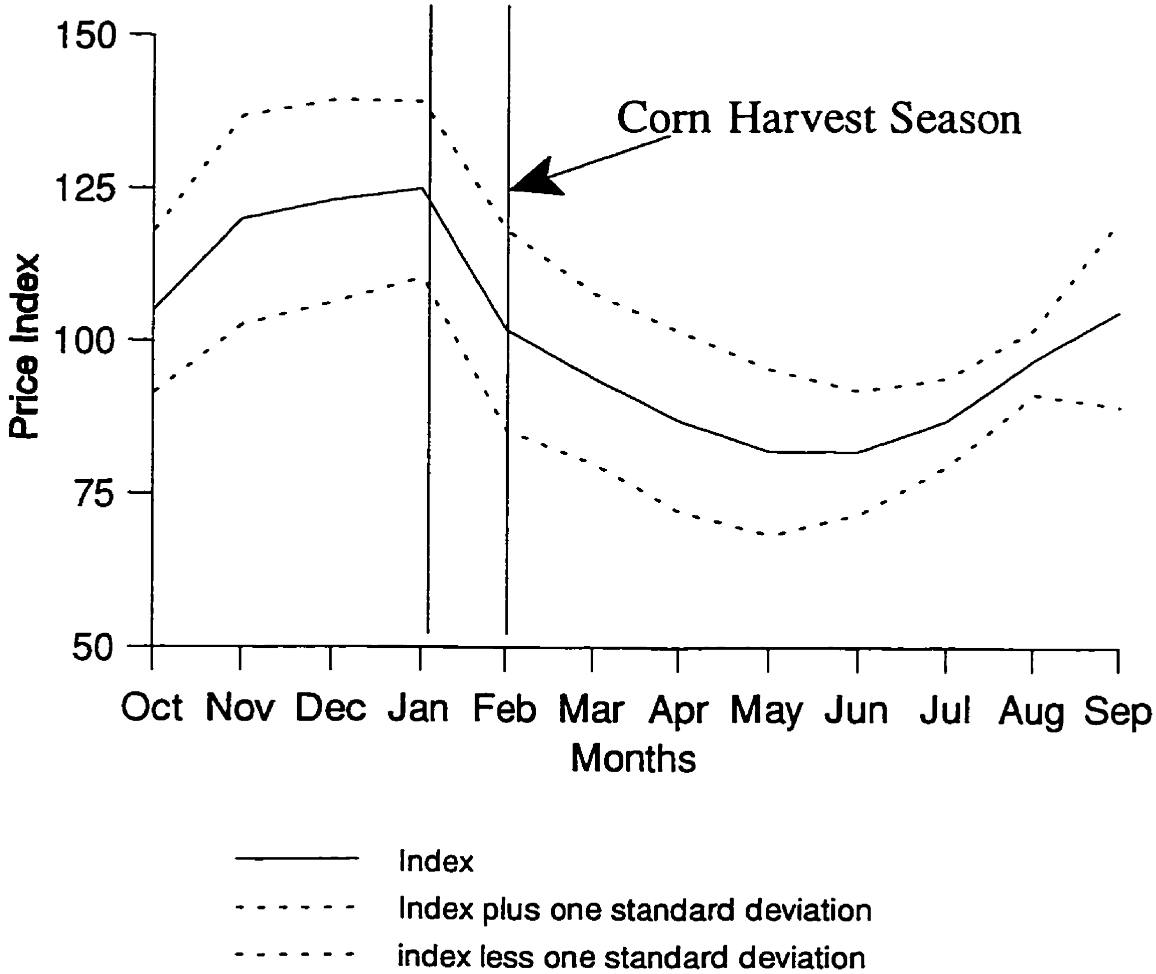


Figure 3.3: Monthly Price Index for Beans
(100 = mean period price)

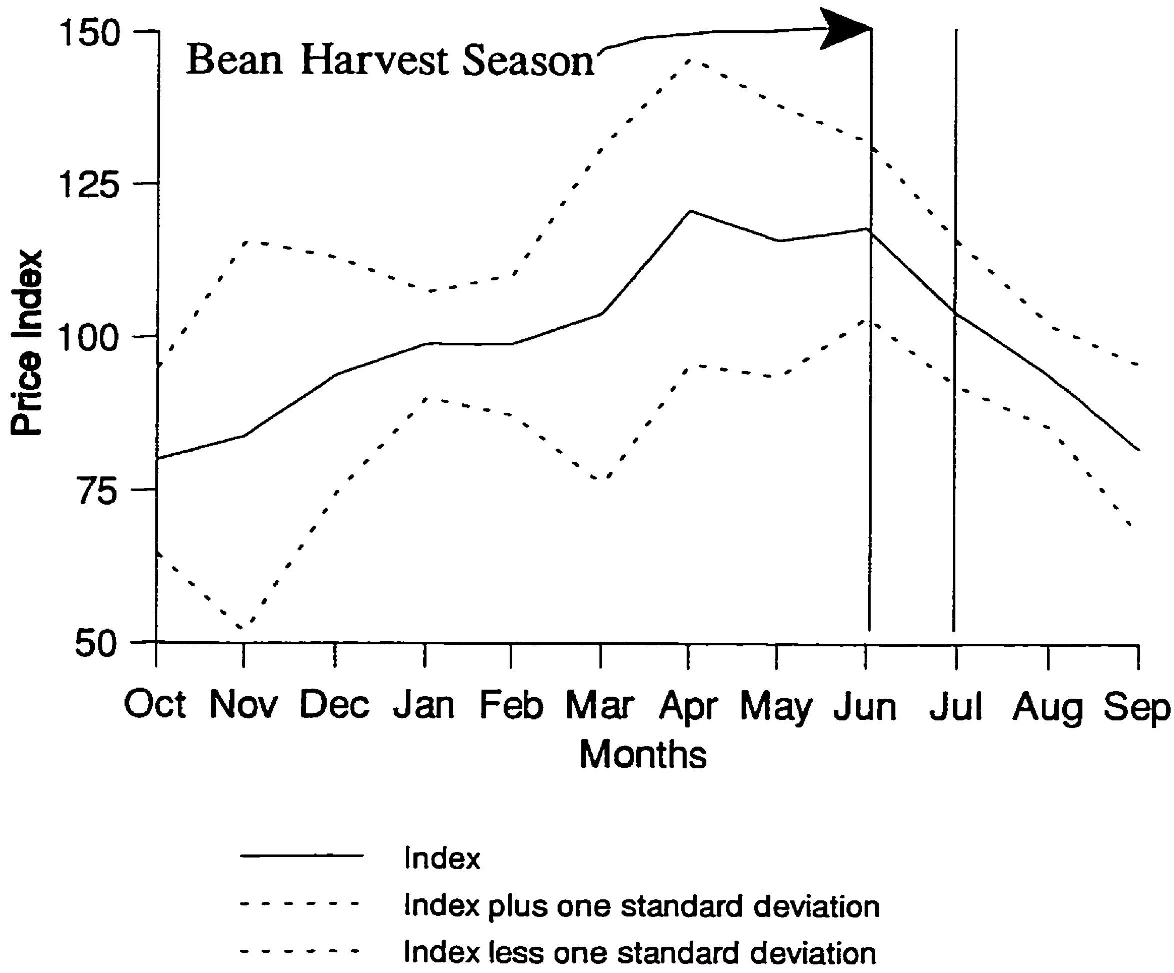


Figure 3.4: Monthly Price Index for Milk
(100 = mean period price)

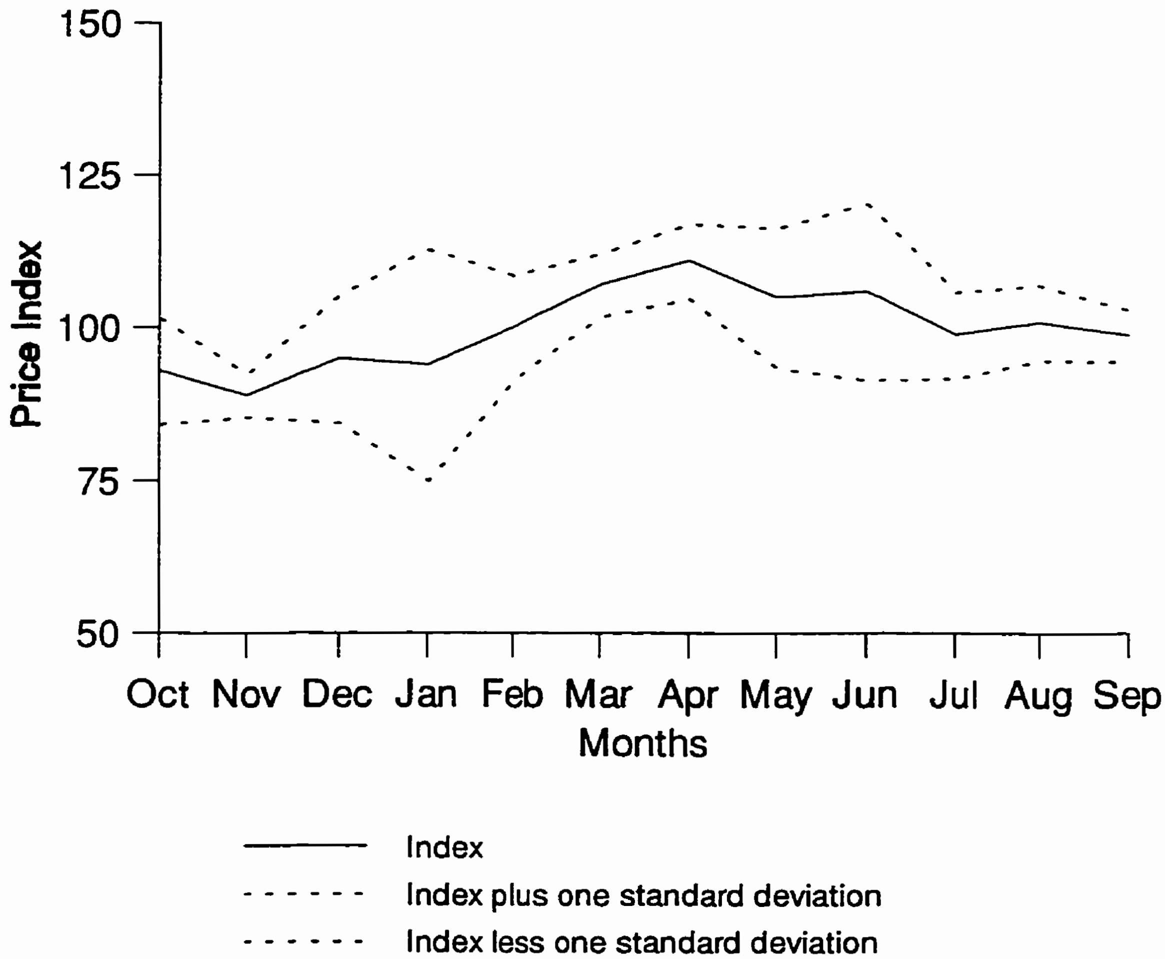


Figure 3.5: Monthly Price Index for Beef
(100 = mean period price)

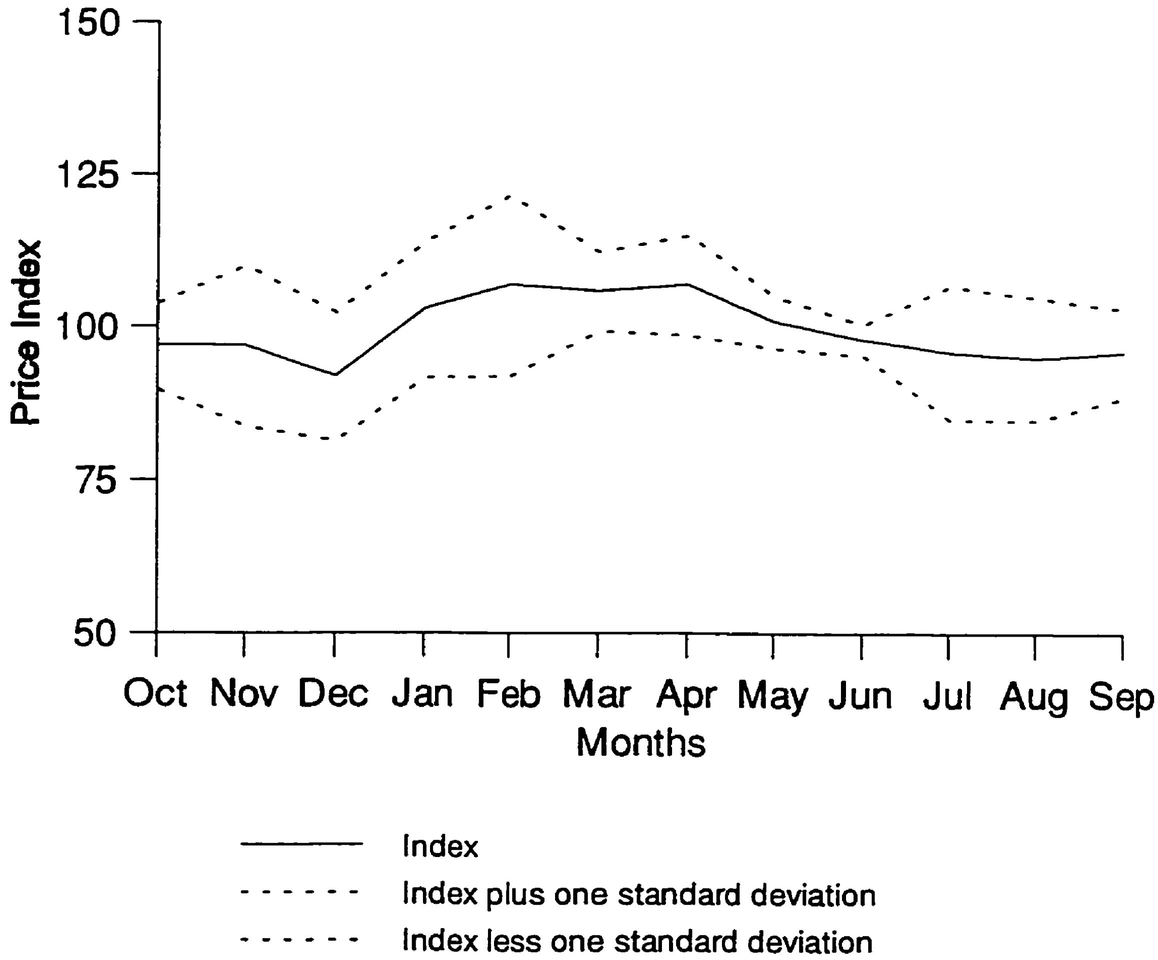
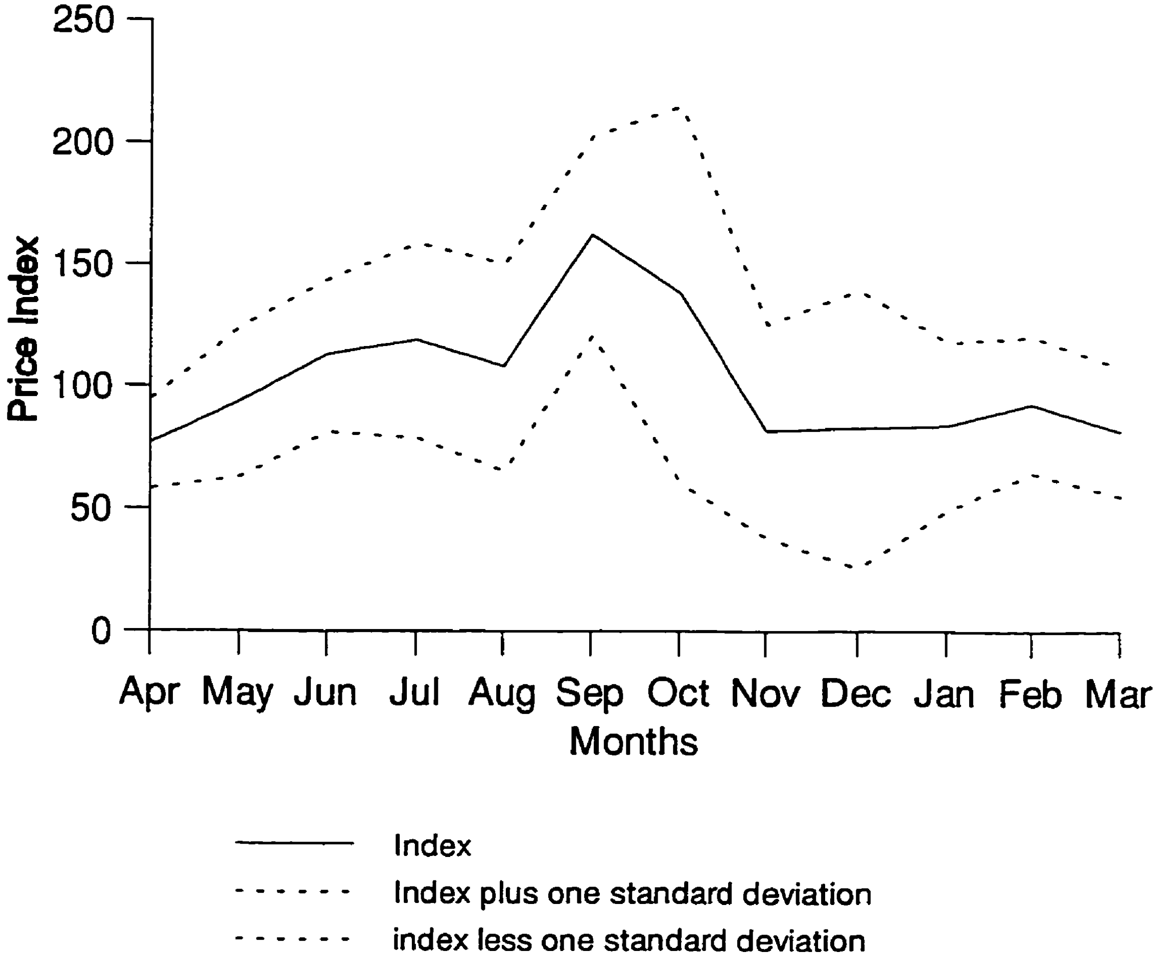


Figure 3.6: Monthly Price Index for Brazil-Nut
(100 = mean period price)



4.0 Changing Prices

July of 1994 is used in this analysis as a turning point in the regional market of Pedro Peixoto, brought on by a combination of policy changes (such as the Plano Real and Mercosul) previously discussed. This chapter will examine trends in expected prices and trends in price variation, before and after July 1994, in an attempt to learn if market changes have had a positive or negative impact on small landholders in the Pedro Peixoto project. In addition, two causes of price trends will be presented in an attempt to determine if the observed trends will continue.

4.1 Evidence of Changing Prices

As described in the previous chapter, the prices for rice, corn, beans, milk, and beef are averages for the municipalities of Plácido de Castro and Rio Branco, except for the price series for Brazil-nut. The Brazil-nut price series is based on an average for the state of Acre, multiplied by 0.65.

Using the time of the Plano Real to separate the time series into before / after components suggest substantial changes in regional market structure, as revealed by the commodity prices received by small landholders. Figures 4.1 through 4.6 give graphical demonstration of this effect. From the graphs it can be seen that the wide variations in monthly prices appear to decrease after July 1994. This decrease in price variation (i.e., a decrease in price risk) is a positive outcome for the risk-averse small landholder. However, the graphs also display another potential consequence of the change in the regional market structure. The mean, or expected price, for many of these commodities appears to be lower after July 1994, relative to the earlier period, and some of these prices appear to be trending downward. All other things the same, rational small landholders will be better off with a higher price. Therefore, the potential downward trend in commodity prices after the July 1994 is a negative result of the change in market structure.

Evidence of structural changes in prices extends beyond simple graphical analysis. This conclusion is also supported by statistics. For all commodities in the sample production basket, one-sided T-tests (95% significance level) have been conducted to learn if the mean price before July 1994 is greater than the mean price after July 1994. The hypothesis of no significant change in mean prices has been tested against the alternative hypothesis that mean prices have declined after July 1994. The calculated T-statistic exceeds the critical value for all commodities other than corn (Table 4.1). Therefore, it can be concluded that the mean prices of rice, beans, milk, beef, and Brazil-nut are significantly lower after July 1994.

From observing Figures 4.1 through 4.6, it appears that the variation from mean prices may fall after July 1994. The significance of this change was tested using one tailed F-tests (95% confidence level) for differences in variation (Table 4.2). The calculated F-statistic exceeds the F critical value for corn, beans, milk, and Brazil-nut. Therefore, the hypothesis that the variance in price is the same before July 1994 and after July 1994 is rejected for these commodities. The hypothesis that the variance does not change after July 1994 is not rejected for rice and beef.

Most of these prices show a downward trend. This trend will have an impact on the deviation from the mean (i.e., because of the trend, the deviation from the mean will be higher). Price trends represent a predictable source of price variation and do not contribute to producers' price risk but the random variability remaining after the predictable variation has been removed does contribute to the price risk faced by producers (Young, 1984). Following procedures in Chapter Two the first difference of each price series was calculated to remove the impact of trends. One tailed F-tests (95% confidence level) were conducted to determine if the first differenced prices show a lower variation after July 1994. When the impacts of trends are removed by first differencing the null hypothesis, that month-to-month price variation before July 1994 is the same as month-to-month price variation after July 1994, is rejected for all cases (Table 4.2). For corn, beans, milk, and Brazil-nut, not only is the variation from the mean price lower after July 1994, the change in price from one month to the next is also lower after July 1994.

Not only is price variation of all the commodities in the production basket different after July 1994, the relative importance of variation, as measured against the mean price, is also changing. As was discussed in the previous chapter, the coefficient of variation, standard deviation divided by the mean, is useful in comparing the degree of price variation inherent in different prices (Law and Kelton, 1991). The coefficient of variation for each price series before and after July 1994 is given in Table 4.3.

The coefficients of variation are lower after July 1994 for corn, beans, milk, and Brazil-nut. For beef, the decline in variation is proportional to the decline in mean. The decline in rice price variation from the mean is proportionally less than the decline in mean.

The results change slightly when price trends are removed by first differencing and random variation is examined in isolation. From the de-trended price series, the coefficient of variation is lower after July 1994 for all commodities other than beans. This means that, except for beans, month-to-month price variation, as measured in relation to the mean price, is lower after July 1994. For beans, the fall in month-to-month variation is slightly greater than the fall in mean.

The coefficient of variation from the de-trended prices gives an indication of the relative price risk of each commodity in the sample production basket. Before July 1994 the commodities produced from pasture, milk and beef, had the lowest de-trended coefficient of variation, and hence the lowest price risk. This was followed by the annual crops, corn, rice, and beans respectively. Before July 1994 the commodity extracted from the forest reserve, Brazil-nut, had the highest de-trended coefficient of variation (Table 4.4).

After July 1994 this ranking changes slightly. Beef still has the lowest de-trended coefficient of variation. In fact, the spread between the de-trended coefficient of variation for beef and the other commodities has increased. After July 1994, rice replaces milk as the commodity having the second lowest coefficient of variation. The ranking of the de-trended coefficients of variation after July 1994, from lowest to highest is; beef, followed by corn, milk, rice, beans, and Brazil-nut respectively.

4.2 Comparison of Prices Before and After July 1994

Based on the T-tests and F-tests (Tables 4.1 and 4.2), it has been established that all the prices for all the commodities included in the 1994 production basket are different after July 1994. The question remains: is the combined impact of the falling price variation and a decline mean price positive or negative for small landholders in the Pedro Peixoto project? This section will address this question.

4.2.1 Methodology for Comparison

Simulations were constructed using the sample production basket for small landholders in the Pedro Peixoto project (discussed in Chapter Three), and EMATER prices, both before and after July 1994. The simulation models follow the techniques outlined in Chapter Two.

Following procedures outlined by Walpole and Myers (1978), prices (both before and after July 1994) were examined for any significant cross correlations. The hypothesis that two prices are uncorrelated will be rejected if the calculated Z-statistic falls outside of the critical region (Walpole and Myers, 1978). At a 95% confidence level, the critical region for the Z-test is -1.65 to 1.65. Based on this test, rice and corn are significantly correlated, corn is negatively correlated with the price of milk, and the price of beans is correlated with the price of beef (Table 4.5). After July 1994, the price of rice is correlated with the price of corn and Brazil-nut, and negatively correlated with the price of beans, the price of corn is negatively correlated with the price of beans, and the price of beans is correlated with the price of milk (Table 4.6). The significant correlations have been integrated into the simulations to yield realistic results (Walker and Helmers, 1984).

4.2.2 Simulation Results - Before and After July 1994

Results from the simulations yield mixed message about the impacts of changes in the structure of the regional market on the sample commodity basket. The simulation process showed that the mean gross return after July 1994 is below the mean gross return before July 1994 (Table 4.7). This 17% reduction in gross return is a negative result for small landholders. However, the standard deviation of the gross return after July 1994 is below the standard deviation before July 1994 which is a positive result for risk-averse small landholders.

The coefficient of variation for gross returns after July 1994 is also below the coefficient of variation before July 1994. However, this difference is not large. The decrease in variation is approximately proportional to the decrease in mean. Therefore it is not possible to use the coefficient of variation to decide if the overall effect of the decreasing variation and the decreasing expected return has been beneficial to the small landholder in the Pedro Peixoto project. This question will be examined more completely in the following section of this chapter, using stochastic dominance techniques.

Evaluation of the portion that each commodity contributes to gross revenue gives an indication of the relative changes in expected prices (Table 4.8). The percentages in Table 4.8 have been calculated at the mean value of gross return before and after July 1994. Examination of the relative changes in expected prices gives an indication of the price signals faced by the small landholders.

The contribution of corn and milk to gross income is higher after July 1994 compared with their contribution before July 1994. This suggests a higher relative price (relative to the other commodities in the sample production basket) for these two commodities. The contribution of beans and Brazil-nut to gross income is lower after July 1994 relative to their contribution before July 1994. This indicates a lower relative price for these commodities. All other things being the same, small landholders can be expected to increase their production of those commodities with an increasing relative price and decrease their reliance on commodities with a falling relative price. However, these price signals are only one part of the production decision. Other factors, such as the availability of labour and credit will also play an important role.

As with the simulations constructed in Chapter Three, the convergence of the simulation model was monitored. The simulation models can be considered stable as the percentage change in every fifth percentile, the percentage change in the means, and the percentage change in the standard deviation of gross returns was 1.5% or less for the simulations (Pallisade, 1997).

4.2.3 Impact of Falling Mean and Falling Variation

Stochastic dominance is used to determine in which of the two periods would be better for small landholders. Figure 4.7 shows the cumulative probability density functions for gross return before and after July 1994. The probability of a higher return is always greater before July 1994. That is, the distribution for gross returns before July 1994 is first degree stochastically dominant over the distribution for gross returns after July 1994.

Based on this result, small landholders producing the sample 1994 basket of commodities would be better off with the conditions found before July 1994. This does not depend upon the risk attitudes of the small producer, nor does it depend upon the difference in variation of gross returns before and after July 1994. That is, the decline in expected return is sufficient to mask the decline in variation.

While small landholders are faced with a declining expected return after July 1994, their gross income from agricultural production is still above the Brazilian poverty line. The poverty line has been estimated by the World Bank to be approximately 1,100 Reais, which is to the left of the Y axis in figure 4.7. Even though the cumulative probability function for returns after July 1994 is closer to the poverty line than the function for returns before July 1994, small landholders are still virtually assured of receiving a gross income greater than 1,100 Reais.

The stochastic dominance analyses was repeated using different distributions for the various commodity prices, normal, lognormal and triangular for all commodities other than Brazil-nut, and normal, truncated-normal, and triangular for Brazil-nut. For all distributions used, gross returns before July 1994 are first degree stochastically dominant over gross returns after July 1994.

The sensitivity of the stochastic dominance to relative changes in production of the commodities in the sample production basket was also tested. The production of each crop was increased 10%, 20%, 50%, 100%, and 200% while the production of all other crops was held constant. In no case did the first degree stochastic dominant results change as a result of a change in the relative production of rice, corn, beans, milk, beef, or Brazil-nut.

The above analysis does not discriminate between the different commodities in the sample production basket. Evaluated as a group, small landholders would be better off producing the commodities in the sample production basket before July 1994. However, the combination of price and variation of some individual commodities after July 1994 may be preferable to the combination of price and variation before July 1994. This topic will be addressed in the next section of this chapter.

4.2.4 Analysis of Individual Price Series

Statistics of individual price series (Tables 4.1 and 4.2) show that the pattern of decreased variation and decreased means, observed in the gross returns, also applies to most prices of commodities in the production basket. Stochastic dominance analysis, as carried out for gross returns, has been repeated for the price of each individual commodity in the sample production basket.

The prices of rice, beef, and Brazil-nut before July 1994 were found to be first degree stochastically dominant over the prices of these commodities after July 1994 (Figures 4.8, 4.9, and 4.10). For these commodities, the probability of receiving a higher price before July 1994 is always greater than the probability of receiving a higher price after July 1994. All small landholders, regardless of their risk preferences, would be better off with the pre-1994 prices of rice, beef, and Brazil-nut. For rice, beef, and Brazil-nut the falling expected value after July 1994 is sufficient to overshadow any fall in price variation. These first degree stochastic dominance results are invariate if the price series are represented by normal distributions truncated at zero, normal distributions, lognormal distributions, or triangular distributions.

The distribution for milk prices were second degree stochastically dominant before July 1994. This result is displayed in Figure 4.11. Risk-averse small landholders would be better off producing milk before July 1994. Second degree stochastic results consider both changes to expected prices, and changes to variation in these prices. For milk the second degree stochastic dominance holds if prices are distributed normally but truncated at zero, are distributed normally, or if prices are distributed lognormally. However, the results for milk are inconclusive if a triangular distribution is used.

The distribution of corn prices after July 1994 were found to be second degree stochastically dominant after July 1994 (Figure 4.12). Therefore, all risk-averse producers would be better off producing corn in the period after July 1994. The second degree stochastic dominance results hold if prices follow a normal distribution truncated at zero, for a normal distribution, for a lognormal distribution, or a triangular distribution.

First and second degree stochastic dominance are not sufficient to yield conclusive results for the bean price series. Like rice, beef, and Brazil-nut, bean prices experienced a sharp drop in both variation and expected return after July 1994 (Table 4.1 and 4.2). Unlike the other three commodities, the decrease in price variation was sufficiently large, so it was not overshadowed by the drop in expected return.

The cumulative probability density function for bean prices, before and after July 1994, are plotted in Figure 4.13. At probabilities of approximately 0.6 or greater the price series after July 1994 dominates the price series before July 1994. This result is reversed for probabilities of approximately 0.6 or below. Generally, the extremely risk-averse producer would be better off with the lower variation after July 1994. However, the moderately risk-averse producer may be better off with the higher potential returns before July 1994. A more definitive statement is not possible without determining the risk preferences of producers in the area.

The results for the bean price series hold if bean prices follow a normal distribution truncated at zero, a normal distribution, or a lognormal distribution. If a triangular distribution is used to define the bean price series, the prices before July 1994 are first degree stochastically dominant over the prices after July 1994.

This analysis of prices is from the viewpoint of small landholders, who are assumed to be net producers of these commodities. For urban consumers in the region the situation is reversed. Like producers, consumers benefit from falling price variation. However, unlike producers, consumers also benefit from falling prices. To the degree that the changes in commodity prices are translated into changes in consumer prices, consumers in the region will be better off in the period after July 1994 (all things other than prices held constant).

4.2.5 Alternative Commodities - Evidence of Changing Prices

The price series of two alternative commodities, coffee and banana, were also examined. Similar to the price series for Brazil-nut, sufficient observations do not exist in the average coffee price for the municipalities of Plácido de Castro and Rio Branco. The average for the entire state of Acre is used as an alternative price series. As with Brazil-nut, the statewide average coffee price appears to be consistently above the price for Plácido de Castro and Rio Branco. To more accurately reflect the price received by small landholders in Pedro Peixoto, the state wide coffee price has been multiplied by 0.70. This adjustment factor is based on a simple linear regression between the state wide price and the observations from the two municipalities (r-square=0.74) and discussions with EMBRAPA / IFPRI researchers.

From observing Figures 4.14 and 4.15, it appears that the mean price may be higher in the period following July 1994. Therefore, the null hypotheses that mean price does not change after July 1994 was tested against the alternative hypothesis that the mean price is higher after July 1994 using T-test. Based on the results of these tests (Table 4.9), it can be seen that the price of both coffee and banana is significantly higher after July 1994.

From observing the graphs in Figures 4.14 and 4.15 it also appears as if the month-to-month variation in these two commodities is increasing along with the expected price. This proposition was statistically tested using F-tests for differences in variance (as previously applied to the commodities included in the sample production basket). As has been carried out in the earlier section of this chapter, the F-tests have been conducted on both the de-trended series as well as the non-transformed data series. As can be seen from Table 4.10, the null hypothesis, that price variation in coffee and banana is the same before and after July 1994 is rejected. This applies to both the non-transformed data series as well as the de-trended data series.

Both expected price and price variation for these commodities is increasing after July 1994. This has mixed implications for small landholders. The increase in month-to-month price variation means increased price risk, offsetting some of the benefit of increased expected return. The impact on these conflicting price signals is analysed through the use of stochastic dominance in the next section of this chapter.

Comparing the relative impact of increasing price variation through the use of the coefficient of variation is useful. Although the variation in coffee price is increasing after July 1994, variation is increasing at a slower rate than the mean (Table 4.11). By looking at the de-trended coefficient of variation, it can be seen that the impact of random variation in relation to the mean for coffee is less after July 1994. If the coefficient of variation is used as a measure of price risk, price risk in coffee declines after July 1994.

This is not the case for Banana. If only the non-transformed data is examined, the increase in variation is approximately in proportion to the increase in mean. However, when the impact of the price trend is removed, and only month-to-month variation is examined it can be seen that the price risk inherent in banana production is increasing after July 1994.

It is also useful to note that the coefficient of variation for both coffee and banana is larger than the coefficient of variation for any commodity in the 1994 sample production basket. That is, while coffee and banana production offers small landholders potential higher returns after July 1994, the production of these commodities brings a greater degree of price risk.

Given the falling coefficient of variation, and the increasing mean price of coffee, it might be expected that small land holders would be better off producing coffee after July 1994. For banana prices the case is not quite as clear, as price risk is rising along with expected return. Through the use of stochastic dominance, the impact of rising expected return and rising variation is tested statistically in the next section

4.2.6 Alternative Commodities - Impact of Changing Prices

For both coffee and banana, the price series after July 1994 is first degree stochastically dominant over the price series before July 1994 (Figures 4.16 and 4.17). Therefore, the increasing expected return for both coffee and banana is sufficient to make producers of these commodities better off after July 1994.

As coffee and banana prices after July 1994 are both first degree stochastically dominant over prices before July 1994, the addition of these commodities in sufficient quantities to the sample production basket should reverse the first degree stochastic dominance results displayed in Figure 4.7. That is, if enough coffee or banana were added to the sample production basket, small landholders would be better off to producing the revised basket after July 1994. This proposition has been tested through simulation analysis. It was found that the addition of 1,000 kg of coffee, the production of all other commodities held constant, would reverse the stochastic dominance results displayed in Figure 4.7. That is, with the addition of approximately 1,000 kg of coffee to the sample production basket, the revised basket after July 1994 becomes first degree stochastically dominant over the revised basket before July 1994. Similarly, if approximately 950 bunches of banana were added to the production basket (all other production held constant) the production of the revised basket after 1994 would be first degree stochastically dominant over the revised basket before 1994. EMBRAPA researchers indicate that this amount of coffee and banana would require about 1 hectare of land. However, the production of these commodities would also require an increase in labour and capital, both of which are in short supply in the region.

A need exists for ongoing price analysis, and communication of these price trends to small landholders. Figures 4.14 and 4.15 show that the prices for both coffee and banana may now be falling after the initial increase in 1994. If this trend continues, coffee and banana prices may reach levels that existed before July 1994. This would reverse the benefits of increased prices. However, many producers may have already made the long term decision to begin production of these commodities.

Agricultural extension in the region must ensure that small landholders have the information needed to make informed production decisions. This may involve the communication of recent price trends or analysis of market forces (international production levels for example) that may affect these trends. Extension efforts may be carried out by state organizations such as EMATER, through community / commodity associations, or a combination of the two. With adequate information, each producer will be able to assess their own level of risk preference and make a more informed production decision as a result.

With the addition of cost data, the stochastic dominance analysis carried out in this section could be extended to calculate the probability of the success or failure of alternative production practices. For example, if an alternative production practice offers a higher potential rate of return than the existing production systems, but has a probability of 60% of negative returns it may not be adopted by small landholders. Conversely, an alternative production system that increases the expected return and has a low probability of negative returns may be highly desirable for small landholders. Because stochastic dominance analysis evaluates all possible returns (and not just the mean or expected returns) it is a valuable tool in assessing the viability of changes to Amazonian production practices.

4.3 Causes of Price Trends

The question remains, why do prices display the trends examined in the previous sections? Understanding the reasons behind the price changes is necessary if future price trends are to be anticipated.

Two explanations are readily available for the observed price trends: a) reduced rates of inflation and; b) increasing market integration. These two explanations will be examined in turn in the following sections.

4.3.1 Impact of Reduced Inflation

Da Silva and Kadota (1984) examined Brazilian inflation rates from 1950 through 1979. They discovered a high positive correlation between the rate of inflation and the degree of variation in inflation (i.e., the higher the rate of inflation the higher the degree of inflation variability). As price expectations are (to a degree) dependant upon inflation expectations (Lemgruber, 1984) it may be expected that price variation would be higher at higher rates of inflation. This expectation is consistent with findings by da Silva and Kadota (1984) who showed that price variation (as measured by the coefficient of variation) is highly correlated with the inflation rate.

Similar results are evident in the prices examined for this study. The correlation coefficient between the annual rate of inflation (measured monthly) and the absolute value of the change in inflation from month to month was found to be significant at 0.75. Similarly, the absolute value of monthly price changes for five of the eight commodities examined, corn, beans, milk, beef, and Brazil-nut, were found to have a significant positive correlation to the rate of inflation (Table 4.12). Inflation fell from a high of 6,603% in April of 1990 to 8.25 % in August of 1997 (Figure 4.18). Table 4.13 shows the annual average inflation rates for 1992 through 1997 (note 1997 is calculated as January through August). The average annual inflation rate fell from a high of 3,146% in 1994 to 8.25 % in 1997. Given the positive correlation between the rate of inflation and month-to-month price changes for most of the commodities examined, it is not surprising that the degree of variation in many commodity prices is lower in the period after 1994 (Table 4.3 and Table 4.11).

Falling inflation rates have other impacts on small landholders that are worth noting. High rates of inflation tend to decrease the availability of credit (Lioi, 1974), and decrease the incentive to save (Baer, 1983; Abel and Beranke, 1998). Access to capital is a constraint for the small landholder in the Amazon region (Cunha and Sawyer, 1997). If the recent lower inflation rates continue, small landholders in the Amazon region may have increased access to capital through increased rates of savings and increased credit availability. Increased capital availability may allow the small landholder the opportunity to take advantage of improved production techniques and / or begin producing alternative commodities that would increase the return from their existing land base.

High rates of inflation also have the tendency to distort price signals (Lioi, 1974, Abel and Beranke, 1998). That is, in periods of high inflation, producers are not able to determine changes in relative prices readily. Given the lack of clear price signals, producers are not able to adjust their production practices to maximize return. Lower inflation will result in clearer price signals that will allow small landholders to take advantage of positive market changes and minimize the impact of negative changes in the marketplace.

Some circumstantial evidence exists for the growing importance of past prices. In the Akaike Information Criterion tests conducted in Chapter Two it was discovered that the influence of past prices extends for a longer period of time after July 1994 (i.e., the lag period was longer for prices after July 1994, Tables 2.2 and 2.3). The growing importance of past prices in the period of lower inflation is an indication of clearer and / or more relevant price signals.

The decline in inflation shown in Figure 4.18 may also account, at least in part, for the downward price trend observed in beef. During the periods of high inflation cattle may have served as a hedge against inflation (Faminow, 1997; 1998). With the decline of the inflation rate, alternative investment became more attractive, reducing the quantity of cattle demanded for this reason, and therefore putting downward pressures on cattle prices. However, Faminow (1997; 1998) also notes that the use of cattle herds as a hedge against inflation only accounts for part of the driving force behind the supply of from the western Amazon. As inflation has only played a part in the quantity supplied in the region, it is likely that the decline in inflation is only one factor influencing the decline in cattle prices.

4.3.2 Impact of Reduced Transaction Costs

Improved transportation links, improved producer marketing skills, and reduced government intervention (e.g., reduced tariff barriers) are all examples of ongoing events in the western Amazon that are reducing the cost of moving commodities between regions and countries. As the costs of moving goods between the western Amazon and other regions within Brazil, as well as to outside nations, decline it is expected that the volume of goods moving between these regions will increase. Because of the decrease in transaction costs, the price producers receive for goods moved out of the region will increase, and the price paid for imported goods will decrease. As a consequence of the decreased transaction costs, and because of the increased trade, markets in the western Amazon will become integrated, at least to a greater degree, with markets outside of the region. For example, price movements in Acre will more closely mirror price movements in other areas of the country. Vosti et al. (1998a) have noted that market integration is one of the most powerful macroeconomic forces acting upon the region.

The price trend described in the previous sections of this chapter may be evidence of decreasing transaction costs. Generally prices are falling for those commodities that are deficit in Acre. Few published data are available on commodity flows in the western Amazon. However, some anecdotal evidence suggests that Acre is a deficit region for rice and beans (the vast majority of rice and beans commercially available in Rio Branco are imported from outside the state). Some empirical evidence suggests (for example Faminow and Vosti, 1998) that Acre is a beef deficit region. Following the arguments on the impact of a reduction in transaction costs, it is expected that the prices for these commodities would fall. This expectation matches the findings outlined in section 4.1.

The pattern of rising prices for banana and coffee also matches the theory of falling transaction costs. Again, few published data exist on flows of banana and coffee in and out of Acre. EMBRAPA researchers (through personal communications) have indicated that Acre exports a surplus of coffee and banana. The price for coffee and banana after July 1994 is significantly above the price before July 1994 (Table 4.9) as would be expected if transaction costs are indeed falling.

The hypothesis of declining transaction costs between Acre and other regions would be supported if evidence of increased integration of prices in Acre with prices in the south of Brazil could be found. Average prices from the state of Paraná and average prices in Acre were examined for evidence of integration using the Johansen test outlined in Chapter Two. The tests were conducted for prices spanning January 1992 through July 1994, and for prices spanning August 1994 through July 1997. The appropriate number of lags were determined through the use of the Akaike Information Criterion (AIC) outlined in Chapter Two. As shown in Chapter Two (through the use of the Dicky-Fuller test) the first differences of all the prices are stationary. The null hypothesis that there are no common trends, is tested against the alternative hypothesis of one common trend using the Johansen test. That is, the null hypothesis in each of the Johansen test is r equal to zero. Failure to reject this hypothesis would lead to the conclusion that there is no evidence of integration between the two price series being tested (i.e., the hypothesis that each price series follows its own trend is supported).

The Johansen tests give little evidence of integrated markets during the period from January 1992 through July 1994. Only with rice prices is the null hypothesis rejected. For all other commodities the test fails to reject the null hypothesis of no integration (Table 4.14). This is not the case for the period from August 1994 through July 1997. In this time period the null hypothesis is rejected for rice, beans, beef, and coffee (Table 4.14) giving some evidence that these prices show a common trend.

Ho and Sorensen (1996) note that misspecifying the number of lag periods can introduce bias into the Johansen test. As noted in Table 4.14, the number of lag periods is generally higher in the period after July 1994. In order to discover if the change in market integration displayed in Table 4.14 may be a result of the change in the number of lag periods, the Johansen tests for the period after July 1994 were rerun using three lag periods for each price series. The results show that there may be some link between the number of lag periods chosen and the rejection of the null hypothesis, as there is no evidence of co-integration in bean prices if three lag periods are used (Table 3.15). However, even with the reduced number of lag periods, three out of the six commodities tested show evidence of co-integration after July 1994.

Some caution should be used in interpreting the results presented in Table 4.14. Of serious concern, the number of data points for all cases is low (31 for the period before July 1994 and 36 for the period after July 1994). Co-integration tests are valid for large sample cases only, and small sample properties are uncertain. Ho and Sorensen (1996) indicate that the asymptotic properties of the Johansen test decline rapidly if the sample size falls below 100 observations. For the purposes of comparison, Benson et al. (1994) used more than 200 observations in all of the time periods that they compared, and in one time period used more than 400 observations. In addition to the concern over the small number of observations, the result of the co-integration tests may be influenced by concerns within the price data. Franses and Haldrup (1994) conclude that the presence of outliers in the data may bias tests for co-integration. As previously noted, the data gathering techniques employed by EMATER may not be consistent through time. This may have introduced outliers into the data that have been difficult to detect due to the high degree of variability inherent within the data, and hence introduce bias into the co-integration tests.

However, these concerns aside, the Johansen tests do provide some evidence of market integration after July 1994 that did not exist before July 1994. This is consistent with the hypothesis that transaction costs between Acre and the south of Brazil are falling.

To date, the reduction in inflation that occurred after the Plano Real has not been reversed. There is no reason to believe that the costs of moving goods between Acre and other regions (including transportation costs, information costs, tariff barriers etc.) will begin to increase in the future. It is therefore reasonable to expect that the impacts of these two market forces (reduced inflation and declining transaction) costs will be long term effects. The impact that these market forces have had on prices will therefore also be long term impacts.

4.4 Summary of Results - Chapter Four

The following is a brief summary of the research presented in Chapter Four.

- Expected prices and price variation are falling afer July 1994 for almost all commodities in the production basket.

- Small landholders would have been better off with the combination of expected price and price variation found before July 1994. However, in spite of decreasing average prices, expected returns are still well above the poverty line.

- For coffee and banana, two commodities not in the typical 1994 production basket, prices are rising after July 1994.

- The reduction in inflation after the introduction of the Plano Real provides one explanation for the observed reduction in price variation for most commodities in the typical production basket. The reduction in inflation also provides a partial explanation for the downward price trend observed in beef prices.

- Prices appear to be falling for commodities in which Acre is deficit and rising for commodities in which Acre is surplus. This would be the expected result if price trends were (at least in part) due to a reduction in transaction costs between Acre and other regions (both within and outside Brazil).

Table 4.1: T-Test for Differences in Mean Pedro Peixoto Prices: Before and After July 1994 (December 1996 Reais)

Commodity	Mean Before July 1994	Standard Deviation Before July 1994	Mean After July 1994	Standard Deviation After July 1994	T-Test Statistic
Rice	14.94	3.84	12.46	3.64	2.61*
Corn	10.34	3.05	10.80	1.81	0.70
Beans	43.67	15.90	38.09	11.17	1.96*
Milk	0.38	0.09	0.33	0.06	1.83*
Beef	26.89	3.67	22.22	3.01	5.27*
Brazil-nut (adjusted state average)	0.17	0.09	0.15	0.05	3.28*

Note: (1) Critical value for the one-tailed t-test at a 95% confidence level is 1.68

(2) * Indicates significant difference in means at a 95% confidence level.

Calculated from EMATER (unpublished)

Table 4.2: F-Test for Differences in Pedro Peixoto Price Variation: Before and After July 1994 (December 1996 Reais)

Commodity	Variance Before July 1994	Variance After July 1994	F-Statistic	F-Statistic First Difference
Rice	14.76	13.22	1.2	2.9*
Corn	9.30	3.28	2.8*	3.9*
Beans	252.81	124.77	2.0*	12.0*
Milk	0.0081	0.0036	2.5*	2.1*
Beef	13.47	9.06	1.5	25.5*
Brazil-nut (adjusted state average)	0.0081	0.0025	3.2*	11.5*

Note: (1) Critical value for the one-tailed f-test at a 95% confidence level is 1.9

(2) * Indicates significant difference in variation at a 95% confidence level.

Calculated from EMATER (unpublished)

Table 4.3: Coefficient of Variation for Pedro Peixoto Prices: Before and After July 1994

Commodity	Coefficient of Variation - Before July 1994	Coefficient of Variation - After July 1994	De-trended Coefficient of Variation - Before July 1994	De-trended Coefficient of Variation - After July 1994
Rice	26 %	29 %	38 %	21 %
Corn	30 %	17 %	28 %	13 %
Beans	36 %	29 %	33 %	37 %
Milk	24 %	18 %	20 %	16 %
Beef	14 %	14 %	15 %	4 %
Brazil-nut	53 %	33 %	66 %	38 %

Calculated from EMATER (unpublished)

Table 4.4: Ranking of the Coefficients of Variation Before and After July 1994

Commodity	Rank - Including Trends Before July 1994	Rank - De-trended Prices Afer July 1994	Rank - Including Trends Before July 1994	Rank - De-trended Prices Afer July 1994
Rice	3	4	5	4
Corn	4	2	3	2
Beans	5	5	4	5
Milk	2	3	2	3
Beef	1	1	1	1
Brazil-nut	6	6	6	6

Calculated from Table 4.3

Table 4.5: Correlations Between Pedro Peixoto Prices Before July 1994

	Rice	Corn	Beans	Milk	Beef
Corn	0.28*	-----			
Beans	0.17	0.05	-----		
Milk	0.05	-0.45*	0.41*	-----	
Beef	-0.17	0.11	0.48*	-0.15	-----
Brazil-nut	0.22	0.20	-0.13	0.18	-0.22

*Significant at a confidence level of 95%
Calculated from EMATER (unpublished)

Table 4.6: Correlations Between Pedro Peixoto Prices After July 1994

	Rice	Corn	Beans	Milk	Beef
Corn	0.45*	-----			
Beans	-0.40*	-0.48*	-----		
Milk	-0.02	-0.10	0.35*	-----	
Beef	0.08	0.23	0.16	0.12	-----
Brazil-nut	0.35	-0.004	-0.20	0.22	0.004

*Significant at a confidence level of 95%
Calculated from EMATER (unpublished)

Table 4.7: Simulation Results: Annual Small Pedro Peixoto Landholder Gross Returns Before and After July 1994 (December 1996 Reais)

	Min	Max	Mean	Standard Dev	+/- 2 Standard Deviations	Coefficient of Variation
Before July 1994	2,186	6,894	3,306	417	2,472-4,140	13 %
After July 1994	1,506	3,801	2,749	329	2,091-3,407	12 %

Table 4.8: Percentage of Small Pedro Peixoto Landholder Gross Revenue By Commodity Before and After July 1994

Commodity	Percentage of Gross Revenue After July 1994	Percentage of Gross Revenue After July 1994
Rice	17 %	16 %
Corn	9 %	12 %
Beans	19 %	16 %
Milk	34 %	36 %
Beef	19 %	18 %
Brazil-Nut	3 %	2 %

Table 4.9: Test for Differences in Mean Pedro Peixoto Prices (Coffee and Banana) Before and After July 1994 (December 1996 Reais)

Commodity	Mean Before July 1994	Standard Deviation Before July 1994	Mean After July 1994	Standard Deviation After July 1994	T-Test Statistic
Coffee (adjusted state average)	0.48	0.26	1.53	0.64	8.55*
Banana	0.92	0.22	2.00	0.24	10.63*

Note: (1) Critical value for the one-tailed t-test at a 95% confidence level is 1.68

(2) * Indicates significant difference in means at a 95% confidence level.

Calculated from EMATER (unpublished)

Table 4.10: Test for Differences in Pedro Peixoto Price Variation (Coffee and Banana) Before and After July 1994 (December 1996 Reais)

Commodity	Variance Before July 1994	Variance After July 1994	F-Statistic	F-Statistic First Difference
Coffee	0.068	0.41	5.98*	2.68*
Banana	0.048	0.058	4.95*	6.13*

Note: (1) Critical value for the one-tailed f-test at a 95% confidence level is 1.6

(2) * Indicates significant difference in variation at a 95% confidence level.

Calculated from EMATER (unpublished)

Table 4.11: Coefficient of Variation for Pedro Peixoto Prices (Coffee and Banana) Before and After July 1994

Commodity	Coefficient of Variation - Before July 1994	Coefficient of Variation - After July 1994	De-trended Coefficient of Variation - Before July 1994	De-trended Coefficient of Variation - After July 1994
Coffee	55%	42 %	57 %	36 %
Banana	24 %	25 %	38 %	46 %

Calculated from EMATER (unpublished)

Table 4.12: Correlation Between Monthly Pedro Peixoto Price Changes and the Brazilian Inflation Rate

Commodity	Correlation Between Inflation Rate and Monthly Price Change
Rice	-0.08
Corn	0.34*
Beans	0.54*
Milk	0.19*
Beef	0.23*
Brazil-nut	0.46*
Coffee	-0.17*
Banana	-0.09

*Significant at a confidence level of 95%
Calculated from EMATER (unpublished) and FGV (various)

Table 4.13: Annual Average Brazilian Inflation Rates 1992 Through 1997

Year	Average Annual Inflation Rate
1992	887%
1993	1,768%
1994	3,145%
1995	139%
1996	11%
1997*	8%

*Note: The 1997 average annual inflation rate is based on January through August only
Source: FGV (various)

Table 4.14: Johansen Test For Co-Integration Between Commodity Prices In Acre and Paraná

Commodity	Test Statistic
Rice: January 1992 - July 1994	21.18*
Corn: January 1992 - July 1994	9.67
Beans: January 1992 - July 1994	10.11
Beef: January 1992 - July 1994	12.61
Coffee: January 1992 - July 1993	12.67
Rice: August 1994 - July 1997	32.20*
Corn: August 1994 - July 1997	10.08
Beans: August 1994 - July 1997	15.46*
Beef: August 1994 - July 1997	22.06*
Coffee: August 1994 - July 1997	18.28*

Note: (1) * Denotes rejection of the null hypothesis at a 95% confidence level (critical value equal to 15.41).

(2) N (the number of matched price pairs) for all tests from January 1992 through July 1994 is 31. N for all test from August 1994 through July 1997 is 36.

(3) For the period from January 1992 through July 1994 three lag periods were used, with the exception of two lag periods for coffee. Four lag periods were used for all commodities for the August 1994 through July 1997 period.

Calculated from EMATER (unpublished) and Secretaria da Agricultura (monthly)

Table 4.15: Johansen Test For Co-Integration Between Prices in Acre and Paraná Using Alternative Lag Periods

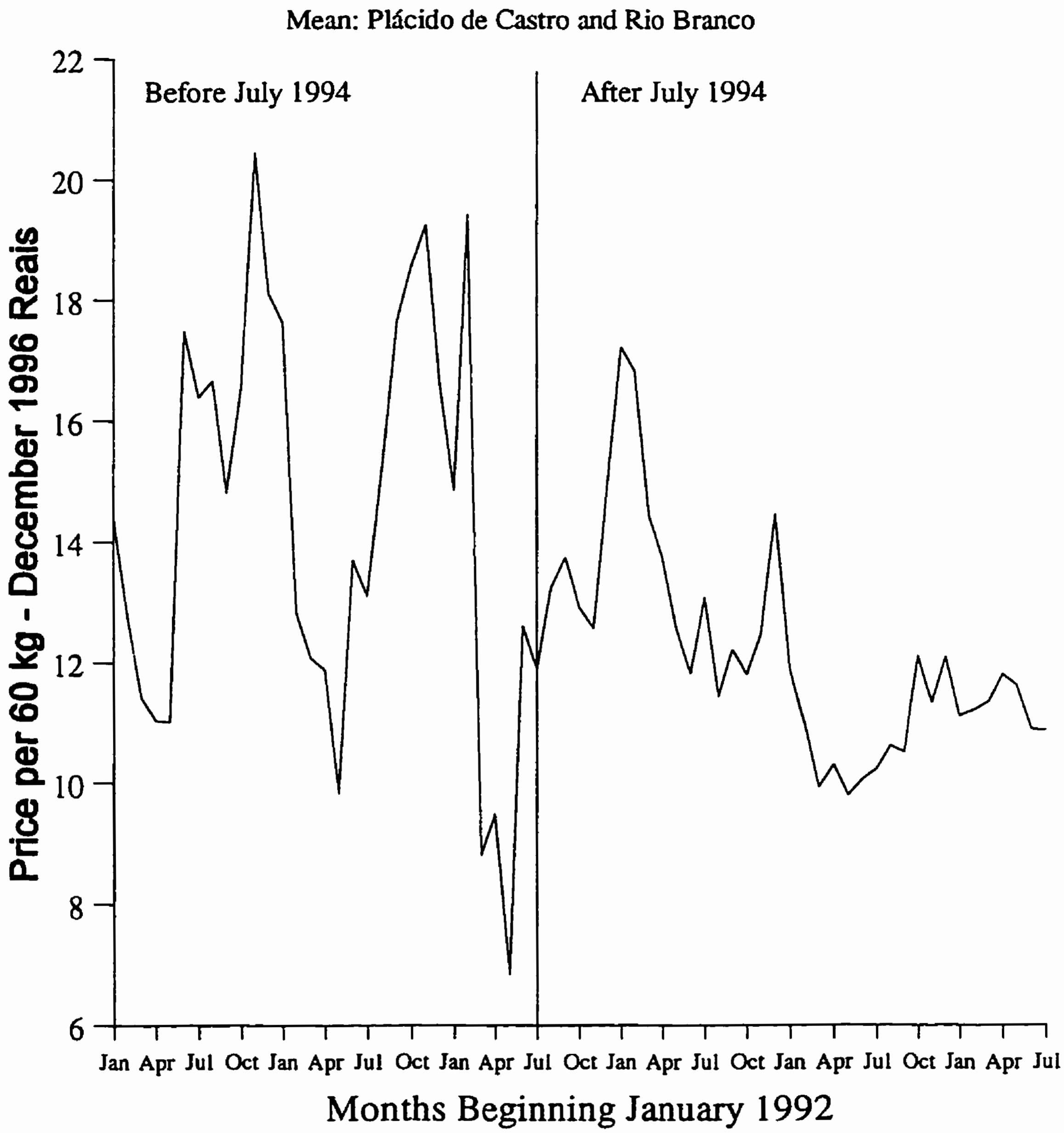
Commodity	Test Statistic
Rice: August 1994 - July 1997	21.47*
Corn: August 1994 - July 1997	14.78
Beans: August 1994 - July 1997	11.71
Beef: August 1994 - July 1997	23.94*
Coffee: August 1994 - July 1997	16.47*

Note: (1) * Denotes rejection of the null hypothesis at a 95% confidence level (critical value equal to 15.41).

(2) Three lags periods were used, with the exception of two lag periods for coffee.

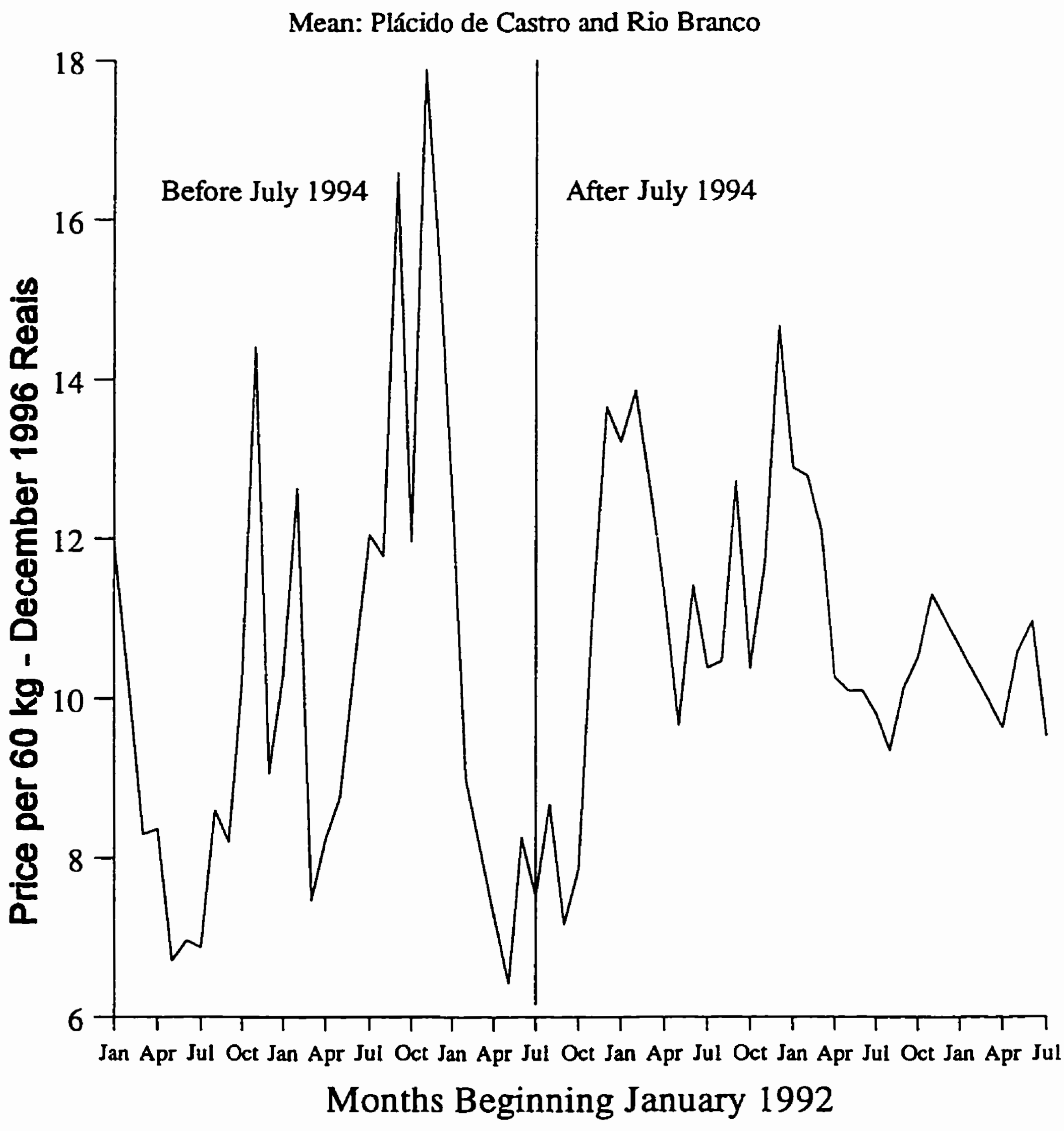
Calculated from EMATER (unpublished) and Secretaria da Agricultura (monthly)

Figure 4.1: Rice Prices January 1992 Through July 1997



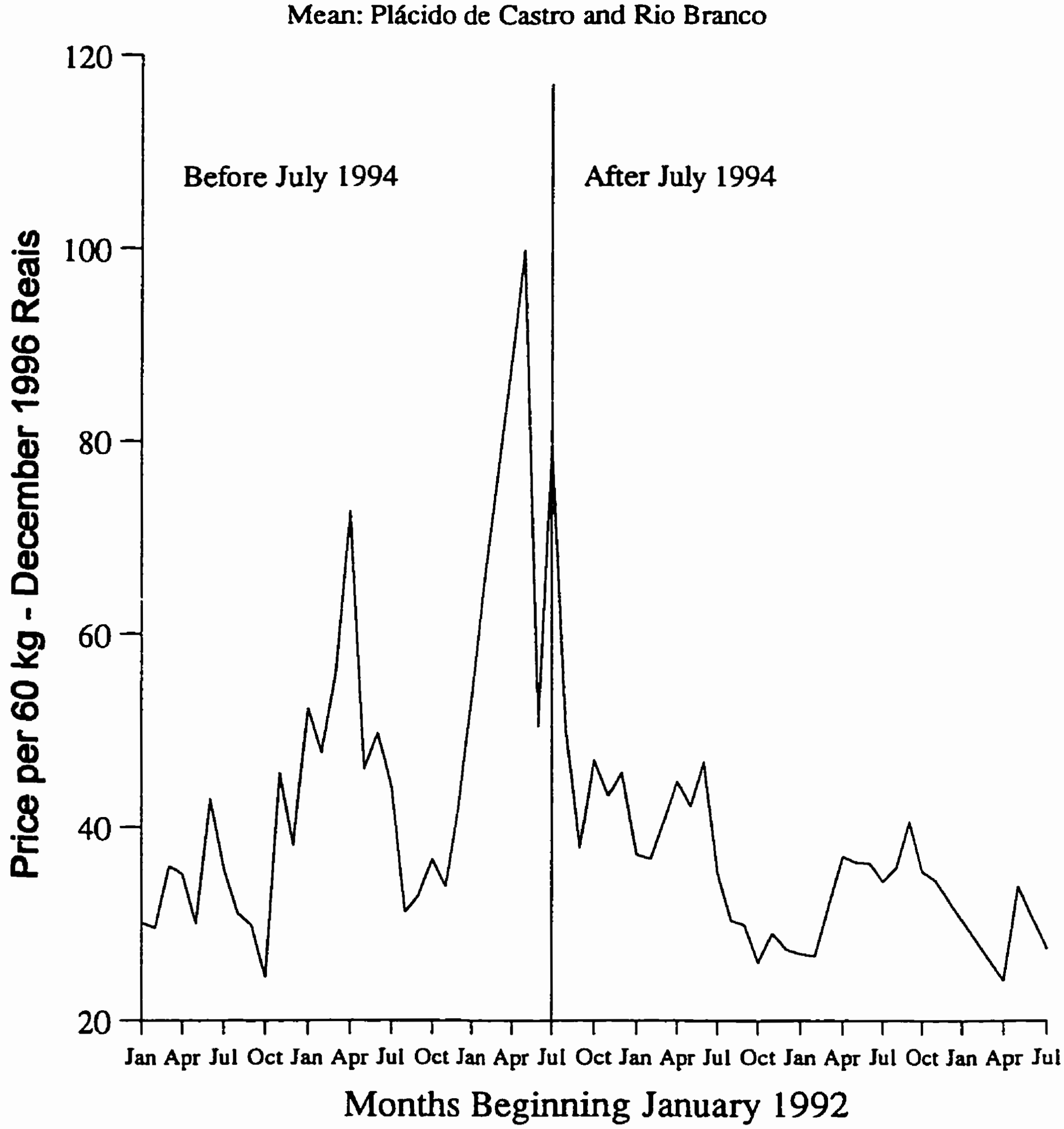
Source: EMATER (unpublished)

Figure 4.2: Corn Prices January 1992 Through July 1997



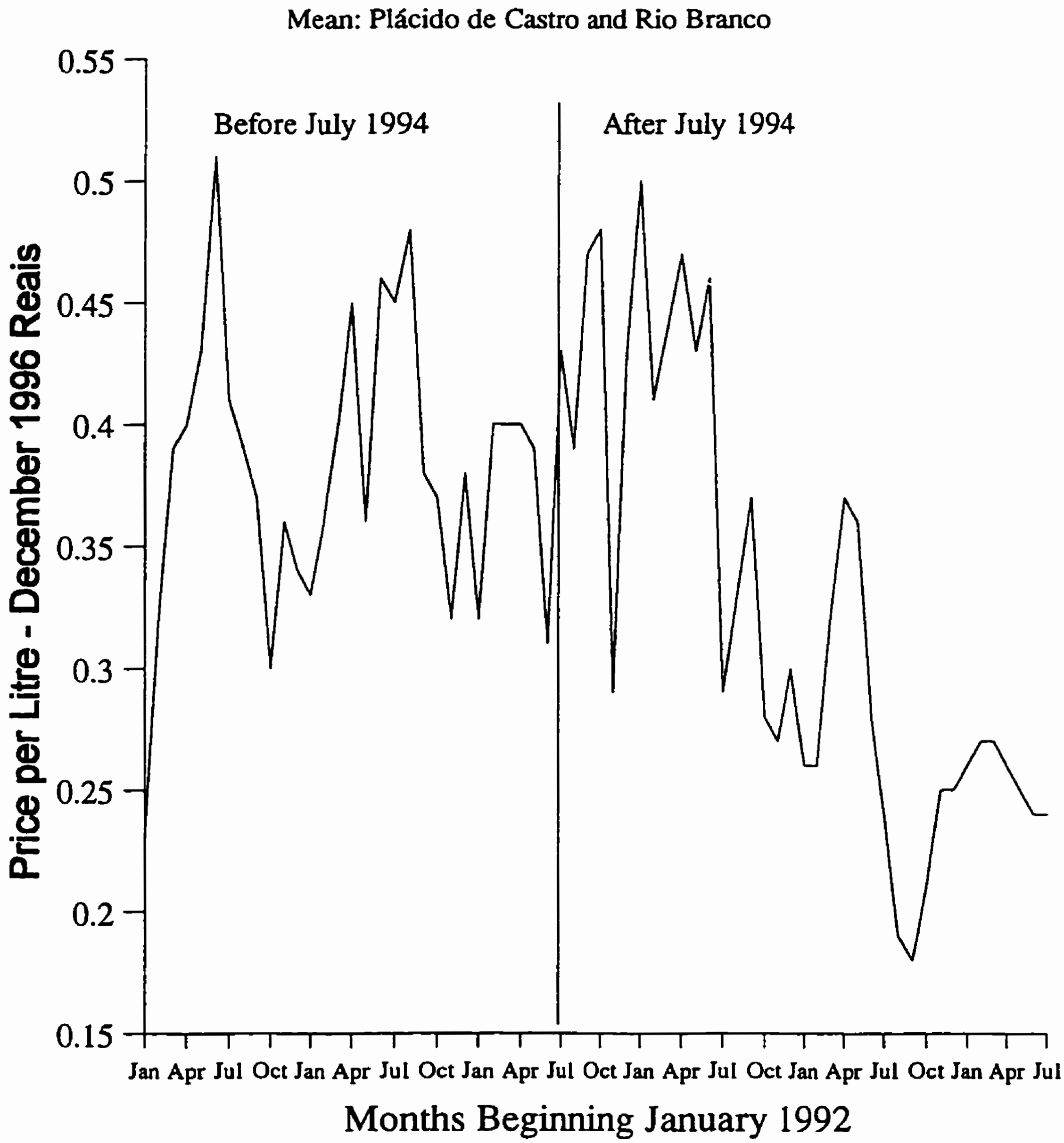
Source: EMATER (unpublished)

Figure 4.3: Bean Prices January 1992 Through July 1997



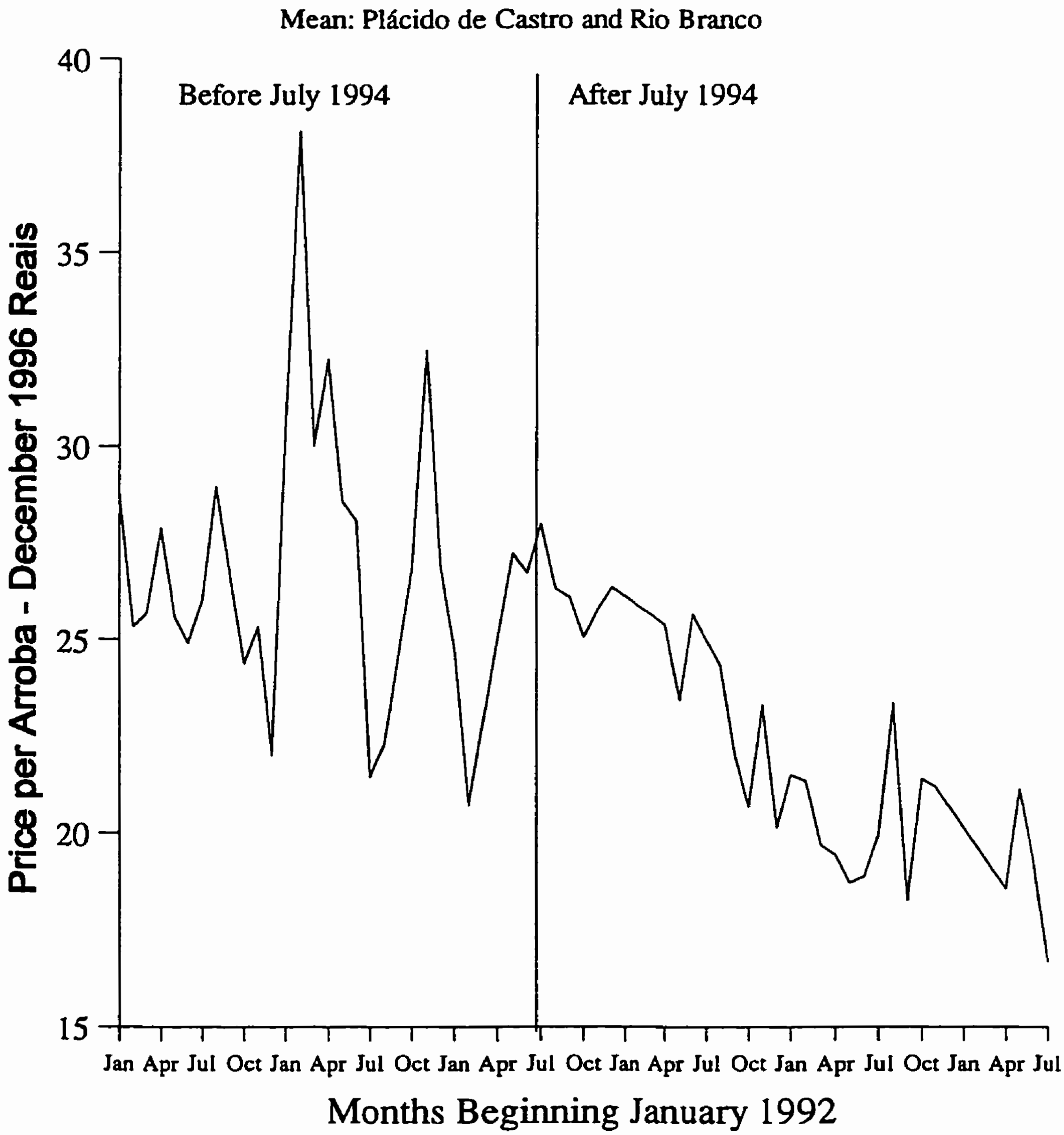
Source: EMATER (unpublished)

Figure 4.4: Milk Prices January 1992 Through July 1997



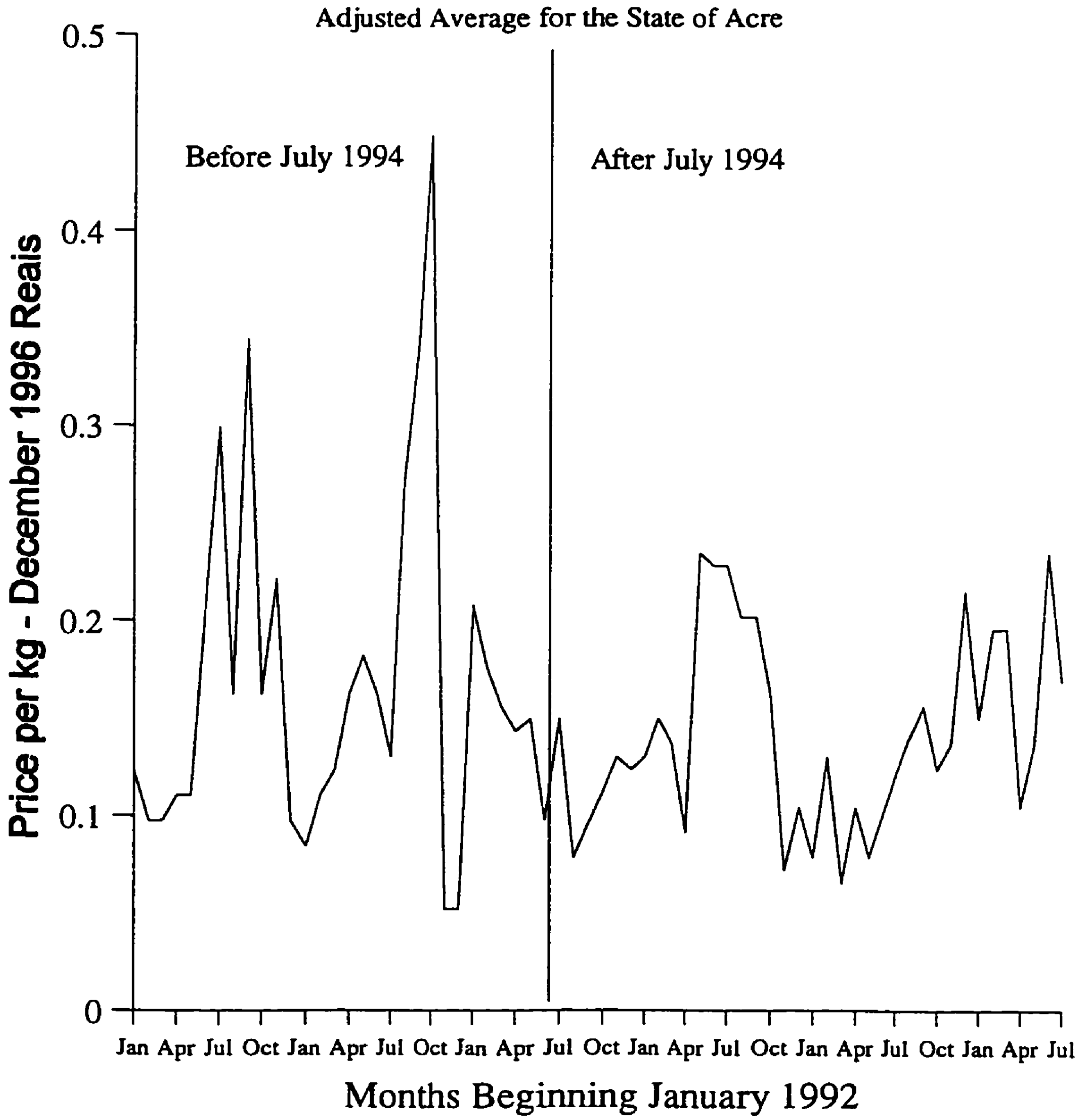
Source: EMATER (unpublished)

Figure 4.5: Beef Prices January 1992 Through July 1997



Source: EMATER (unpublished)

Figure 4.6: Brazil-Nut Prices January 1992 Through July 1997



Source: EMATER (unpublished)

Figure 4.7: Distribution of Annual Gross Returns Before and After July 1994

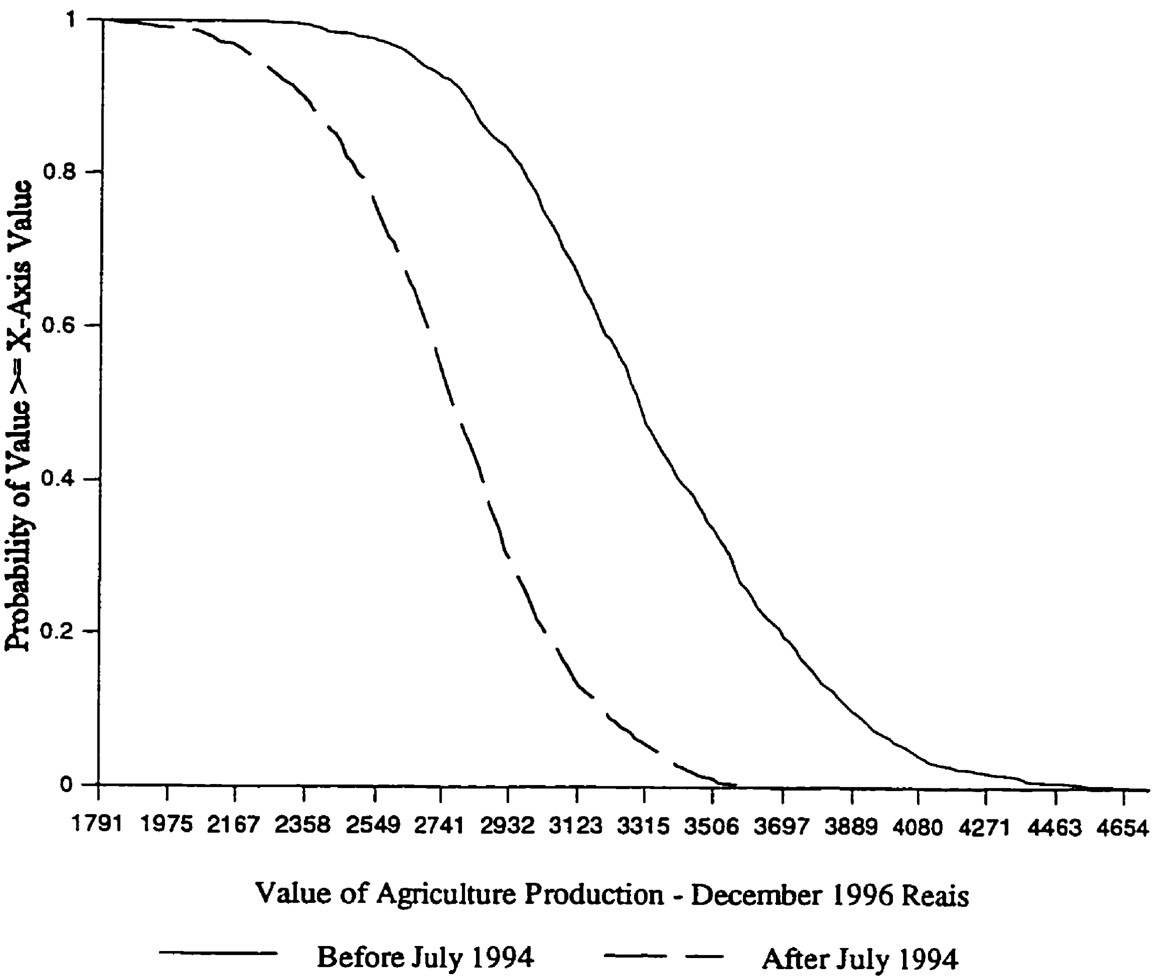


Figure 4.8: Distribution of Rice Prices Before and After July 1994

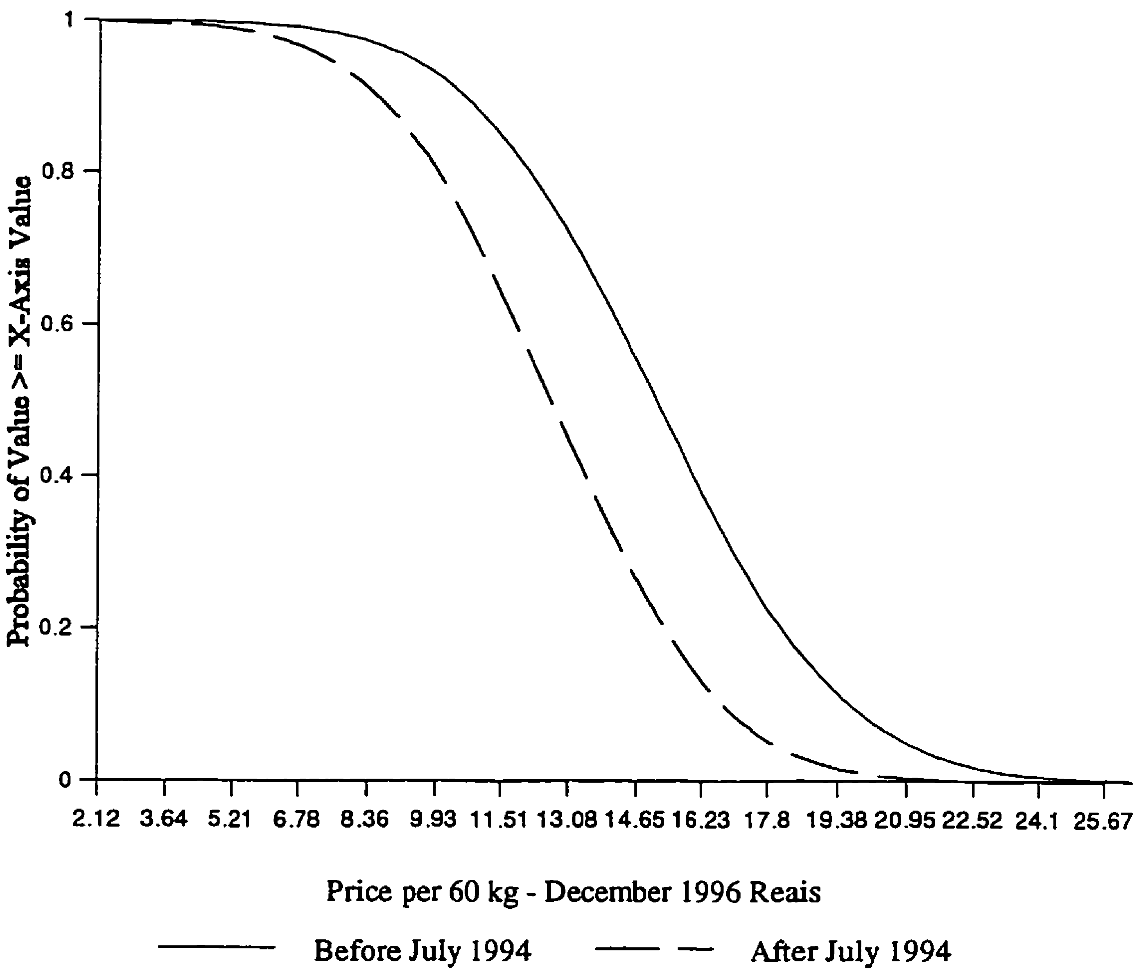


Figure 4.9: Distribution of Beef Prices Before and After July 1994

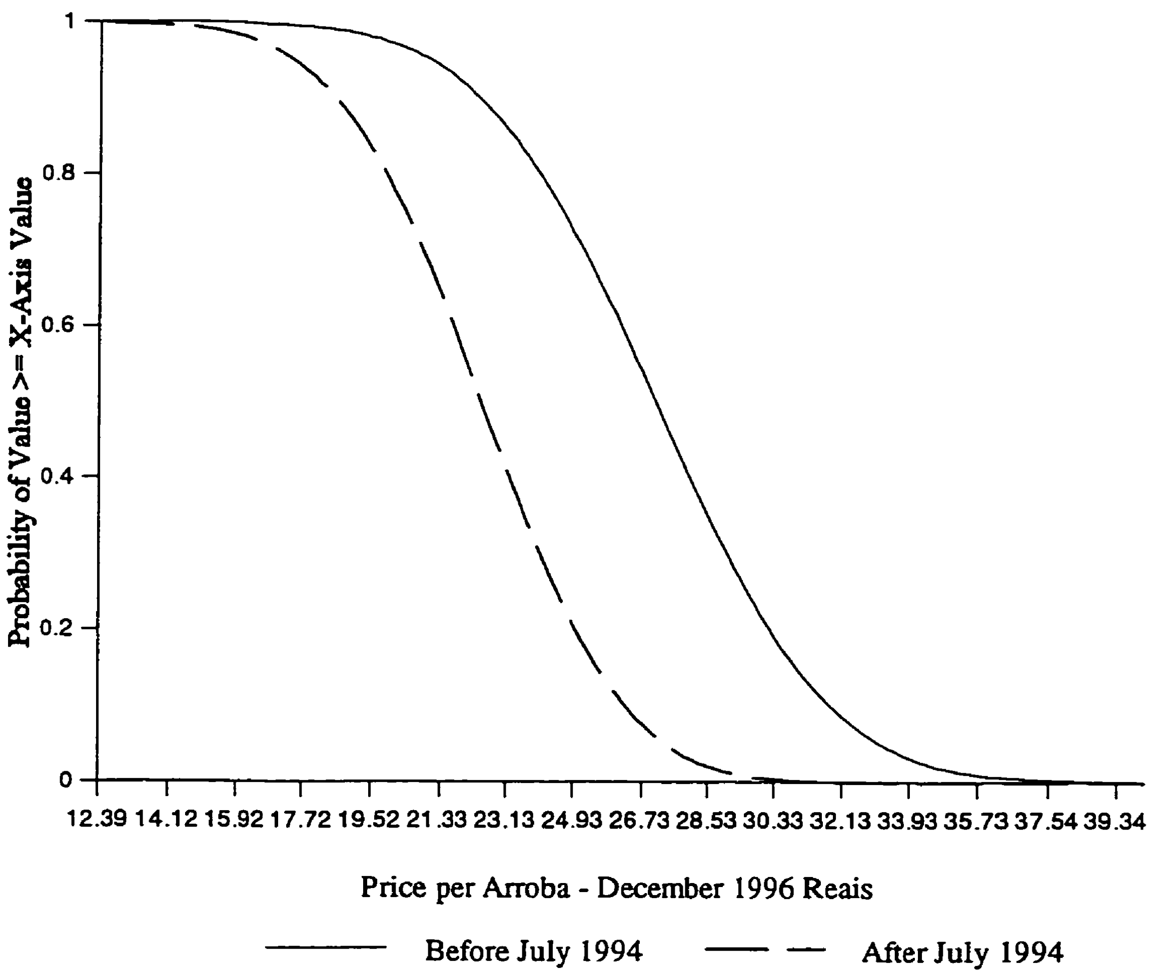


Figure 4.10: Distribution of Brazil-Nut Prices Before and After July 1994

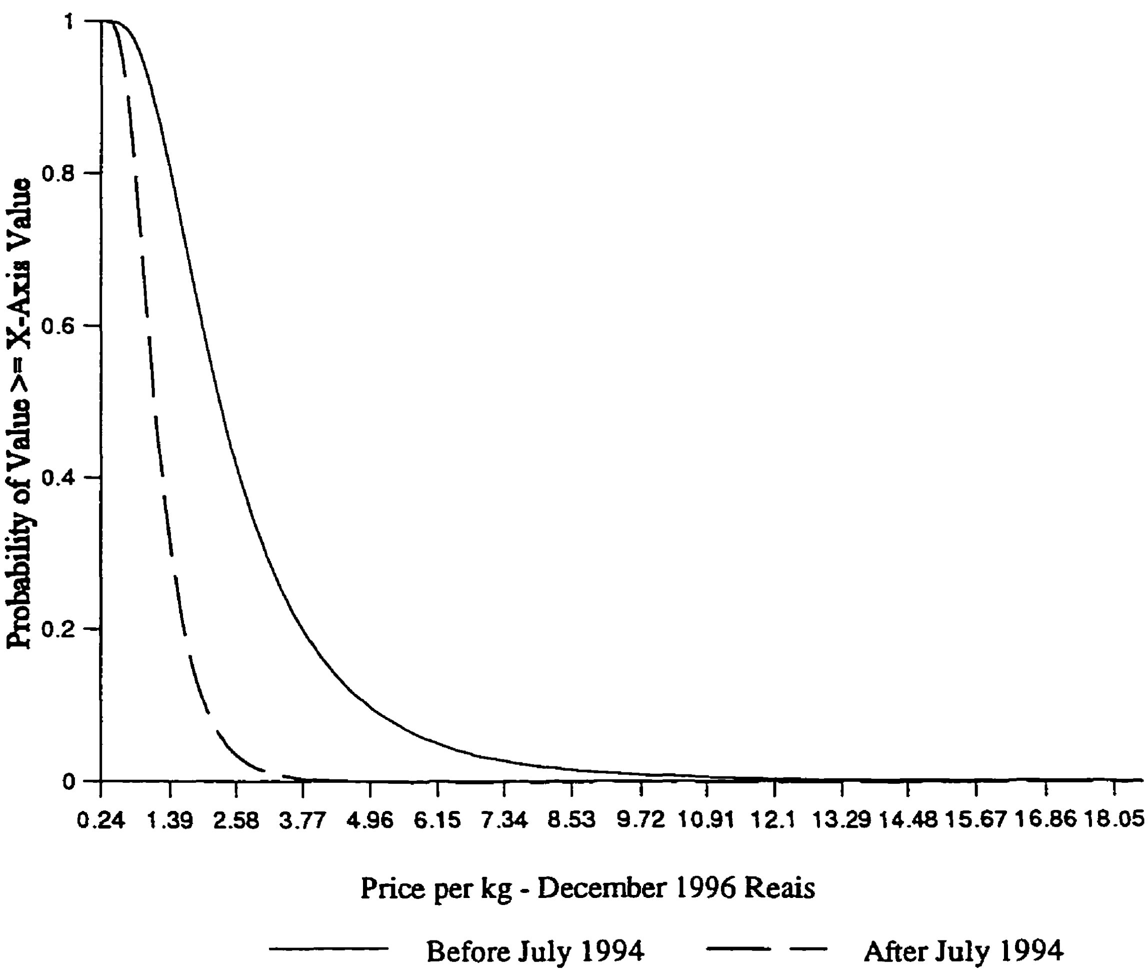


Figure 4.11: Distribution of Milk Prices Before and After July 1994

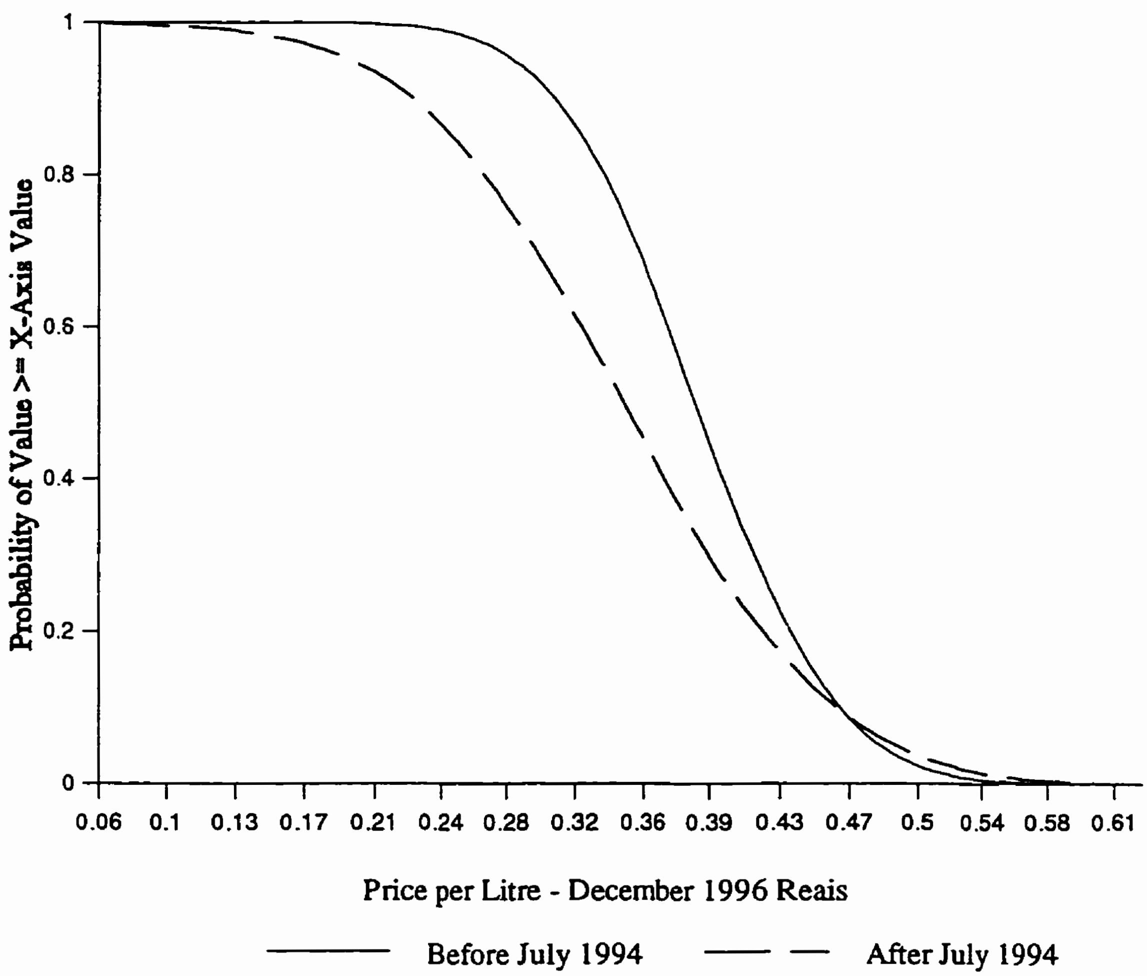


Figure 4.12: Distribution for Corn Prices Before and After July 1994

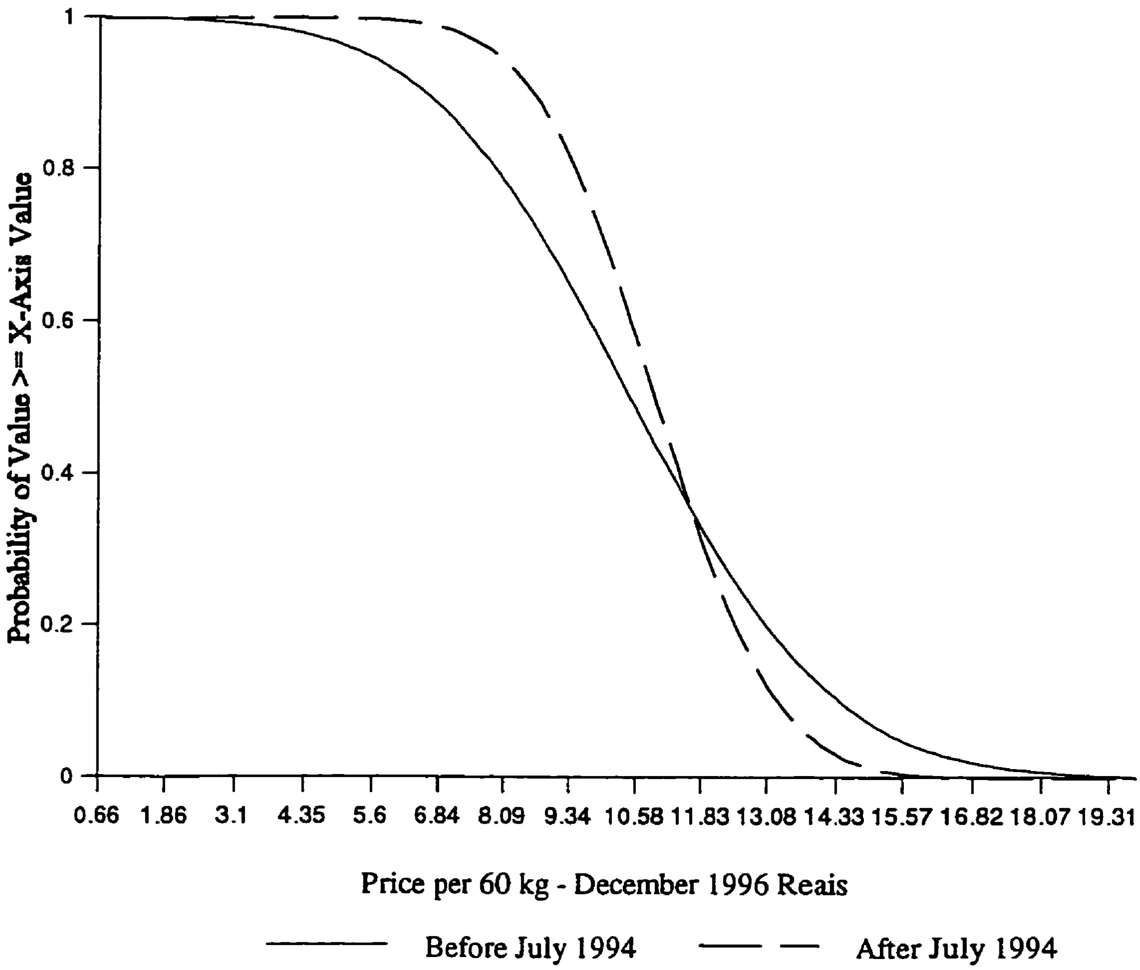


Figure 4.13: Distribution of Bean Prices Before and After July 1994

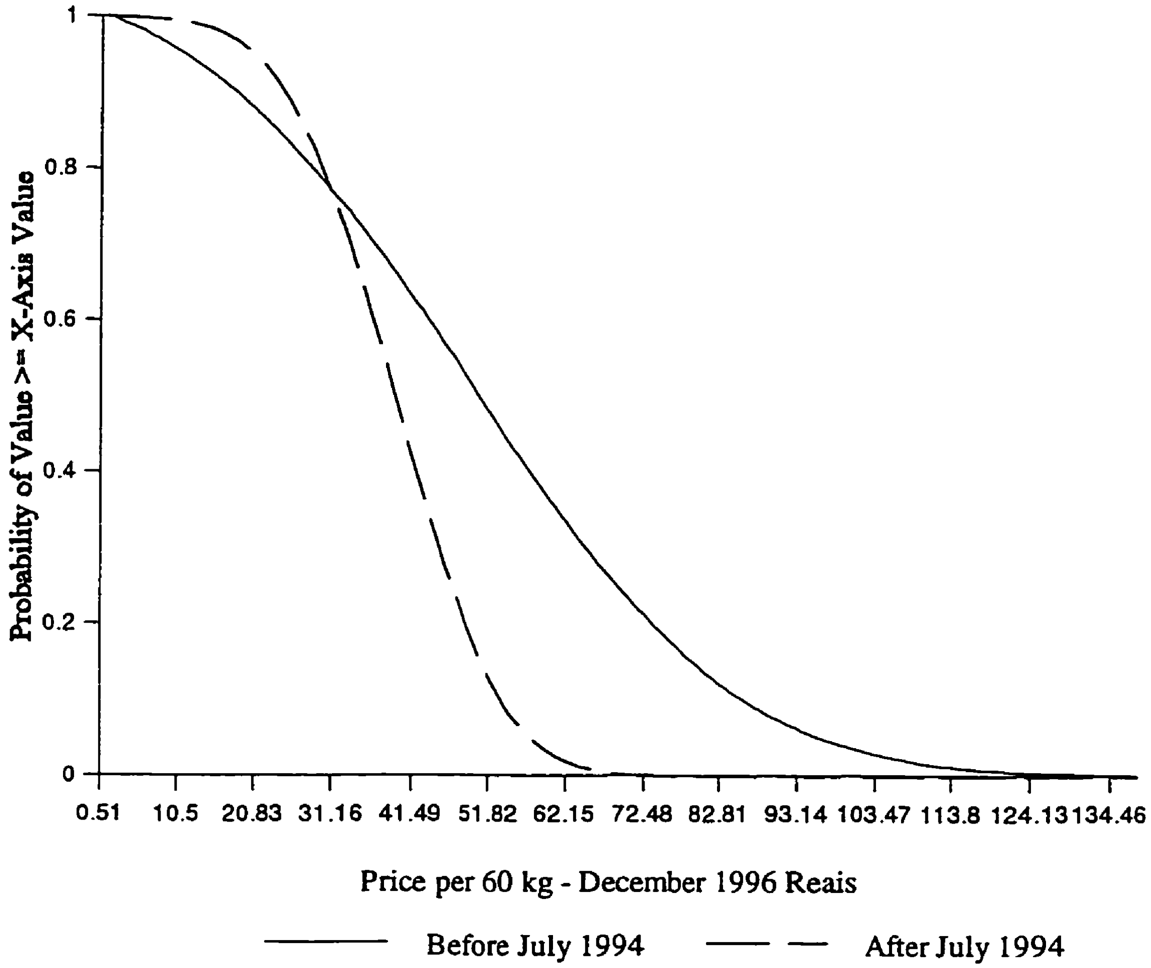
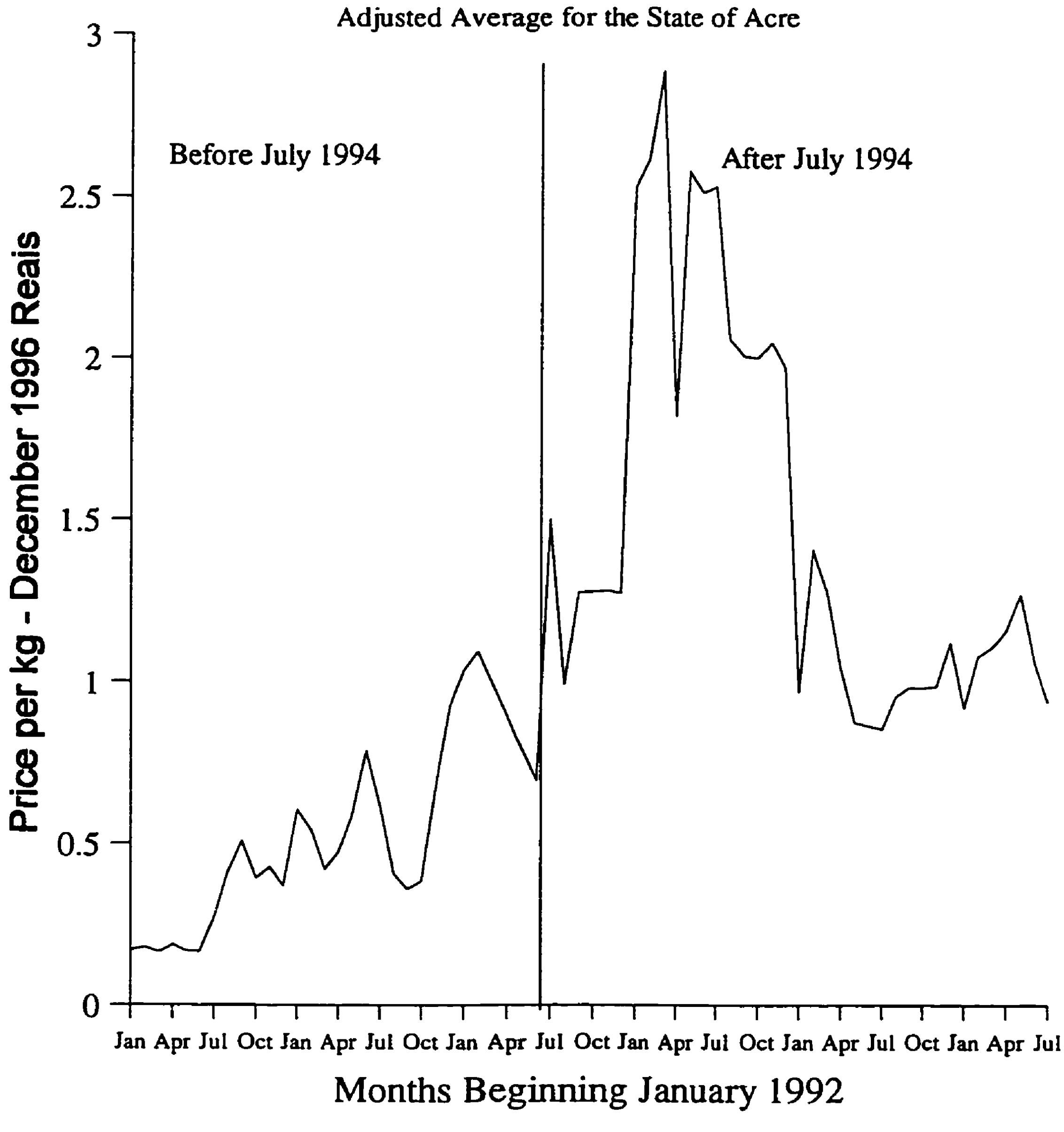
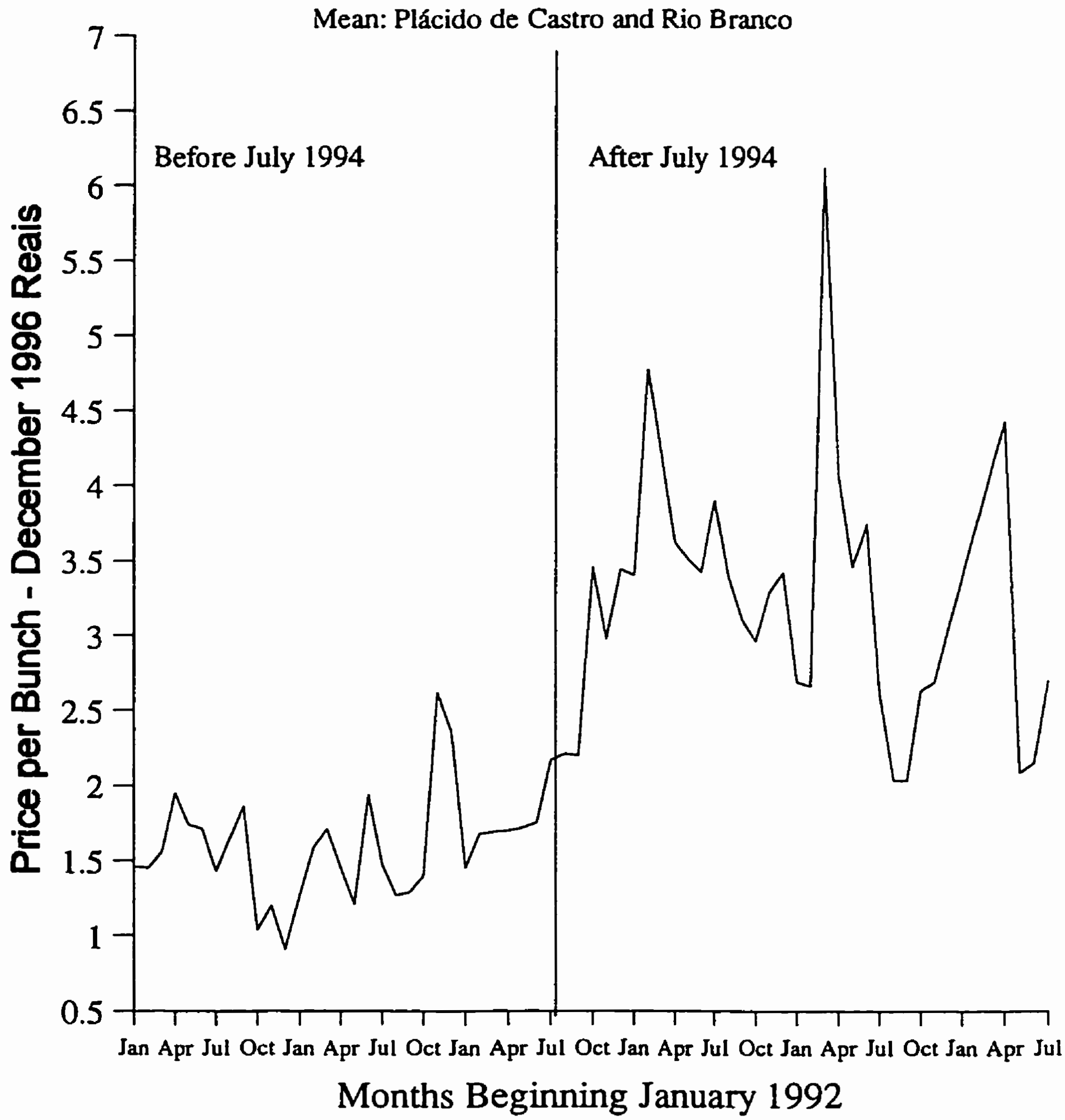


Figure 4.14: Coffee Prices January 1992 Through July 1997



Source: EMATER (unpublished)

Figure 4.15: Banana Prices January 1992 Through July 1997



Source: EMATER (unpublished)

Figure 4.16: Distribution of Coffee Prices Before and After July 1994

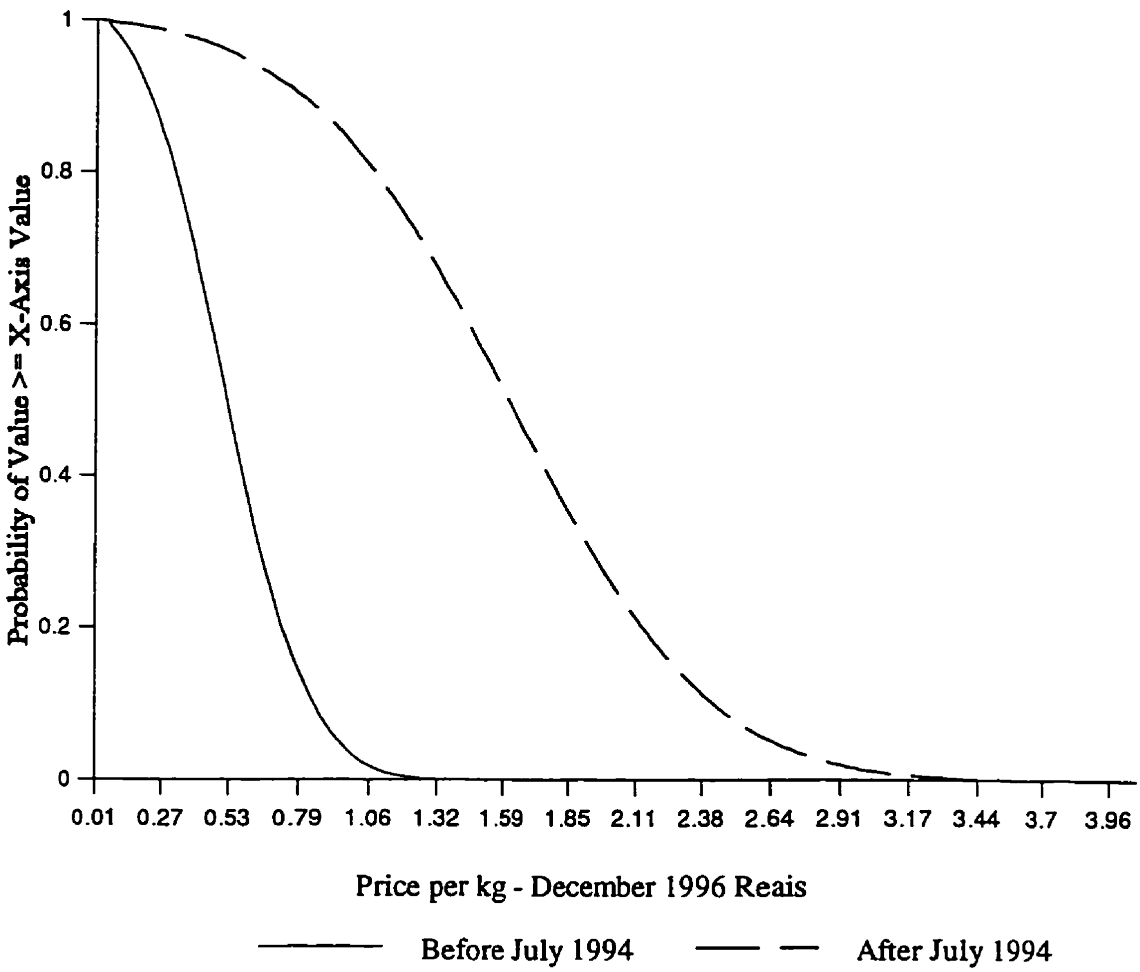


Figure 4.17: Distribution of Banana Prices Before and After July 1994

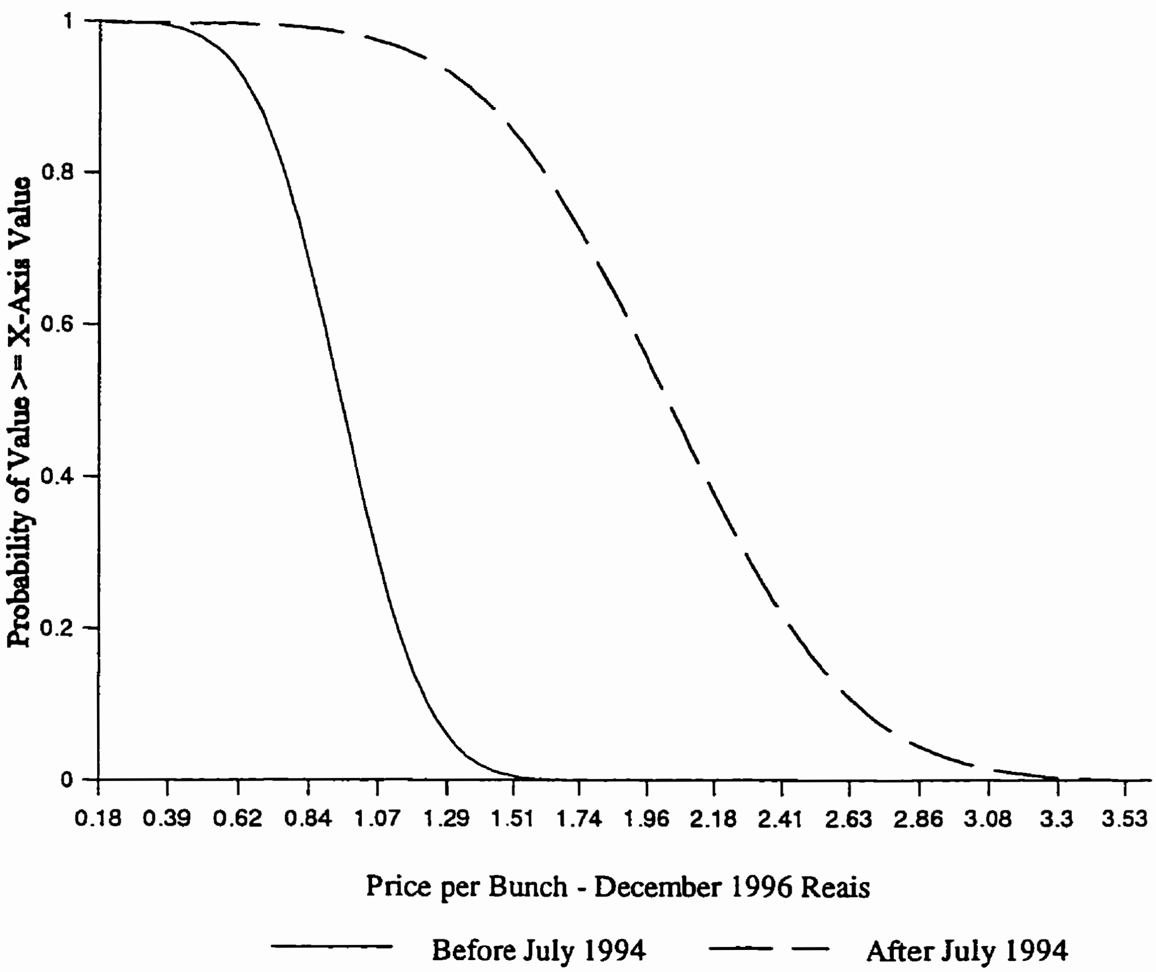
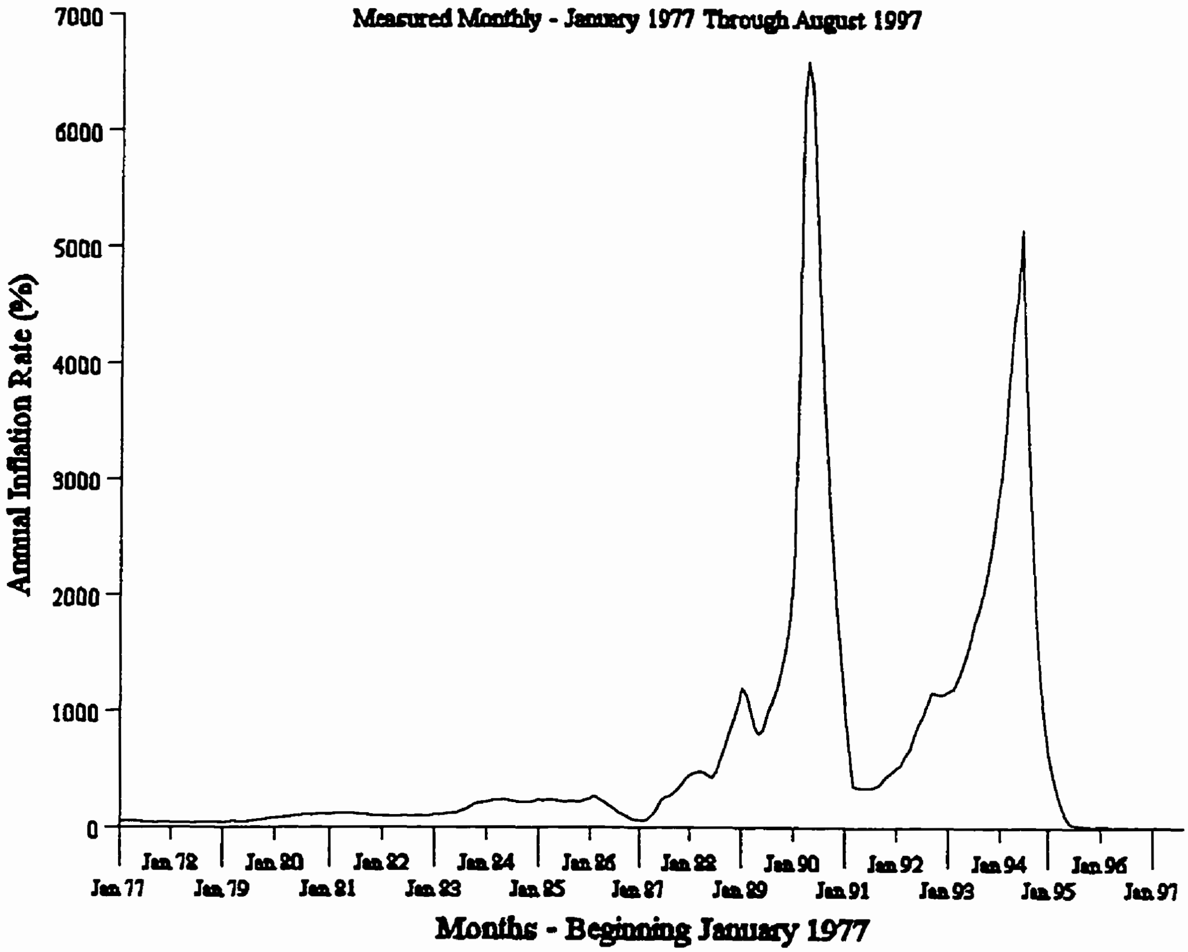


Figure 4.18: Annual Brazilian Inflation Rate



Source: FGV

5.0 Conclusion

This chapter will briefly review the results of this study. This will be followed by a discussion of the implication of these findings for agricultural researchers and policy makers. Finally, the work concludes with an outline for further research.

5.1 Summary of Findings

Chapter Three outlined the commodities typically produced by small holders in the Pedro Peixoto region. The typical production basket, derived from the 1994 IFPRI / EMBRAPA survey of small landholders, was defined by all commodities with median production greater than zero. The typical annual production basket was found to be: 2,180 kg of rice, 1,780 kg of corn, 720 kg of beans, 2,900 litres of milk, 300 kg dressed beef (600 kg live weight), and 800 kg of Brazil-nut.

An analysis of price variation of the different commodities found that price risk is lowest for the pasture products included in the production basket (beef and milk), followed by the annual crops (corn, rice, and beans respectively) and is highest for the extracted product, Brazil-nut. The analysis of price variation also found that the degree of price risk is considerably higher in the Pedro Peixoto region than in the south of Brazil or external markets (e.g., Chicago Board of Trade).

Due (at least in part) to the high degree of risk, producers in the Pedro Peixoto Settlement District have chosen to produce a diversified portfolio of commodities. The high degree of risk is a barrier to the production of alternative commodities and the adoption of alternative production practices that require increased intensification.

In Chapter Three the expected return from the production of the typical production basket was estimated to be 3,000 Reais. This estimate is appreciably above the World Bank's estimate of the Brazilian poverty line (1,100 Reais) and the annual minimum wage (1,200 Reais).

The settlement project has provided people with an opportunity to acquire land and provided the settlers with an opportunity to improve their way of life. That is, the settlement project has arguably met the major poverty reduction objective of the official settlement projects.

In Chapter Four the price series were divided into two groups, before and after the Plano Real. Two price trends were found to be evident for the majority of the commodities found in the typical production basket. First, it was found that the month-to-month price variation was declining for all commodities after July 1994. Second it was discovered that the expected return for almost all commodities fell after July 1994. Stochastic dominance analysis was applied to determine if the combination of falling price and falling price variation was beneficial for small landholders. It was discovered that small landholders producing the typical production basket would have been better off under the conditions found before July 1994.

While agriculture has provided small landholders with an opportunity to improve their way of life, their potential return from the production of traditional commodities has declined in the 1990s. Small landholders are faced with a number of options: (a) increase production by increasing their land base, (b) accept a lower standard of living, or (c) supplement current production with alternative commodities, and/or increase production of traditional commodities through more intensive and specialized production practices. Producers must be encouraged to choose option (c) if a balance is to be maintained between growth, the environment, and the desire to alleviate poverty.

Stochastic dominance analysis was extended to the individual price series. It was discovered that all producers of rice, beef, and Brazil-nut would have been better off with the combination of expected return and variability found before July 1994. Risk averse producers of milk would have been better off with the combination of price and variability found before July 1994, while risk averse producers of corn are better off with the combination of price and variability found after the Plano Real. The stochastic dominance analysis did not yield conclusive results for bean prices. Two alternative commodities not found in the typical 1994 production basket, coffee and banana, were also examined using the stochastic dominance techniques. It was discovered that, for these two commodities, producers in the Pedro Peixoto region are better off with the combination of price and variability found after July 1994.

> *Expected prices are generally falling for the commodities in which Acre is deficit and rising for commodities in which Acre is surplus. If producers are able to incorporate alternative commodities into their production basket, they will be able to take advantage of the macroeconomic changes occurring in the region. The desire to produce commodities that offer higher potential returns must be balanced with the associated increase in price risk that results from increased intensification and the inherently higher risk associated with the alternative commodities examined.*

Two explanations for the price trends were explored in Chapter Four. First, the possibility of a link between falling inflation rates and falling price variability was investigated. Evidence of such a link was discovered, and therefore the decline in the inflation rate may help explain the observed decline in price variability. The fall in the inflation rate may also provide a partial explanation for the downward trend in beef prices.

Declining transaction costs were also explored as a possible explanation for price trends. Evidence was presented that supported the idea that transaction costs between the rest of Brazil and Acre are declining. The observation that prices tend to be falling for commodities imported into Acre and rising for commodities exported from Acre supports the hypothesis of falling transaction costs. The hypothesis is further supported by an indication that some Acre prices may be integrated with prices in the South of Brazil after July 1994 that were not integrated before July 1994.

If the trends observed in commodity prices can be largely explained by falling inflation and decreasing transaction costs, they can be expected to be long term effects. That is, it is unlikely that the downward trend observed in most commodities typically produced by small landholders will be reversed. Therefore, the pressure for small landholders to increase their return from agricultural production will likely continue to build. As previously mentioned this can be accomplished through increasing the land base or by modified production practices and/or the production of alternative commodities.

5.2 Implications of Findings

Given that agricultural production in the Pedro Peixoto region provides small landholders with returns that are greater than alternative labour uses there are ongoing economic incentives for continued expansion of small landholder production. The pressures for expanded production may be intensified by the decline in expected return observed after July 1994 (i.e., producers may have to increase production to maintain their income level). Unless research can provide alternative forms of income expansion (e.g., alternative production practices or the production of alternative commodities), it is likely that this increase in small landholder production will largely accrue from deforesting more land.

The ability of producers to adopt alternative production practices may be hampered by the high degree of price variability observed in commodity prices in the region. This research has shown that the degree of price risk is higher for small landholders in Pedro Peixoto than in the south of Brazil, or in other markets outside Brazil. Small landholders in the Pedro Peixoto region have been able to reduce this price risk through diversified production. The high degree of price risk, and the need to diversify to reduce the exposure to risk, may decrease the desirability of alternative production practices and/or alternative commodities that require increased intensification (e.g., agroforestry, improved pasture management). However, the analysis in this study has shown that price variability may be declining over time. If this price trend continues, there may be an optimal time (i.e., when price variability has declined to a sufficient degree) to implement intensification plans.

The economic pressures on small landholders, resulting in part from a changing market environment, have significant implications for policy makers. Many of the large macroeconomic forces that have caused the changes in prices are beyond the control of local policy makers. However, some policies can be put in place to help small landholders take advantage of these changes.

Toniolo and Uhl (1995) note three basic impediments to increased income from the existing land base: poor access to technical assistance, lack of credit, and frontier markets. Each of these impediments can be eased by policy makers in the region.

Extension efforts must give small landholders the market information they need to make informed production decisions. This may be as simple as communicating current price trends and expectations of price changes. As markets in the Pedro Peixoto region become more integrated with markets outside the area, commodity prices will be influenced to a greater degree by outside factors (international production, for example). Small landholders may not be aware of the impact of outside forces on local prices and giving them this knowledge may improve their production decisions. Small landholders may also need assistance in identifying and taking advantage of new market opportunities that are created out of the changing market environment.

Technical support is also needed to help small landholders develop the knowledge required to produce alternative commodities. Small landholders can also adjust their current production practices to increase the revenue earned by traditional commodities. For example, studies have shown (e.g., Faminow et al., 1998, and Valentim, 1989) that improved pasture and herd management can increase the return from the production of beef and milk, two commodities with relatively lower price risk. Again, small landholders may require technical assistance in adopting new management practices.

Lack of available credit will also inhibit small landholders from taking advantage of the changing market environment. Capital (along with labour) is one of the factors of agricultural production in short supply in the Amazon region. Increased access to capital through credit programs will give small landholders the opportunity to adapt their production practices and/or introduce additional commodities into their production basket. In addition, Vosti et al. (1998b) note that rural financial institutions do not adequately direct capital created by small farmers back into rural investments. Investments in rural financial institutions will assist in the reinvestment of locally generated capital, as well as improve the availability of credit. As noted in Chapter Four, continued low inflation rates also aid in improving capital availability through increased access to credit as well as reinvested savings.

Increased market access may lead to decreased price variability because this will decrease the sensitivity of local prices to changes in local production. Decreased transaction costs may also increase the return from products exported from Acre. As improvements in market infrastructure can lead to higher returns and lower price variability, these improvements also increase the likelihood that small landholders will choose to expand their income through the adoption of alternative production practices and/or through production of alternative commodities. Investment in market infrastructure is therefore an important policy tool that can assist small landholders in adapting to changes in the market environment.

Improving transportation links is one way in which local policy makers can reduce the market isolation of small landholders in the Pedro Peixoto region. Not only will improved transportation links reduce the sensitivity of local market to local changes in production (and hence reduce price variability) it will also improve the ability of small landholders to deliver high quality products to the market. This is especially important to commodities (banana for example) that quickly deteriorate. Other investments in market infrastructure may improve the processing of products, the packaging of products, and improve marketing strategies through increased awareness of customer needs.

5.3 Further Research

Of primary importance in ongoing research is the need to continue to gather, deflate and analyse price data from the settlement districts in the western Amazon. This must be done to allow ongoing research to learn if the trends identified in this study continue, or if they were short term events that will be reversed in the future. In order to determine the likelihood of the observed trends continuing, a more rigorous market integration study should be conducted. A longer time series is required to complete the market integration research.

The hypothesis brought forward in this study that transaction costs were declining was supported by the idea that prices were falling for imported products and rising for exported products. However, evidence to support this hypothesis is mainly anecdotal. Therefore, a need exists for market research to detail the flows of products in and out of the region if current and future trends in prices are to be understood.

In order to assess the desirability of alternative commodities, the price analysis carried out in this research study should be extended to other alternative commodities, such as agroforestry products (heart-of-palm production for example). An analysis of price risk should be included in any research project analysing the viability of alternative commodities or alternative production practices in the region. This must include an analysis of price trends, as the inherent risk in some commodities may be declining over time, so that even if they present too large a risk today, they may become viable alternatives in the future.

As previously mentioned, the addition of cost structures to stochastic dominance analysis would allow researchers to determine the probability of ongoing profits from alternative production strategies, and determine the probability of small landholder bankruptcy. This could prove to be an important analytical tool in comparing the desirability of various alternative production practices and/or commodities.

Finally the risk analysis carried out in this study should be extended to an analysis of production risk. Price risk, while important to small landholders, is only one part of the risk equation. A clear understanding of production risk is necessary to gain a more complete understanding of why small landholders in the Pedro Peixoto region choose particular production practices.

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