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DISTRIBUTIONAL EFFECTS OF CURRENCY DEVALUATION
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AN APPLICATION OF WILLINGNESS-TO-PAY
WELFARE MEASURES

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DISTRIBUTIONAL EFFECTS OF CURRENCY DEVALUATION ON HOUSEHOLDS IN RWANDA: AN APPLICATION OF WILLINGNESS-TO-PAY WELFARE MEASURES

By

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ABSTRACT

Distributional Effects of Currency Devaluation on Households in Rwanda: An Application of Willingness-To-Pay Welfare Measures

By

Nicholas W. Minot

Currency devaluation is a controversial policy measure in developing countries. One of the most common criticisms is that devaluation causes disproportionate suffering among the poor. This study investigates the distributional impact of price changes associated with devaluation in Rwanda. It uses a simplified household-firm model based on household budget data and both hypothetical and historical prices to simulate the effect of devaluation on demand, real income, and nutrition.

Two aspects of the research approach deserve note. First, rather than using the standard method of simulating the impact on a handful of "archetypal" households, this study approximates the effect of price changes on each household in the sample, allowing the results to be aggregated to any desired sub-group of the population. Second, in addition to the standard measures of welfare impact (consumer surplus and the Laspeyres price index), the two "willingness-to-pay" measures are calculated using the method suggested by Vartia (1983).

The results indicate that the price changes associated with devaluation have a proportionately greater negative impact on the real income of urban and high-income households than on rural and low-income households, principally because the latter are insulated from all price changes by the importance of home production. These results highlight the risks of simple generalizations about the distributional impact of devaluation.

DEDICATION

I dedicate this work to Lisa,
my wife, colleague, and friend

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CHAPTER ONE

INTRODUCTION

1.1 Background

Since the early 1980s, an increasing number of less developed countries have been forced to implement macroeconomic adjustment policies to deal with large current account deficits, inflation, and stagnant economic growth. The reasons for these difficulties vary from country to country, but they include international events such as falling commodity prices and the world recession in the early 1980s, as well internal factors such as overly expansionary economic policies. In sub-Saharan Africa, these problems have been exacerbated by increasing variable rainfall and, in some countries, civil unrest (World Bank/UNDP, 1989).

In a number of countries, the historically high commodities prices of the mid- and late-1970s allowed a significant expansion of government revenue and spending. The fall in commodity prices in the early 1980s, generated both budget and trade deficits. Initially, these deficits were financed by external borrowing, a policy based on both unjustified optimism about commodity prices and political resistance to reductions in imports and government spending. When low commodity prices proved not to be transitory, governments often resorted to excessive monetary expansion to finance the budget deficits. The resulting inflation, in the context of a fixed exchange rate, exacerbated the current account deficit, leading to import restrictions and controls on foreign exchange transactions (Zulu and Nsouli, 1985).

The standard economic prescription for trade imbalances in a fixed-exchange-rate regime is to adjust the exchange rate, devaluing the local currency with respect to those of its trading partners. When successful, devaluation raises the local returns to import substitution and export activities, while dampening the demand for exportable goods and imports. At the same time, it often serves to restore confidence in the currency, reducing the incentives for capital flight.

For these reasons, devaluation is frequently a key element in structural adjustment packages promoted by the World Bank and the International Monetary Fund (IMF). Approximately two thirds of the countries in sub-Saharan Africa devalued between 1983 and 1987. Most of these devaluations were implemented as part of World Bank structural adjustment loan programs (Sahn, 1990: 249).

At the same time, devaluation is a highly controversial policy measure. Policy-makers in less developed countries often postpone devaluation as long as possible, appearing to implement it only under pressure from the international financial organizations. Critics argue that devaluation has a contractionary effect on the economy, is ineffective in reducing external deficits, and has a regressive impact on income distribution (Godfrey, 1985; Cornia, Jolly, and Stewart, 1987).

One result of this controversy is that the World Bank and other donor agencies have given greater attention to designing complementary programs to alleviate the impact on vulnerable groups, particularly the poor (World Bank, 1990b). These programs are defended both on humanitarian grounds and on the grounds that the sustainability of the reforms often depends on maintaining a minimum degree of political support during the difficult initial stages.

Another by-product of the controversy is that devaluation has been the subject of numerous theoretical and empirical studies. The effect of devaluation on aggregate demand, the price level, and the external balance has been extensively studied using a variety of research approaches (see section 3.2.2). On the other hand, the distributional impact of devaluation, although powerful, is less well understood. Part of the explanation is that indicators of income distribution are not regularly collected, thus limiting the possibilities for cross-country or time-series analysis. In addition, the distributional impact of devaluation is quite sensitive to the structure of the economy (whether staple food crops are imported, who produces the export commodities, and so on). Thus, it is difficult to generalize across countries.

This is unfortunate because knowledge of the distributional impact of devaluation would assist the design of complementary policies to alleviate the impact on those harmed. Furthermore, better knowledge about the distributional impact may help explain the political economy of currency devaluation.

1.2 Objectives of the study

The principle objective of this research is to use household budget data from Rwanda to estimate the short-run distributional impact of relative price changes associated with currency devaluation. Household budget data are used to estimate income and price elasticities of demand. The survey results, combined with projected changes in prices, will provide a picture of the impact of devaluation along three dimensions: real income, the composition of demand, and the nutritional intake of households. The distributional impact will be evaluated by disaggregating the results by location of residence, by income level, by occupation, and by sex of head of household.

Because we examine only the short-run impact of one aspect of devaluation, no attempt is made to judge the overall desirability of devaluation. Nonetheless, the results should address concerns about the distributional impact of devaluation.

A second objective of the study is to provide some generalizations about the impact of devaluation in less developed countries. As mentioned above, the distributional effect of devaluation varies greatly among countries depending on the structure of the economy, but this research may help specify the variables that are most important in determining the outcome.

Third, the methods developed in this study could have applications elsewhere. In spite of the growing recognition of the importance of addressing the distributional effects of devaluation, most of the empirical work done thus far is merely suggestive. Household budget data, available in many less developed countries, are a rich source of information for this type of policy analysis.

Two methodological issues are of particular interest. First, in most applied studies, the welfare impact of alternative price scenarios is approximated using simple price indexes or, in some cases, consumer surplus. At the same time, several approaches to estimating the "exact" welfare impact have been developed in the literature (McKenzie, 1983; Vartia, 1983). These "willingness-to-pay" measures are theoretically superior to consumer surplus and yet require no more information about the shape of the demand curves. Thus, one of the methodological objectives of this study is to compare alternative "willingness-to-pay" measures and to evaluate their usefulness relative to simpler but less accurate measures.

Second, aggregate household behavior is generally analyzed by classifying households into three to seven categories such as small farmers, large farmers, wage earners, and so on. Then, models of each type are constructed and allowed to interact, usually with weights to represent the relative importance of each group in the population. However, such an approach does not take full advantage of the information available in any household budget survey. Nor does it reflect the diversity of household income and expenditure patterns. This study makes use of "micro-simulation" in which the behavior of each household in the sample is simulated (Smith and Strauss, 1986). Although this approach involves somewhat more computation, it allows the researcher to estimate the impact on any sub-group of the population, making full use of the diversity found in the survey data base.

1.3 Organization of the study

This study comprises eight chapters. Chapter 2 provides a brief overview of the geography, history, and economy of the Republic of Rwanda. In addition, the background of the current economic crisis and the response of the government are described.

In Chapter 3, a fairly diverse body of previous research is reviewed. First, theoretical and empirical studies of the impact currency devaluation are discussed. Second, models of consumer behavior are considered, with emphasis on the theory of consumer demand and various problems in estimating demand. Finally, an overview is provided on the theory and practice of measuring the welfare impact of price changes on individual households.

Chapter 4 outlines the methods of the study. This includes a description of the Rwandan household budget survey which forms the basis of the study. In addition, the estimation of the demand model is discussed, along with the implied behavioral assumptions. Next, the methods of obtaining the price changes associated with devaluation are explained. And finally, we describe the process of using the demand model to calculate the welfare and nutritional impact of the price changes.

The results of the study are presented in Chapters 5, 6, and 7. Chapter 5 presents some basic descriptive results from the household budget survey. The sources of income, patterns of expenditure, and variation across different types of households are described. Because of the importance of agriculture in the Rwandan economy, special attention is given to the patterns of agricultural production and marketing patterns in the rural sector. The importance of subsistence production, the patterns of net sales of staple crops, and the tradeable component in household income and expenditure are considered.

In Chapter 6, the results of the econometric analysis of household demand are described. Budget shares of some 25 categories of goods and services are estimated as a function of total household expenditure, the demographic characteristics of the household, and food prices.

Chapter 7 uses the demand model to simulate the impact on each household in the sample of various price changes associated with currency devaluation. The welfare and nutritional impact of these changes is discussed.

Finally, in Chapter 8, we summarize the results of the study and draw implications for economic policy in Rwanda and similar countries. In addition, the results of the study are examined in light of the need to improve the methods used in similar studies in the future.

CHAPTER 2

BACKGROUND ON RWANDA

This chapter provides a brief description of Rwanda and the developments leading up to the recent economic problems in order to set the stage for the analysis in later chapters. Section 2.1 provides an overview of the geography, climate, people, and economy of Rwanda. Section 2.2 describes the external events and economic policies which precipitated the current economic crisis. And section 2.3 reviews the most important elements of the structural adjustment program, implemented to confront the economic problems.

2.1 Description of Rwanda

2.1.1 Geography and climate

The Republic of Rwanda is a small landlocked country in the highland region of east-central Africa. It covers just 26,338 square kilometers (10,169 square miles), virtually all of which is over 1000 meters (3250 feet) above sea level. The country is surrounded by Tanzania on the east, Uganda to the north, Zaire across Lake Kivu to the east, and Burundi to the south. Mombassa, the port through which most international trade flows, lies about 1700 kilometers (650 miles) to the east by road.

Although quite close to the equator (1-3° S.), Rwanda enjoys a mild temperature, averaging about 20° C. (68° F.) with relatively little seasonal variation. Rainfall follows a bi-modal pattern, with the long rainy season being between March and May and a less pronounced rainy season from October to November. Most parts of the country receive 900-1300 mm of rainfall annually.

In spite of its small size (less than that of Maryland), Rwanda has a variety of geo-climatic zones. The eastern third of the country is dominated by rolling savannah, being lower (1000-1500 m), drier (800-

1000 mm), and warmer (21-22° C) than most of Rwanda. The central plateau lies between 1500 and 1900 meters and has intermediate temperatures and rainfall. To the west is the Zaire-Nile Ridge which runs north-south, separating the Nile watershed to the east and Lake Kivu to the west. These mountains generally have altitudes from 2000 to 3000 m, although several volcanic peaks in the northern portion of the range are over 3500 m., including Mt. Karisimbi (4500 m). Thus, much of the western third of Rwanda is cool (15-17° C.) and damp (more than 1300 mm rainfall) (Sirven *et al.*, 1974).

2.1.2 People and history

Rwanda is the most densely populated country in sub-Saharan Africa and has one of the highest population growth rates in the world. The mid-1988 population was estimated at 6.7 million, yielding a population density of 254 persons per square kilometer (approximately 650 per square mile). This density is higher than that of most Asian countries including India and the Philippines. The World Bank estimates that the population growth will average 3.8% through the 1990s, reaching 10 million by the year 2000 (World Bank, 1990a).

The high population density is even more surprising given the small proportion of the population living in urban areas, around 7%. The principal urban center is the capital, Kigali, with around 150,000 residents. In the rural areas, there are very few towns or even hamlets, almost all dwellings being dispersed throughout the hills. The population density is lowest in the eastern savannah and highest in the fertile volcanic zone of the northwest. Most of the population, however, lives in the intermediate altitudes of 1500 to 1900 meters (Sirven, 1974).

Ethnically, the population of Rwanda is composed of the Hutu (87-89% of the population), the Tutsi (10-12%), and the Twa (barely 1%). The Twa were the original hunter-gatherer inhabitants of the region. The Hutu are said to have arrived between the 7th and 10th century, bringing sedentary agriculture with them as part of the great Bantu migrations. The pastoral Tutsis migrated into the area in the 13th and 14th century, establishing feudalistic control over the existing population. The network of kingdoms expanded slowly, encompassing by 1900 much of what is today Rwanda and Burundi (Heremans, 1988).

Although Germany occupied Rwanda and Burundi from the turn of the century until World War I, their presence was minimal. Belgium seized the territory in 1916 and received a League of Nations mandate to administer it three years later. The Belgian administration concentrated on road building, reforestation, the promotion of sweet potatoes and manioc as anti-famine measures, the introduction of coffee, and the expansion of internal trade. Devoting only a small staff to the territory (numbering just 205 in 1945), Belgium ruled through the existing Tutsi monarchy (Leurquin, 1963). In the 1950s, educated Hutus began demanding a greater role in the political process, culminating in a violent rebellion in 1959. This led to Belgian-organized elections in 1960-1961 and independence in 1962 under a Hutu-dominated government. In 1964, Burundi and Rwanda separated from each other, the former being ruled by minority Tutsi governments to this day (Heremans, 1988).

In Rwanda, the "First Republic," under President Gregoire Kayibanda, lasted from independence in 1962 until 1973. His rule ended when the current president, Major General Juvenal Habyarimana, took control in a bloodless coup, establishing the "Second Republic." While the First Republic was explicitly pro-Hutu, President Habyarimana has attempted to reduce ethnic tensions by incorporating Tutsis in the government in numbers roughly proportional to their population.

Some have argued that the Hutus and Tutsis are not, strictly speaking, ethnic groups since they share the same territory, language, and culture. Furthermore, intermarriage has somewhat blurred the physical differences between the two groups. On the other hand, tensions between the groups have been an important factor in the history of Rwanda and Burundi, which has been punctuated by periods of violence. In 1974, an estimated 100 thousand people were killed in ethnic conflict in the two countries. In 1988, perhaps 10,000 were killed in an ethnic uprising in Burundi.

And most recently, in October 1990, exiled Tutsis in Uganda mounted an invasion of Rwanda from Uganda. Although unsuccessful, the invasion and subsequent skirmishes have heightened ethnic tension and greatly weakened the economy. At the same time, these events may have accelerated the gradual democratization process already underway. In 1991, opposition political parties were legalized and press freedoms greatly expanded. An interim government has been formed to pave the way for presidential elections.

2.1.3 Structure of the economy

Rwanda is one of the 20 poorest countries in the world, with the gross national product (GNP) per capita estimated at $ 320 in 1988. On the other hand, its performance in terms of economic growth has been fairly good, particularly by sub-Saharan African standards. Per capita GNP grew at 1.5% annually over the period 1965-1988, a rate higher than almost three quarters of the sub-Saharan African countries for which data are available (World Bank, 1990).

Agriculture represents 40% of the gross domestic product and employs 90% of the economically active population (Ministère des Finances et de l'Economie, 1987). There are over a million farm households in Rwanda, over half of whom cultivate less than one hectare of land (World Bank, 1991). In terms of volume, the most important crops are plantains, sweet potatoes, manioc, beans, sorghum, and white potatoes. Arabica coffee is grown by about 40% of the smallholders and is the principal export commodity of Rwanda (Ministère de l'Agriculture, 1987).

Until the mid-1980s, Rwanda was able to increase food production to meet the needs of the growing population. This was accomplished by expanding production in swampy valley bottoms, on steep hillsides, and in the less populated eastern region of the country. Some intensification has taken place, primarily by changing the production mix toward crops with high caloric output per hectare. In recent years, however, food production appears to have lagged behind the population growth. Localized outbreaks of weather-induced famine in 1989-90 may be a manifestation of the increasingly fragile food security of the rural population in Rwanda.

The industrial sector represents about 23% of gross domestic product. This category includes manufacturing (15% of GDP), construction, a small mining sector, hydro-electric production, and water (World Bank, 1990). The manufacturing sector includes a large-scale "modern" sector and a small-scale "informal" sector. The large-scale manufacturing sector produces a relatively wide range of goods: beer, carbonated drinks, soap, paint, fruit products, foam rubber, matches, cigarettes, radios, corrugated metal sheets, and plastic consumer products. Small-scale manufacturing includes traditional beer brewing, metalwork, woodwork, tailoring, and brick-making.

Services account for about 40% of gross domestic product. This includes commerce, tourism, transport, banking, insurance, and public administration. Tourism is a small but growing source of foreign exchange, particularly since the initiation of "gorilla tourism" in 1985 (Ministère des Finances et de l'Economie, 1987) .

Because of the cost of transporting merchandise overland to the coast, international trade is limited: official exports represent only 8-9% of GNP. Coffee accounts for 75-85% of the value of exports, while other crops such as tea constitute another 10-15%. Minerals and animal skins are also exported. Official Rwandan imports include consumer goods (44% of the value), fuel and lubricants (17%), equipment (23%), and raw materials (16%). Officially imported food products include rice, sugar, powdered milk, vegetable oil, and processed foods (Ministère des Finances et de l'Economie, 1987). There is also evidence of informal trade with neighboring countries, notably imports of palm oil, beans, and coffee, and export of consumer goods and possibly white potatoes (Loveridge, 1989 and Ngirumwami, 1989).

2.2 Background of crisis

In order to understand the nature of the recent economic crisis, it is useful to review briefly the economic policies and external events that preceded it. In general terms, the crisis can be attributed to the fall in coffee prices, compounded by poor weather and inappropriate policy response.

2.2.1 Economic policy

A consistent theme in Rwandan economic policy has been fiscal and monetary conservatism. The public sector of Rwanda is relatively small, with current expenditures accounting for just 10-13% of GNP. Until recently, budget surpluses were as common as deficits, and the deficits rarely surpassed 2% of GNP. With a modest public deficit, there was little pressure to finance it through monetary expansion. Expansion of the supply of (narrow) money over the period 1966-86 was thus kept to 14% per year. The result was only moderate inflation, averaging just 7% over the 20-year period (Ministère des Finances et de l'Economie, 1987).

Public investment in roads, schools, and health centers in the rural areas has been significant. Agricultural research and extension efforts has also been supported by public investment. Direct government intervention in agricultural markets, however, has been largely focused on the export crops. Some efforts have been made to control food crop marketing by setting "official prices" and through the operations of a parastatal marketing board, OPROVIA. Neither has had much influence, and these efforts have been scaled back (Loveridge, 1989).

Paradoxically, the policies with the most significant impact on the rural population may be those promoting import-substitution industrialization. Most of the "modern-sector" industries involve a single firm, established with government participation and import protection. Their dependence on imported inputs is such that the domestic value added is often only a small portion of the value of output. In fact, a few have been shown to have negative value added at international prices (World Bank, 1985; Ngirabatware, Murembya, and Mead, 1988). Such policies raise the price of manufactured goods and implicitly tax exports, most of which are agricultural commodities.

2.2.2 External sector

In 1987, the international price of coffee began to fall from the heights it had reached in the mid-1980s. In Rwanda, this resulted in stagnating real gross national product in 1987-88. A further decline of coffee prices in 1989, combined with reduced coffee output and poor weather, resulted in a sharp decline (-6.6%) in real GNP. The current account deficit (excluding official aid) rose to 10.7% of GNP. At the same time, since the producer price of coffee had been fixed at 120 FRw/kg, the coffee sector changed from a source of government revenue to a drain on the treasury.

The external deficit was financed by borrowing and by depletion of foreign reserves, which were reduced from the equivalent of five months of imports in 1987 to less than one month in 1990. The government responded by placing tighter controls on import licenses and foreign exchange allocation and by reducing the producer price of coffee to 100 FRw/kg in March 1990. In addition, new taxes were imposed on cigarettes and beer, but these caused a reduction in demand so large that government revenue also fell, forcing the abandonment of the new taxes.

2.3 Structural adjustment program

In September 1990, the details of the structural adjustment program were published in two documents. One document described the policies to be implemented in the first year of the program (Republique Rwandaise, 1990a), while a second one outlined economic policies for the medium term (Republique Rwandaise, 1990b). As of October 1991, most of the reforms mentioned had been implemented. The program involves trade policy, fiscal policy, monetary policy, and structural reforms, each of which are described below.

2.3.1 Trade and exchange rate policy

Trade policy reforms include currency devaluation and import liberalization. On 10 November 1990, the Rwandan franc (FRw) was devalued by 40% relative to the International Monetary Fund's Special Drawing Right (SDR), so that the rate rose from 102.71 FRw/SDR to 171.18 FRw/SDR. At the same time, all export taxes except those on coffee were eliminated in December 1990.

The system for allocating (rationing) foreign exchange to importers was to be reformed to make it less arbitrary and more transparent, thus reducing uncertainty and the risk of corruption. In the first phase, initiated in June 1991, foreign exchange is allocated each month at the official rate according to requests made by importers. If the sum of the requests exceeds the available supply, allocations "will be determined by reducing proportionately for each importer the amounts requested" (République Rwandaise, 1990a: 6). A fee of 5% of the value of the request discourages importers from exaggerating their needs. The only goods exempted from these proportionate reductions are goods of "primary necessity," including petroleum products, sugar, salt, milk powder, vegetable oil, fertilizer, and pharmaceutical products. To render the system more transparent, the amount available and the values requested and received by each importer are published each month.

In the second phase, import licenses will be granted without restriction (except for health and safety considerations) and foreign exchange will be allocated to all at a "realistic" exchange rate. This phase was to be implemented by January 1992, or earlier if foreign exchange availability allows (République Rwandaise, 1990a).

A number of reforms have been undertaken to simplify the tariff structure and reduce the level of protection. In December 1990, import quotas and prohibitions were converted to ad-valorem tariffs, the minimum tariff was raised from 5% to 10%, and the number of exemptions reduced. In August 1991, the maximum tariff was reduced to 100%, and the number of tariff rates was reduced to six. The list of imports exempted from tariffs will be progressively shortened and the maximum rate reduced over time.

2.3.2 Fiscal and monetary policy

Fiscal policy changes include measures to increase revenue and restrict expenditure. In addition to raising the minimum tariff, as mentioned above, business taxes have been raised from 2-6% of gross revenue to 5-10%. Expenditures is being limited by the reduction of the coffee support price payments, reduction in indirect subsidies to state enterprises, and a freeze on public sector employment except for teachers. In January 1991, public transport fares were raised 20%, and in July 1991 water and electricity rates were increased by 50%.

Monetary policy is to be restrictive, with the money supply growth being kept below the rate of increase of nominal GNP. In addition, the structure of interest rates will be simplified, eliminating preferential rates and ensuring that term-deposit rates are positive in real terms. Interest rates on loans and demand-deposits will also be deregulated.

2.3.3 Structural reforms

A number of "structural" reforms are also envisaged. The government has eliminated the regulation of profit margins (except those of public utilities) and prices (except those of petroleum products and export crops). The prices of petroleum products have risen 100% to reflect the devaluation, higher international prices, and higher taxes. In addition, indirect subsidies to state enterprises will be gradually removed. Government shares will be sold for three state enterprises: SONATUBE (a PVC tube manufacturer), STIR (a trucking firm), and RWAN-TEXCO (a textile company). Privatization or liquidation is planned for state enterprises in printing, metal products, paper products, regional development, and hotels.

Other policy reforms include liberalization of coffee export marketing, measures to improve coffee quality, rehabilitation of the tea and mining sectors, reorganization of the agricultural extension service, simplification of administrative procedures for registering small enterprises, and extension of family planning services to the entire network of health centers.

This study concentrates on the distributional impact of one component of the structural adjustment program, the currency devaluation. Furthermore, as mentioned in section 1.2, we examine only the short-run impact of the change in relative prices due to devaluation.

CHAPTER 3

REVIEW OF THE LITERATURE

3.1 Introduction

Because this study attempts to analyze the household-level impact of macro-economic policy, it is necessary to review a fairly diverse body of literature to serve as background for the analysis. Section 3.2 reviews previous research, both theoretical and empirical, on the topic of currency devaluation. The principal topics to be addressed in this section are the mechanism by which devaluation influences the economy and the effects of devaluation on prices, output, and income distribution.

In section 3.3, models of household behavior will be discussed. The household-firm model, which incorporates the role of the household as both consumer and producer, will be described. The theory of consumer behavior helps to identify some restrictions on the functional form of the regression model, but there are a number of issues outstanding.

Finally, in section 3.4, the measurement of welfare effects on households is considered. The traditional consumer surplus measure is compared to more sophisticated "willingness-to-pay" concepts. In addition, some approaches to estimating these welfare measures are reviewed.

3.2 Impact of currency devaluation

This section will review recent research on the impact of devaluation, with particularly emphasis on the case of less developed countries. First, various theoretical approaches to understanding devaluation will be discussed. Then, the results of empirical research on the impact of devaluation are considered.

3.2.1 Theory of devaluation

Currency devaluation is a discrete increase in the nominal exchange rate in the context of a fixed-rate regime, where the exchange rate is expressed as the number of local currency units per foreign currency unit. Devaluation is designed to raise the real exchange rate, defined here as the price of tradeable goods (imports, import substitutes, exports, and exportable goods) relative to the price of non-tradeable goods. In theory, an increase in the real exchange rate encourages the production and discourages consumption of tradeable goods, improving the external balance, while a decrease in the real exchange rate does the reverse, causing a deterioration in the trade balance.

The above implies that there is an equilibrium real exchange rate at which external balance is achieved[1]. As Edwards (1989) demonstrates, the equilibrium real exchange rate will vary with real variables: the terms of trade, trade policies, technology, exogenous shifts in demand, interest rates, and other factors. On the other hand, the actual real exchange rate varies (in spite of the fixed nominal rate) with monetary variables such as the price level. For example, if domestic inflation is higher than international inflation, the local currency prices of non-tradeables rise relative to those of tradeables, so the real exchange rate falls.

A common response to external deficits is import restrictions and exchange controls. However, this is likely to create severe distortions in the external sector. Another possible response is to allow adjustment to occur automatically: as international reserves are depleted, the money supply contracts, and deflation reduces nontradeable prices relative to tradeable prices. With flexible prices and full employment, this would be identical to devaluation. But given sticky prices and

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1. External equilibrium does not necessarily imply exact balance of payments, but rather that any net capital flows are sustainable and correspond to intertemporal preferences.

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unemployed resources, adjustment under devaluation will be more rapid and expansionary (or less contractionary) than automatic deflationary adjustment.

Three approaches have been developed to look at the impact of devaluation. The *elasticity approach* focuses on the impact of relative price changes on the supply and demand of tradeable goods. Although it allows derivation of the conditions under which devaluation improves the trade balance, it assumes no changes in income[2], no money market, and no capital flows (Niehans, 1984). The *expenditure approach* is based on the idea that a current account deficit results from an excess of expenditure (including imports) over output (including exports). Thus, for devaluation to improve the trade balance it must cause either "expenditure switching" (from tradeables to non-tradeables) or "expenditure reducing" (Alexander, 1952). The *monetary approach* concentrates on the impact of devaluation on the demand for money. Since tradeable prices rise, consumers attempt to restore the real value of their cash balances by temporarily "hoarding" money, so that spending declines relative to income. This improves the trade balance for as long as is required to restore the initial real value of cash balances (Frenkel and Johnson, 1976).

These approaches are different perspectives on devaluation rather than rival interpretations. The expenditure approach is correct in focusing on the gap between expenditure and output, but has, by itself, little explanatory power. The elasticity approach helps explain expenditure switching, but ignores expenditure reducing by assuming constant income. Similarly, the monetary approach provides an explanation for expenditure reducing, but de-emphasizes the composition

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2. This is true if the parameters are partial elasticities. If they are interpreted as "total" elasticities, including all income effects, then the theory "incorporates" income changes but the elasticities are unobservable, thus eliminating the predictive capacity of the theory.

of demand for goods by concentrating on money demand (Tsiang, 1961; Cooper, 1971; Niehans, 1984).

Traditionally, devaluation was considered expansionary. In the standard Keynesian model, nominal wages are sticky so that an increase in tradeable goods prices reduces real wages, inducing firms to expand employment and output. However, several mechanisms by which devaluation may be contractionary have been identified: 1) by the increase in the cost of imported inputs for domestic production (Krugman and Taylor, 1978), 2) by redistributing income toward households with higher propensities to save or to import (Diaz Alejandro, 1963), or 3) by deteriorating the terms of trade of a "large" country (Alexander, 1952). The first mechanism is probably the most common, being particularly relevant to semi-industrialized middle-income countries.

The impact of devaluation on income distribution depends heavily on the structure of the economy. In a classical flexible-price model, there is no unemployment and devaluation cannot affect the level of output. In the short run with immobile factors of production, expenditure switching benefits both labor and owners of capital in the tradeable goods sector and hurts those in the non-tradeable goods sector. In the medium term, labor will flow toward the tradeable sector and the returns to labor will rise relative to non-tradeable prices and fall relative to tradeable prices. And in the long run, with both factors mobile, labor (capital) will gain if tradeable goods are more labor intensive (capital intensive) than non-tradeable goods (Johnson and Salope, 1980).

However, the distribution of income between labor and capital is not closely linked to the size distribution of income in less developed countries. This is because "owners of capital" often include large numbers of small-scale entrepreneurs and independent farmers, while "labor" includes relatively high-income employees of larger urban firms.

In a Keynesian model, devaluation may affect the aggregate level of output and employment. Since, as mentioned above, it is not clear whether the net effect of devaluation will be expansionary or contractionary, this further complicates the analysis of the distributional impact. Addison and Demery (1990: 122) conclude:

> While theory provides an essential framework for tracking the distributional effects of adjustment, it does not yield unambiguous predictions... Researchers must therefore go beyond pure theory to empirical analysis.

3.2.2 Empirical studies of devaluation

Empirical analysis of devaluation is complicated by two factors. First, devaluation is generally implemented as part of a package of reforms which may include import liberalization, removal of exchange controls, contraction of domestic credit, and so on. Second, the appropriate comparison is between devaluation and an alternate policy which addresses the external imbalance. Simple before-after comparisons ignore the fact that the pre-devaluation situation was unsustainable. These problems can be addressed in part by controlling for other variables using regression analysis (e.g. Edwards, 1989) or by comparing results to a control group (e.g. Kamin, 1988).

Currency devaluation is usually implemented as a last resort after other measures to control the external imbalance have failed. The pre-devaluation situation is generally characterized by accumulated appreciation of the real exchange rate, reduced export growth, depletion of international reserves, increasing restrictions on imports and foreign exchange transactions, and slower economic growth (Cooper, 1971; Connolly and Taylor, 1978; Edwards, 1989; Kamin, 1988).

Devaluation and prices: Some critics of devaluation have questioned whether devaluation affects the real exchange rate. For example, Godfrey (1985) argues that a devaluation may raise non-tradeable prices enough to "negate itself within less than a year." Indeed, it is easy to find cases in which inflation negates the effect of devaluation in a short period. However, studies which isolate the price increases attributable to devaluation (as opposed to excessive monetary expansion and other factors) have not found any cases of devaluation "negating" itself. Cooper's (1971) study of 36 cases of devaluation over 1953-1969 showed that "devaluation does lead to price increases, but not by amounts great enough to undermine the devaluation." Similar results are found by Connolly and Taylor (1976) in a study of 18 devaluations, Donovan's (1981) review of 12 IMF stabilization programs, and an analysis of 72 cases of devaluation by Kamin (1988). Regression analyses by Edwards (1989) and Connolly and Taylor (1976) confirm, however, that the effect of devaluation is diluted by expansionary monetary policy.

Devaluation and trade: If devaluation is able to influence relative prices, the next question is whether this improves the balance of payments. Most studies find that the balance of payments improves in two thirds to three quarters of the cases (Cooper, 1971; Connolly and Taylor, 1976; Donovan, 1981; Kamin, 1988; Edwards, 1989). Only Miles (1979), in a study of 16 devaluation episodes, failed to find any impact. These studies indicate that devaluation fairly consistently increases export growth, but the pattern of imports is more mixed, presumably due to concurrent import liberalization programs. Because devaluation may encourage capital inflow (or discourage capital flight), some studies report improvements in the balance of payments even when the trade balance does not.

Devaluation and output: The impact of devaluation on the level of aggregate output has been addressed by a number of studies with mixed results. Cooper (1971) found "some depression in economic activity is frequently found" after devaluation. On the other hand, Donovan (1981) reports that devaluation was associated with higher growth rates, particularly when accompanied by import liberalization. Edwards (1986) found a mild contractionary effect in the first year after devaluation, offset by an expansionary effect in the second year. Similarly, Kamin (1988) identified falling growth rates in the year before and the year of devaluation, with output rebounding the year after.

Although devaluation is often associated with temporary reduction in growth rates, avoiding devaluation when the currency is overvalued probably restricts growth as well. Edwards (1989) and Schafer (1989) find a negative correlation between the degree of currency overvaluation and economic growth.

Devaluation and income distribution: The distributional impact of devaluation is more difficult to study because of the lack of regularly collected indicators. Several studies report that, following devaluation, nominal wages rise but real wages fall (Cooper, 1971; Heller *et al.*, 1988, and Edwards, 1988). The implications of this result for income distribution are not clear for several reasons. First, published wage data generally refer to official minimum wages or formal-sector urban wages. These figures may not reflect wages in the rural areas and in the informal sector. Indeed, in most cases, official wages are significantly higher than average rural incomes. Second, many workers, particularly among the poor, are self-employed. And third, even households with wage-earnings have diversified sources of income (Sahn, 1990).

Heller *et al.* (1988), in a study of nine structural adjustment programs, draw tentative conclusions about income distribution from the characteristics of the major export crops. They argue that devaluation may have reduced income inequality in Kenya and Ghana (where small farms produce most of the major export), but contributed to greater rural inequality in the Dominican Republic and the Philippines (where export-oriented plantations are important).

Bleijer and Guerrero (1988) use monthly data from the Philippines and a three-equation model to estimate income distribution as a function of macroeconomic variables. They find that unemployment and inflation hit the poor the hardest, while the relative price effect of devaluation and fiscal contraction tended to reduce income disparities.

Glewwe and de Tray (1988) discuss the impact of structural adjustment in Côte d'Ivoire by examining household budget data. In particular, they look at the characteristics of the poorest 10% and 30% of Ivorian households, including the occupation of the household head, the budget shares allocated to three imported foods, and the proportion of poor households growing different crops. They conclude that bulk of the poor, being predominantly rural and self-employed, should either benefit from higher agricultural prices or be unaffected. The urban poor, on the other hand, are more likely to be hurt. Similar results are obtained from a study of household budgets in Peru (Glewwe and de Tray, 1989).

The comparison of poor and non-poor household is further elaborated in the "poverty profiles" developed by the Social Dimensions of Adjustment Unit at the World Bank (see Boateng *et al.*, 1990 and Kanbur, 1990). These methods are useful for examining the impact of individual price changes, but they are only suggestive of the combined effect of relative price increases for tradeable goods.

By contrast, Sahn and Sarris (1991) combine income and expenditure data from five African countries and historical price data before and after structural adjustment to calculate an index of real income for the rural poor[1]. The index is a ratio of fixed-weight Laspeyres indexes of nominal income and consumer prices. Income is divided into three tradeable and two non-tradeable categories, while expenditure is broken down into five tradeable and three non-tradeable groups. The results

1. The countries are Côte d'Ivoire, Ghana, Tanzania, Malawi, and Madagascar. The budgets were based on the poorest 20% of households in two regions each for Côte d'Ivoire and Ghana, small farms in three regions in Madagascar, the Zomba district in Malawi, and rural households in general in Tanzania.

indicate a mixture of gains and losses on the order of 5-10%. The authors conclude:

> that there is no unequivocal pattern of increase or decline in the real welfare of the rural poor but that there are marked differences among countries and regions... earlier efforts which arrived at simplified statements on the harmful or beneficial effects of adjustment based on stylized facts were not useful. They failed to account for sources of income, patterns of expenditure, and movements in relative prices (Sahn and Sarris, 1991: 281-282).

The impact of devaluation has also been analyzed using context of computable general equilibrium (CGE) models[1]. Dervis, de Melo, and Robinson (1982) develop CGE models of three "archetypal" economies, each with eight production sectors and seven household types. In each case, the devaluation increases the income share of farmers, but landless farmers and unorganized urban workers lose.

CGE models of Morocco, India, and Egypt confirm that the distributional impact of stabilization programs are highly dependent on the assumptions used. The impact on the urban poor is generally negative, while the impact on the rural poor depends on the structure of production (de Janvry *et al.*, 1988).

To summarize the empirical studies, devaluation does influence the real exchange rate, although the effect is diluted by excessive monetary expansion. Devaluation stimulates export growth, though its impact on import growth is mixed. The trade balance and the overall balance of payments generally improve. The impact on growth is mixed, but any negative impact is usually temporary. Finally, the distributional impact of devaluation depends on the structure of the economy, but the urban poor are more likely to suffer than the rural poor.

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1. CGE models involve a set of equations describing factor markets, product markets, and the behavior of households and the government. Although similar to input-output models, they incorporate neoclassical production functions which allow substitution rather than fixed-coefficient technology. See Dervis, de Melo, and Robinson (1982) for a description of CGE models and Thorbecke and Berrian (1990) for a review of applications to macroeconomic adjustment.

3.3 Models of household behavior

This section provides an overview of attempts to model household behavior. It begins with a brief summary of the theory of consumer demand. Next, various issues in the estimation of demand systems are considered. Finally, household-firm models, which integrate the consumption and production decisions of the semi-subsistence household are described. Greater emphasis is given to consumer behavior than producer behavior because the data base on household demand in Rwanda is much richer and justifies a more sophisticated analytical treatment.

3.3.1 Theory of consumer demand

The theory of consumer demand is an attempt to model how the consumer chooses between alternative bundles of goods subject to a budget constraint. In its classical form, the model is static and assumes perfect information on the part of the consumer. It is also assumes that the consumer takes prices and income as given.

Preferences: Several assumptions are made about preferences to ensure that they are well-behaved (more precise definitions are provided in Varian, 1984: 111-113):

1) *Reflexivity*: each bundle is as good as itself.
2) *Completeness*: preferences exist between any two bundles, so that either bundle A is preferred to B, or B is preferred to A, or the consumer is indifferent between them.
3) *Transitivity*: if bundle A is preferred to B and B is preferred to C, then A is preferred to C.
4) *Continuity*: if bundle A is preferred to B and bundle C is close enough to A, it too will be preferred to B.
5) *Local non-satiation*: even with small changes in the bundle of goods, one can always make it better to the consumer.
6) *Strict convexity*: if bundles A and B are preferred to C, then a weighted average of A and B will also be preferred to C.

Given the first four assumptions, preferences can be described by a utility function, in which utility is a function of the quantities of each good. This can be written as follows:

$$u = f(q_1, q_2 \ldots q_n) \quad \text{(3-1)}$$

where u = utility
q_i = quantity of good i

The final two assumptions restrict the shape of the utility function: the fifth ensures that there are no local maxima, while the sixth corresponds to the assumption of diminishing marginal rates of substitution.

It is important to note that a given utility function describes the ordering of preferences, but it is not the only function to describe the same preferences. More specifically, any monotonic transformation of the utility function will correspond to the same preferences, and will thus constitute an equally valid representation of preferences in the absence of some cardinal measure of utility.

The consumer problem is to maximize utility subject to prices (**p**) and income or total expenditure (x). The solution to this constrained maximization problem is a set of Marshallian (or uncompensated) demand equations, which describe the demand for each good as a function of prices and income. If these equations, denoted by $q_i(\mathbf{p},x)$, are substituted into the direct utility equation, we get the indirect utility function, $v(\mathbf{p},x)$:

$$\begin{aligned} v(\mathbf{p},x) &= \max u(\mathbf{q}) \qquad s.t.\ \mathbf{pq}=x \\ &= u[q_1(\mathbf{p},x),\ q_2(\mathbf{p},x)\ldots q_N(\mathbf{p},x)] \\ &= u^*(\mathbf{p},x) \end{aligned} \tag{3-2}$$

The indirect utility function gives the maximum level of utility attainable as a function of prices and income. Given the assumptions about preferences described above, the indirect utility function must have certain properties:

$v(\mathbf{p},x)$ is continuous for all positive prices and incomes
$v(\mathbf{p},x)$ is nonincreasing in prices
$v(\mathbf{p},x)$ is nondecreasing in income
$v(\mathbf{p},x)$ is quasi-convex in p
$v(\mathbf{p},x)$ is homogeneous of degree 0 in **p** and x

<u>Duality</u>: The dual of the utility maximization problem is the cost minimization problem. Here, the cost of a bundle of goods is minimized subject to the requirement that a given level of utility (u^*) be maintained. The solution of this constrained minimization problem

generates demand functions for each good, but in this case they are the Hicksian (or compensated) demand equations, expressed in terms of prices and utility. When these demand functions, denoted $h_i(\mathbf{p},u)$, are substituted into the budget constraint, the result is the minimum cost of attaining a given utility at given prices, known as the expenditure function, $e(\mathbf{p},u)$:

$$\begin{aligned} e(\boldsymbol{p},u) &= \min \boldsymbol{pq} \qquad s.t.\ u(\boldsymbol{q}) = u \\ &= p_1h_1(\boldsymbol{p},u) + p_2h_2(\boldsymbol{p},u) + \ldots + p_Nh_N(\boldsymbol{p},u) \end{aligned} \tag{3-3}$$

The expenditure function can also be obtained by inverting the indirect utility function, that is, by solving the indirect utility function for income (total expenditure). The assumptions about preferences also imply certain properties of the expenditure function:

$e(\mathbf{p},u)$ is continuous for all positive prices
$e(\mathbf{p},u)$ is nondecreasing in prices
$e(\mathbf{p},u)$ is concave in $\mathbf{p}$
$e(\mathbf{p},u)$ is homogeneous of degree 1 in $\mathbf{p}$

If preferences satisfy the standard assumptions listed earlier, maximization of utility subject to a given level of income yields the same solution as minimization of the cost of the consumption bundle subject to a given level of utility. In other words,

$$\begin{aligned} v(\boldsymbol{p},\ e(\boldsymbol{p},u)) &= u \\ e(\boldsymbol{p},\ v(\boldsymbol{p},x)) &= x \end{aligned} \tag{3-4}$$

The Hicksian and Marshallian demand functions can be derived directly from the expenditure function and the indirect utility function, respectively. In the first case, the Hicksian (or compensated) demand can be obtained by applying Shephard's lemma[1] to the expenditure function:

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1. For a proof of Shephard's lemma, see Deaton and Meulbauer (1980a: 40).

$$\frac{\partial e(\mathbf{p},u)}{\partial p_i} = h_i(\mathbf{p},u) \tag{3-5}$$

The Marshallian (or uncompensated) demand function can be derived from the indirect utility function using Roy's identity[1]:

$$q_i(\mathbf{p},x) = \frac{-\dfrac{\partial v(\mathbf{p},x)}{\partial p_i}}{\dfrac{\partial v(\mathbf{p},x)}{\partial x}} \tag{3-6}$$

For a given level of prices and income (or prices and utility), the Marshallian and Hicksian demand is the same. In other words,

$$\begin{aligned} h_i(\mathbf{p},u) &= q_i(\mathbf{p},e(\mathbf{p},u)) \\ h_i(\mathbf{p},v(\mathbf{p},x)) &= q_i(\mathbf{p},x) \end{aligned} \tag{3-7}$$

However, the partials derivatives with respect to price are different because the Marshallian partial describes the impact of price holding income constant, while the Hicksian partial assumes that utility is unchanged. The Slutsky equation[2] gives the relationship between the two partial derivatives:

$$\frac{\partial q_i(\mathbf{p},x)}{\partial p_j} = \frac{\partial h_i(\mathbf{p},u)}{\partial p_j} - \frac{\partial q_i}{\partial x}q_j \tag{3-8}$$

This equation decomposes the effect of a price change on Marshallian demand into a substitution effect (the first term) and an income effect (the second term). This equation can also be expressed in terms of elasticities:

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1. Roy's identity can be demonstrated by taking the derivative of equation (3-4b) with respect to p_i, applying Shephard's lemma, and solving for q_i (see Deaton and Meulbauer, 1980a: 41).

2. The Slutsky equation can be derived by taking the partial of equation (3-7) and applying Shephard's lemma.

$$\epsilon_{ij} = \epsilon^*_{ij} - \epsilon_i s_j \tag{3-9}$$

where ϵ_{ij} = the Marshallian price elasticity
ϵ^*_{ij} = the Hicksian price elasticity
ϵ_i = the expenditure elasticity of demand

<u>Properties of demand</u>: The properties of the demand function, which are the result of the assumptions made about preferences, are the following:

1) *Adding up*: The total value of demand is equal to total expenditure. In other words, $\Sigma\, q_i(\mathbf{p},x)p_i = \Sigma\, h_i(\mathbf{p},u)p_i = x$.
2) *Homogeneity*: h(p,u) is homogeneous of degree 0 in **p**, and q(p,x) is homogeneous of degree 0 in **p** and x together.
3) *Symmetry*: The substitution matrix (defined as the matrix of Hicksian partials with respect to price) is symmetric. In other words, $S_{ij} = S_{ji}$, where S_{ij} is the partial of h_i with respect to p_j.
4) *Negativity*: The substitution matrix is negative semi-definite.

It is useful to briefly review some of the implications of these properties. The adding-up property appears trivial, but this property is violated by a number of functional forms which are often used to estimate demand (e.g. the double logarithmic form). In addition, the adding-up property can be used to derive two useful equations: the Engels and Cournot aggregation conditions[1]:

$$\sum_{i=1}^{N} w_i \epsilon_i = 1 \tag{3-10}$$

$$\sum_{i=1}^{N} w_i \epsilon_{ij} + w_j = 0$$

The property of homogeneity implies that only relative prices and incomes matter. In other words, it rules out "money illusion" in the behavior of the consumer. Symmetry is merely a reflection of the fact that consistency has been imposed on consumer behavior. With regard to negativity, the most important implication is that the diagonal elements

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1. These two equations are obtained by taking the partial derivative of the adding-up property with respect to total expenditure and the price of good j, respectively, and then converting the results into elasticity form.

of the substitution matrix must be negative. This means that the Hicksian own-price elasticities are negative.

Duality theory shows that, if the preferences obey the assumptions made earlier, each direct utility function is associated with a unique indirect utility function, an expenditure function, and set of demand functions. Furthermore, any expenditure function, indirect utility function, or set of demand functions which satisfies the properties listed above will correspond to a direct utility function and thus to a well-ordered set of preferences. This is useful in empirical work because it is easier to derive demand functions from expenditure functions and indirect utility functions than from direct utility functions.

Consumer theory, as described so far, concerns the allocation of income among well-defined goods by a single utility-maximizing entity. Empirical research, however, is generally interested in results for commodity categories (e.g. meat) and for household groups (e.g. rural households). The issues of aggregation over goods and over consumers are discussed in turn.

Aggregation over goods: In theory, it would be quite possible to disaggregate "goods" into thousands of categories. In practice, however, it is generally necessary to limit them to several dozen at most, both because of data limitations and because of processing complexity. The issue then arises how to divide goods into categories (this section is based on Deaton and Muelbauer, 1980a and Phlip, 1983).

The composite commodity theory states that a set of goods can be treated as a single good if their prices move together (Hicks, 1936). In practical terms, this means that close substitutes (e.g. imported rice and domestic rice) can be combined into a single category.

In order to justify further grouping, it is necessary to make some assumptions about the structure of preferences. For example, it is often assumed that preferences are weakly separable between commodity groups. Under weak separability, the direct utility function has the following structure:

$$u = f[g_1(q_1 \ldots q_a),\ g_2(q_{a+1} \ldots q_b),\ \ldots\ g_n(q_z \ldots q_N)] \qquad (3\text{-}11)$$

where u = utility
f is a function ($f_i > 0$ for all i)
g_i is the sub-utility functions for group i

Weak separability may be understood in terms of "two-stage budgeting," in which the household first maximizes utility by allocating expenditure among the commodity groups, and then allocates group expenditure among the goods comprising each group. The implication in terms of the substitution matrix is that:

$$s_{ij} = \mu_{GH} \frac{\partial q_i}{\partial x} \frac{\partial q_j}{\partial x} \qquad (3\text{-}12)$$

where q_i = the quantity of good i in group G
q_j = the quantity of good j in group H
μ_{GH} = a constant

A common application of this assumption is the case in which only food expenditure data are available. By assuming weak separability between food and non-food, the composition of the food budget can be analyzed without reference to non-food spending patterns.

A much more restrictive assumption is strong (or additive) separability. Under this assumption, the direct utility function has the following structure:

$$u = f[g_1(q_1 \ldots q_a) + g_2(q_{a+1} \ldots q_b) + \ldots + g_n(q_z \ldots q_N)] \qquad (3\text{-}13)$$

where u = utility
f is a function ($f_i > 0$ for all i)
g_i is the sub-utility function for group i

Because it is expressed as a monotonic function of the sum of the sub-utilities, even a utility function in which the sub-utility functions are multiplied together would fit into this definition. One implication of strong separability is that the substitution matrix has the following restriction:

$$s_{ij} = \mu \frac{\partial q_i}{\partial x} \frac{\partial q_j}{\partial x} \qquad (3\text{-}14)$$

where q_i = the quantity of good i in group G
q_j = the quantity of good j in group H
μ = a constant

This equation differs from that corresponding to weak separability in that the constant, μ, does not vary among pairs of commodity groups. An even more important implication of strong (or additive) separability is that there is a fixed relationship between the expenditure elasticity and the price elasticity, as first noted by Frisch (1959). This explains the popularity of strong separability in the context of empirical work. Nonetheless, Deaton and Meulbauer (1980a: 139) caution that the powerful results come at the cost of strong, often unrealistic, restrictions on preferences.

Aggregation over consumers: The next issue is concerns aggregation of demand across consumers. In particular, under what conditions can aggregate consumer behavior be described as if it were the result of decisions made by a utility-maximizing representative consumer? The simplest case is that of exact linear aggregation, in which the average demand across consumers is a function of prices and the *average* level of total expenditure. It is possible to show that this property can only exist if 1) the demand is a linear function of total expenditure and 2) the marginal propensities to consume a given good are the same across consumers. Although aggregate demand in such a model is consistent with utility maximization, the restrictions on preferences are quite strong and unrealistic (Deaton and Muelbauer, 1980a).

Exact non-linear aggregation requires that average demand across consumers be a function of prices and some *representative* level of total expenditure. This representative level of expenditure could be a function of prices and the distribution of expenditure. It turns out that this implies that, for a given household, the marginal propensity to consume (MPC) of each good varies linearly with the MPC of other goods. A special case of exact non-linear aggregation occurs when the representative expenditure level is independent of price. Under these conditions, called Price Independent Generalized Linearity (PIGL), the representative expenditure function and the demand function take the following forms:

$$e(u,\boldsymbol{p}) = \left[(1-u)\,[a_1(\boldsymbol{p})]^{\alpha} + u\,[a_2(\boldsymbol{p})]^{\alpha}\right]^{1/\alpha} \qquad (3\text{-}15)$$

$$w_i = b_{1i}(\boldsymbol{p}) + b_{2i}(\boldsymbol{p})\left(\frac{x}{k}\right)^{-\alpha} \qquad (3\text{-}16)$$

where k and α are parameters
u is utility
$a_i(\mathbf{p})$ and $b_i(\mathbf{p})$ are functions of prices

As α approaches zero, the exponents become logarithms and the form is thus known as PIGLOG. The expenditure and demand functions are as follows:

$$e(u,\boldsymbol{p}) = (1-u)\,\log[d_1(\boldsymbol{p})] + u\,\log[d_2(\boldsymbol{p})] \qquad (3\text{-}17)$$

$$w_i = f_1(\boldsymbol{p}) + f_2(\boldsymbol{p})\log\left(\frac{x}{k}\right) \qquad (3\text{-}18)$$

where $d_i(\mathbf{p})$ and $f_i(\mathbf{p})$ are functions of prices
u is utility

In summary, the advantage of exact aggregation is that it simplifies the calculation of aggregate responses to changes in income or prices. Exact aggregations, however, imposes some restrictions on the shape of the demand curves. The decision whether to use a model characterized by exact aggregation must depend on 1) the degree to which the restrictions of exact aggregation are violated by the data and 2) the additional calculation costs involved in using models that do not have exact aggregation.

3.3.2 Functional form of demand equations

Economic theory does not specify the functional form of the demand equations. Early studies, such as Allen and Bowley (1935), estimated demand assuming a linear relationship between demand for a given commodity and total expenditure. Prais and Houthaker (1955) compare a variety of functional forms, suggesting that the choice among them be based on goodness-of-fit. The double-logarithmic form has been used often because the estimated parameters are directly interpreted as elasticities. This procedure is acceptable when only one or a small number of commodities is being estimated, but is inappropriate for estimating a complete system because the equations do not satisfy the properties of demand. For example, the double-log form does not even satisfy adding up. This has led to the development of functional forms which are appropriate for a system of demand equations.

Systems of demand equations: The linear expenditure system (LES), developed by Stone (1954), was the first demand system to satisfy all the general properties of demand: adding-up, homogeneity, symmetry, and negativity. The LES is highly restrictive, however, prohibiting inferior goods and complements. Furthermore, it is based on an additive utility function, which imposes a relationship between expenditure and price elasticities. In spite of these restrictions (or perhaps because of the advantages they yield), the LES has been a frequent choice of researchers (see for example Lluch, Powell, and Williams, 1977).

The Rotterdam model is similar to the LES, but instead of imposing homogeneity and symmetry algebraically, it allows them to be imposed (and thus tested) statistically. Most empirical studies have rejected symmetry and homogeneity, but it is not clear if this is a rejection of the consistency of consumer behavior or some misspecification of the demand model (Deaton and Muelbauer, 1980a).

In the 1970s, duality theory suggested the possibility of deriving new "flexible" demand functions from direct utility functions, indirect utility functions, and expenditure functions. For example, using an indirect utility function in the form of the transcendental logarithmic function, the "indirect translog" demand system can be derived using Roy's Identity. The "direct translog" system is similarly derived from a translog direct utility function. However, these systems are non-linear in the parameters and are thus difficult to estimate (Deaton and Muelbauer, 1980a and Phlips, 1983).

Almost Ideal Demand System (AIDS): The flexible demand function which has been most widely used in recent years is the Almost Ideal Demand System (AIDS), proposed by Deaton and Muelbauer (1980b). It is based on an expenditure function in the PIGLOG class, permitting exact aggregation over consumers. By applying Shephard's Lemma to the expenditure function, the following demand function is obtained:

$$w_i = \beta_{i0} + \beta_{i1}\log\left(\frac{X}{P}\right) + \sum_j \alpha_{ij}\log(p_j) \tag{3-19}$$

where w_i is the budget share of good i, p_i is the price of good i, and P is the price index. In the true AIDS, the price index is defined as follows:

$$\log(P) = \alpha_0 + \sum_k \alpha_k \log(p_k) + \frac{1}{2}\sum_j\sum_k \gamma_{kj}\log(p_k)\log(p_j) \tag{3-20}$$

However, the use of the true price index makes the system non-linear, thus complicating estimation. In most applications, researchers have followed Deaton and Muelbauer's (1980b) practice of replacing the true price index by Stone's index, which is a geometric average of prices, weighted by budget shares:

$$\log P = \sum_i w_i \log(p_i)$$

$$or \qquad (3\text{-}21)$$

$$P = \prod_i p_i^{w_i}$$

This allows the AIDS to be estimated equation-by-equation using ordinary least squares (OLS). The advantages of the AIDS are summarized by Deaton and Muelbauer (1980b: 312):

> [The AIDS] gives an arbitrary first-order approximation to any demand system; it satisfies the axioms of choice exactly; it aggregates perfectly over consumers without invoking parallel linear Engel curves; it has a functional form which is consistent with known household-budget data; it is simple to estimate, largely avoiding the need for non-linear estimation [provided the Stone's price index is used]; and it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters.

One restriction of the AIDS is that budget share is linear in log expenditure, so that budget share cannot, for example, rise and then fall as total expenditure increases.

Quadratic extension of the AIDS: In order to render the AIDS more flexible, Swamy and Binswager (1983) add a quadratic term (squared log expenditure). This modification means that the model no longer has the property of "exact aggregation," by which the aggregation of demand over many households can be represented by a single rational consumer. In addition, the demand system does not correspond to an explicit expenditure function.

On the other hand, it allows more flexible consumer behavior, allowing a good to be a "luxury" ($\epsilon > 1$) over some range of expenditure and a "necessity" or "inferior" ($\epsilon < 1$) over another range. This property is particularly important when the system includes a large number of disaggregated commodities. In addition, the quadratic version retains most of the advantages of the AIDS: it is linear in the parameters when Stone's index is used, adding-up is imposed automatically when estimated with OLS, and homogeneity and symmetry can be imposed and/or tested using linear restrictions on the parameters.

The restrictions necessary to impose adding-up if the model is <u>not</u> estimated with OLS are as follows:

$$\sum_{i} \beta_{i0} = 0, \sum_{i} \beta_{i1} = 0, \sum_{i} \beta_{i2} = 0, \sum_{i} \alpha_{ij} = 0 \qquad (3\text{-}22)$$

The restrictions to impose homogeneity and symmetry are the same as those for the AIDS:

$$\begin{aligned} \sum_{j} \alpha_{ij} &= 0 \qquad (homogeneity) \\ \alpha_{ij} &= \alpha_{ji} \qquad (symmetry) \end{aligned} \qquad (3\text{-}23)$$

Swamy and Binswanger (1983) find the coefficient on the quadratic term to be statistically significant in a model of food demand in India. Deaton and Case (1988) use the quadratic version of the AIDS in estimating demand in Indonesia and Sri Lanka. Similarly, Thomas, Strauss, and Barbosa (1989) find the quadratic term significant for 15 of 20 products in a demand model for Brazil. And in preliminary estimates of demand from the Rwandan data, the quadratic terms were significant for many budget categories, particularly in the urban areas (Ministère du Plan, 1988 and 1991).

3.3.3 <u>Issues in the estimation of consumer demand</u>

The simplest approach to estimating demand equations is to use single-equation ordinary least squares (OLS). According to the Gauss-Markov theorem, OLS yields the "best" (least variance) linear unbiased estimates of the true parameters under conditions of classical linear regression. These conditions are described in terms of the Nx1 vector of error terms (ϵ) and the Nxk matrix of independent variables (X):

1) $E(\epsilon) = 0$
2) $E(\epsilon\epsilon') = \sigma^2 I_N$
3) X is of rank k (the number of variables) where k<N
4) X is non-stochastic
5) (X'X)/N approaches a finite non-singular matrix as the number of observations, N, approaches infinity

The standard statistical tests are based on either the additional assumption that the errors are normally distributed or, in "large" samples, the application of the central limit theorem (see Schmidt, 1976: 2-7 and Judge *et al.*, 1988: 202-205).

As mentioned in section 3.3.2, the AIDS and the quadratic extension of the AIDS can be estimated using single-equation ordinary least squares (OLS) if the true price index is approximated with Stone's index. Five issues related to the methods used to estimate the demand parameters deserve mention.

Quality and measurement error effects: Until recently, it was assumed that the price elasticities of demand could not be estimated using cross-sectional data because of the lack of variation in prices across the sample. However, a number of recent studies, starting with Timmer and Alderman (1979), have estimated price elasticities, making use of the fact that there may be significant spatial variation in prices due to transportation costs, particularly in less developed countries.

One problem with this procedure is that most household surveys collect quantities and values but not prices *per se*. Unit values (value/quantity) differ from prices in two ways. First, unit values reflect both quality and price variation. Since higher prices might induce consumers to choose a lower quality, the variation in unit value will generally understate the variation in price. Thus, "price" elasticities derived from unit values are likely to be biased upward. Second, measurement error is likely to introduce spurious negative correlation between quantity and unit value. For example, a positive error in measuring quantity generates a negative error in the calculated unit value, so the two may be negatively correlated even in the absence of price variation (Deaton, 1987a).

One approach is to use average market prices across regions and perhaps across seasons. For example, Strauss (1983) uses village-level average prices instead of prices observed by individual households in a study of demand in Sierra Leone. This reduces the quality component of price variation to the extent that quality varies within the village and reduces the measurement error in proportion to the number of transactions observed within the village.

A more elaborate method of dealing with these problem is suggested by Deaton (1987a and 1988). The procedure makes use of the fact that household budget data are generally based on a clustered sample. If prices are assumed constant in the cluster, then quality effects and measurement error can be estimated from within-cluster variation. These effects are then used to adjust the estimates of price elasticities. Deaton (1989) compares several applications of these procedures, noting that quality effects were relatively small in a study of demand in Indonesia, but large in a demand study of the United States.

Estimating price response for non-food categories: In addition to the problems related to unit values, estimating price response is difficult when the commodity categories are highly diverse. This is the case for most non-food categories such as clothing or transportation. In principle, one could either disaggregate these categories into more specific products (e.g shirts and bus trips) or construct price indices for each category based on a subset of goods within the category. These approaches rely on the availability of a large number of observations of non-food purchases. This may be difficult when such purchases are relatively infrequent, as is the case in the rural areas of less developed countries.

An alternative is to derive price response more indirectly by imposing restrictions on the structure of non-food preferences. As discussed in section 3.1, strong (or additive) separability of utility implies that the Hicksian substitution term is a function of the marginal propensity to consume (MPC) each good and a fixed parameter (Frisch, 1959). The MPCs of non-food categories can be estimated econometrically, while the fixed parameter can be estimated from price and expenditure elasticities of food. This is the approach used by Newberry (1987) in a model of the agricultural sector in Korea.

Deaton and Muelbauer (1980a) argue that the assumption of additive utility should be avoided in empirical work. Nonetheless, estimating food price elasticities directly and deriving non-food price response from strong assumptions is more justifiable than the widely-used linear expenditure system which assumes strong separability among *all* goods. Furthermore, even a very rough approximation of non-food price elasticities is preferable to the alternative of implicitly assuming no price response.

Zero-expenditure observations: Not all households consume all goods during the recall period of a household budget survey. Thus, cross-sectional demand studies typically contain a number of zero values for the dependent variables, particularly when the commodity categories are highly disaggregated. To the extent that the observations of the dependent variable are "clumped" at zero, the errors are not normally distributed. More importantly, the expected value of the error term is positive, violating one of the classical assumptions. In this circumstance, OLS estimates are biased (see Judge *et al.*, 1988: 796).

The most obvious "solution" to this problem is simply to exclude from the regression the households that did not consume the good being modeled. This approach, however, is not acceptable because the resulting parameter estimates would suffer from sample selectivity bias. In other words, the model would not represent the behavior of all households (Alderman, 1986; Deaton and Case, 1988).

Another approach might be to aggregate across commodities to eliminate the zero observations. Unfortunately, this would greatly reduce the value of the results and even categories as broad as "animal products" and "cereals" would still have some zero observations. A similar strategy would be to aggregate over groups of households. This reduces the precision of the estimates and is generally only practical when the sample size is quite large (see Gray, 1982).

An econometric solution is to adopt a "censored dependent variable" (CDV) model which compensates for the bias due to the non-normal error. This model takes the following form:

$$Y = Z\delta + \epsilon$$
$$w = \begin{cases} X\beta + u & if\ Y > 0 \\ 0 & if\ Y \leq 0 \end{cases} \quad (3\text{-}24)$$

The first equation determines whether the observed dependent variable (w) will be zero or positive and the second gives the expected value of w conditional on its being positive.

The original and most common type of CDV model is the "Tobit" model, developed by Tobin (1958) to estimate durable good expenditures. The Tobit model is a special case in which the two equations have the same independent variables (X = Z) and the same coefficients (ß = δ). More recently, Heckman suggested a two-step procedure which uses OLS to obtain consistent parameter estimates when the dependent variable is censored (Fomby, Hill, and Johnson, 1984: 358-364).

Several studies have used censored dependent models to estimate demand systems, although the results have been mixed. Pitt (1983) estimates food demand in Bangladesh using a Tobit model. He avoids using expenditure or budget share as the dependent variable because of the Tobit restriction that ß be equal to δ. He notes that:

> [if] expenditure or expenditure share is the dependent variable in a tobit demand model and if demand is inelastic, an increase in own-price necessarily implies an increase in the probability of consuming (positive) quantities of the commodity. (Pitt, 1983: 106)

At the same time, the price coefficients of these goods are likely to be biased downward by the negative effect of price on the probability of consumption (an unrestricted CDV model would avoid these problems).

Deaton and Irish (1984) attempt to apply a version of the Tobit model on data from the United Kingdom. They find that zero observations are significantly less frequent than would be suggested by the Tobit model. Deaton is skeptical of the validity of CDV models in demand analysis. He notes that it is difficult to give a theoretical justification for the latent variable, particularly since zero expenditure may be caused by non-consumption or by consumption outside the survey recall period (Deaton and Case, 1987: 78).

Heien and Wessells (1990) estimate US dairy demand using an AIDS with the Heckman two-step correction for zero observations. In spite of their claim that homogeneity and symmetry are "readily" imposed, the standard linear restrictions that they adopt ignore the effect of prices on the probability of zero expenditure. As McDonald and Moffit (1980) show, the relationship between E(w) and X, and hence the restrictions necessary to impose symmetry, are highly non-linear. Pudney (1989) describes various complications that arise in attempting to reconcile consumer choice and CDV models. Even adding-up cannot be readily imposed on a set of equations in a CDV model.

In summary, CDV models would appear to be an attractive solution to the problem of zero expenditures, but they may introduce a new set of problems: it is difficult or impossible to impose the standard restrictions of economic theory, combining Tobit with the AIDS will bias the coefficients for price inelastic goods, and the theoretical justification is not well established.

Using panel data for demand estimation: The fourth issue is the possible use of the variation in consumption behavior within the household across seasons. In order to avoid seasonal bias, household budget data are often collected in several visits or "rounds." Although ordinary least squares estimates based on annual averages for each household are unbiased in this case, they are not efficient because they do not incorporate the additional information provided by variation across rounds. The fixed-effect model uses *only* the within-household variation in the dependent and independent variables, whereas the random-effect model uses both the variation among households and the variation among rounds for the same household (Fomby, Hill, and Johnson, 1984: Chapter 15).

There are several limitations, however, to using this cross-round within-household variation in household budget analysis. First, some independent variables, such as the demographic characteristics of the household, do not vary (or vary little) across time. For these variables, the random effect model would yield (virtually) the same results as a regression based on annual averages. Second, budget share is thought to be influenced by "permanent income," for which *annual* expenditure is a good proxy. *Seasonal* expenditure would be a less accurate proxy for permanent income and is thus less desirable as an independent variable. Thus, the value of cross-round variation in demand analysis is generally limited to the estimation of price response.

Simultaneous equation estimation: Another type of information which is not used by single-equation OLS estimation is the correlation of error terms across equations for the same household. If such correlation exists, OLS estimates are still unbiased but they are not efficient because they do not use all available information. In this case, the estimating the entire system simultaneously using the seemingly unrelated regressions (SUR)[1] model generates more efficient parameter estimates[2].

In the two-step estimation procedure suggested by Zellner (1962), the residuals from single-equation ordinary least squares estimation are used to estimate the cross-equation covariance matrix. This matrix is

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1. Although related through the correlation of error terms, they are "seemingly unrelated" because each equation has only one endogenous variable.

2. One exception is the case where the independent variables are the same in all equations. This does not apply to our model since the food equations contain price terms while the non-food equations do not.

then used in a generalized least squares estimation of the entire system (see Judge *et al.*, 1988: 444-452 and Fomby, Hill, and Johnson, 1988: 155-162).

The SUR model may be useful even when the error terms are not correlated across equations since, unlike single-equation estimation, SUR allows cross-equation restrictions to be tested or imposed. For example, the symmetry of the Hicksian substitution matrix can be imposed in the context of a SUR model. Furthermore, SUR must be used if we wish to carry out cross-equation tests of significance, such as a test of the joint hypothesis that $\beta_2=0$ in every equation.

In summary, the SUR model is necessary to impose symmetry, and it may be appropriate even for unrestricted estimates of the parameters. In the latter case, the magnitude of these correlations is an empirical issue and is subject to testing. The SUR model and associated tests are described further in section 4.3.3.

3.3.4 Household-firm models

Empirical models of consumer demand using cross-sectional data have a relatively long history, extending back into the 19th century[1]. In the context of the industrial economies where income generally takes the form of wages and salaries, it was natural to exclude the production side of household behavior. However, the situation is quite different in less developed economies, particularly in the rural sector, for several reasons. First, since agricultural commodities are an important part of household output as well as consumption, a given price change may affect production decisions and income as well as consumption choices. Second, the issue of how prices influence *marketed* output cannot be determined without a model that integrates both consumption and production behavior. And third, since agricultural households are generally self-employed, labor-leisure

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1. A historical overview of demand analysis is provided by Deaton and Brown (1972).

decisions are an important element of household behavior. Thus, a model which allows labor input to vary is desirable.

One of the earliest treatments of time allocation and subsistence production decisions is that of Chayanov (1966). He described household behavior in terms of a subjective equilibrium between the "drudgery" of alternate tasks and the consumption needs of the households. He drew implications from this theory for the influence of household size and structure on production patterns.

Becker (1965) formalized a model of time allocation which has become the basis for modern household-firm theory. In Becker's model, household utility is a function of "commodities," which are produced by the household using time and purchased goods. The household must allocate time among various work and leisure activities, and they must distribute income from wages and other sources among various purchased goods. Thus, they maximize utility subject to a time constraint and a cash budget constraint. This model has been used to interpret a wide variety of phenomena relating to the demand for convenience goods, fertility decisions, intra-household division of labor, and queuing behavior under rationing.

A similar model is developed by Hymer and Resnick (1969) in which utility is a function of home-produced "Z-goods" (artisanal goods and services), home-produced food, and market goods purchased with revenue from crop sales. Since the production choices are expressed in terms of a production possibility frontier, time is not explicitly modeled, and leisure is assumed constant. A key element of the model is the assumption that Z-goods are inferior, an assumption which is not supported by empirical evidence (see King and Byerlee, 1978 and Liedhom and Mead, 1987).

Barnum and Squire (1979) generalize the Hymer and Resnick model by allowing the purchase and sale of labor and by allowing total labor input (and hence leisure) to vary. The assumption of Z-good inferiority is dropped, allowing it to be absorbed into "leisure." The model can be expressed as follows:

$$\begin{aligned} &\textit{maximize}: \\ &\quad U = U(L, C, M) \\ &\textit{subject to}: \\ &\quad p_F(F-C) + wN = p_M M \\ &\quad L + N + H = T \\ &\quad F = F(H) \end{aligned} \tag{3-25}$$

where L = leisure time
C = the value of agricultural output retained for consumption
M = the value of market goods purchased
p_F = the price of agricultural output
p_M = the price of market goods
w = the wage rate
F = the value of agricultural output
N = sales of labor time (negative if labor is purchased)
H = time devoted to agricultural production
T = total available time

By successive substitution, the three constraints can be combined to an expression which equates "full income" (farm profits and the value of total available time) and the total value of consumption (the value of goods consumed plus the opportunity cost of leisure):

$$(p_F F - wH) + wT = p_F C + p_M M + wL \tag{3-26}$$

The model is recursive in the sense that the profit-maximizing production decisions can be derived without reference to consumption decisions. The first-order conditions for profit maximization require that the marginal value product (MVP) of labor in agricultural production must be equal to the MVP of wage labor:

$$p_F \frac{\partial F}{\partial H} = w \tag{3-27}$$

This expression defines the level of agricultural output and thus farm profits and "full income." Utility maximizing consumption decisions can then be made on the basis of prices, preferences, and the level of full income obtained from the production decisions. The recursiveness of the model depends on several assumptions: that there is a market for the purchase and sale of labor, that family labor and hired labor are perfect substitutes, and that risk is not an issue (Singh *et al.*, 1986).

A key result of this model is that prices affect demand for goods and labor not just through the familiar income and substitution effects, but also through a "profit effect." In other words, prices influence the level of farm profits and thus the level of income, which in turn alters the pattern of demand. The total effect of price on consumption can be decomposed as follows:

$$\frac{dC}{dp_F} = \frac{\partial C}{\partial p_F} + \frac{\partial C}{\partial x^*}\frac{\partial x^*}{\partial p_F} \qquad (3\text{-}28)$$

where x^* is the value of full income associated with profit-maximizing behavior. The first term on the right side is the partial of Marshallian demand and is negative except in the case of Giffen goods. The second term is the profit effect and is positive for any normal good. Thus, in the case of a household-firm, the profit effect will dampen, and may even reverse, the negative effect of traditional demand theory. The profit effect is particularly important when 1) the commodity is an important source of income for the household and 2) the income elasticity of the commodity is large.

The total effect of price on *marketed* output is written in a similar way:

$$\frac{d(F-C)}{dp_F} = \frac{\partial F}{\partial p_F} - \left(\frac{\partial C}{\partial p_F} + \frac{\partial C}{\partial x^*}\frac{\partial x^*}{\partial p_F}\right) \qquad (3\text{-}29)$$

If the supply response of the commodity (the first term on the right side) is small and the effect of price on consumption (in parentheses) is positive due to the profit effect, then a price increase could actually reduce marketed output.

Various approaches have been adopted for modeling the demand and supply sides of household-firm models. Barnum and Squire (1979) use data from the Muda River Valley in Malaysia where rice is the dominant crop and model rice production with a Cobb-Douglas production function. Demand for rice, manufactured goods, and leisure is estimated using a modified linear expenditure system. Lau, Lin, and Yotopoulos (1978) analyze Taiwan data using a linear-logarithmic expenditure system on the demand side and a profit-function approach on the production side. Strauss (1983) extends the model by disaggregating agricultural output and purchased goods into various categories and by adopting a more flexible demand specification. Using data from Sierra Leone, farm-households are modeled with a quadratic expenditure function and a constant-elasticity-of-transformation production function.

The estimated profit effect is large enough to make the impact of price on consumption positive in four of the seven studies reviewed by Singh, Squire, and Strauss (1986). In all of these cases, the commodity in question was the dominant staple in the region (e.g rice in Korea and sorghum in northern Nigeria). On the other hand, in none of the studies did the profit effect make the elasticity of marketed output negative.

The model has been used to explore a number of issues. Pitt and Rosenweig (1986) use the household-firm model to look at the impact of price changes on health. Iqbal (1986) develops a two-period household-firm model to analyze credit. Roe and Graham-Tomasi (1986) show that the recursive nature of household-firm models disappears when risk is introduced. Household behavior and intra-household division of labor are discussed in the context of a household-firm model (albeit less formally) by Low (1986) and Jones (1986), among others.

3.3.5 Summary

Models of household behavior are generally based on the assumption of utility maximization subject to a budget constraint. If preferences are assumed to be rational and consistent, then demand functions will satisfy several properties: adding up, homogeneity, symmetry, and negative semi-definiteness. A number of functional forms either satisfy these restrictions or allow the restrictions to be tested and imposed statistically.

One of the more popular models is the Almost Ideal Demand System. Adding a quadratic income term makes the AIDS more flexible, although it loses the convenient property of exact aggregation and no longer corresponds to an explicit expenditure function.

Several issues in the estimation of demand systems include: 1) adjustment for quality effects and measurement error in estimating price response, 2) estimating price response for non-food categories, 3) the appropriate treatment of zero-expenditure observations, 4) whether to use the across-round variation in estimating parameters, and 5) whether to use single-equation estimation or model the system with an SUR model.

The household-firm model integrates production and consumption decisions, providing a more realistic view of the behavior of semi-subsistence farm households. At the same time, these models have very heavy data requirements.

3.4 Welfare effects of price and income changes

Household survey data has frequently been used to evaluate the welfare impact of alternative policies in less developed countries. For example, household budget data were used to evaluate the distributional impact of wheat subsidies in Morocco (Laraki, 1988), food price policy in Nepal (Pakpahan, 1988), rice policy in Indonesia (Mudbhary, 1988), sugarcane-for-ethanol promotion policies in Brazil (Gray, 1982), and structural adjustment policies in Côte d'Ivoire and Peru (Glewwe and de Tray, 1988 and 1989).

However, these studies have generally adopted fairly rough measures of welfare impact. Often the impact of a price increase is assessed purely in terms of the budget share of the good in question. This measure over-estimates the welfare impact of price increases because it does not take into account the ability of household to substitute away from the now more expensive goods. Other studies rely on consumer surplus to measure welfare impact. Although this measure has been shown to be seriously flawed, it remains popular among practitioners because of its simplicity and the (erroneous) view that it requires less information than do more precise measures. This section discusses producer and consumer surplus, the more modern "willingness-to-pay" measures, and several methods of calculating willingness to pay.

3.4.1 Producer surplus

Producer surplus is the amount of money a producer receives for her output above and beyond the minimum she would accept for it. Since the minimum acceptable amount is the cost of production, the change in producer surplus is the change in net income. This can be expressed as follows:

$$PS = \Delta x = \sum_{i=1}^{N} \int_{p_{i0}}^{p_{i1}} F_i(p)\, dp \tag{3-30}$$

where $F_i(p)$ is the supply function of good i. A first-order approximations of producer surplus can be obtained from:

$$\Delta x = \sum_{i=1}^{N} F_{0i}\, \Delta p_i \tag{3-31}$$

In the short run, before output has adjusted, this expression is exact. More common is the second-order approximation of producer surplus:

$$\Delta x = \sum_{i=1}^{N} \frac{1}{2} (F_{0i}+F_{1i})\, \Delta p_i \tag{3-32}$$

where the subscripts refer to time (0 is before, 1 is after).

A change in producer surplus implies a simple change in net income which has an unambiguous affect on welfare. It is consistent with either of the two willingness-to-pay concepts, which are discussed in section 3.4.3. Unlike consumer surplus, producer surplus generates little controversy.

3.4.2 Consumer surplus

Although welfare measures are implicitly based on the concept of utility, the concept of consumer surplus actually predates the formalization of the theory of consumer preferences. In 1844, Jules Dupuit, a French engineer, developed the concept of consumer surplus to evaluate the benefits associated with the construction of a bridge. Consumer surplus may be defined as the amount a consumer is willing to pay for a good above and beyond the amount actually paid for it. In practice, we are generally interested in the change in consumer surplus associated with a price change, defined as follows:

$$CS = \sum_{i=1}^{N} \int_{p_{i0}}^{p_{i1}} q_i(p)\, dp_i \qquad (3\text{-}33)$$

where $q_i(p)$ is the Marshallian demand for good i. The most common way to calculate consumer surplus is with the following approximation:

$$CS = \sum_{i=1}^{N} \frac{1}{2}(q_{0i}+q_{1i})\,\Delta p \qquad (3\text{-}34)$$

Several criticisms have been made of consumer surplus. First, when consumer surplus is calculated from market demand curves, it represents the unweighted sum of the consumer surplus of individual consumers. In effect, it assumes the marginal utility of money is the same for all consumers. Second, Samuelson (1942) showed that with changes in more than one price, the concept of consumer surplus is not well-defined because the result is generally path-dependent. In other words, the value of consumer surplus varies depending on the order that the different price changes are introduced into the calculations. Path independence would require that the matrix of uncompensated (Marshallian) price effects be symmetric:

$$\frac{\partial q_i(\mathbf{p},x)}{\partial p_j} = \frac{\partial q_j(\mathbf{p},x)}{\partial p_i} \quad for\ all\ i,j \tag{3-35}$$

It can be shown that this implies that preferences must be homothetic and, hence, that budget shares must not vary with income (McKenzie, 1983). This condition is, of course, highly unrealistic in light of empirical evidence.

3.4.3 Compensating variation and equivalent variation

Hicks (1940) introduced the concepts of compensating variation and equivalent variation[1]. These two "willingess-to-pay" measures are defined, interpreted graphically, and compared in this section.

Definitions: Compensating variation (CV) is the amount of money which exactly compensates the individual for the price and income changes, thus restoring her original level of utility. For a price decrease, CV is the amount she is willing to pay for the change, and for a price increase, it is minus the amount she would have to receive to be willing to accept the change. CV can be expressed in terms of the expenditure function as follows:

$$CV = e(\mathbf{p}_1, u_0) - e(\mathbf{p}_1, u_1) \tag{3-36}$$

where the subscripts refer to time (0 is before, 1 is after).

Equivalent variation (EV) is the amount of money which would have to be given to a consumer in order to create a change in utility equivalent to the price and income changes. For a price decrease, it is the amount of money the consumer would have to receive to be willing to give up the price change, and for a price increase it is minus the

1.. These concepts were first discussed in Hicks (1940), but it was Henderson (1940), commenting on Hicks' paper, that first recognized that consumer surplus, compensating variation, and equivalent variation are different concepts (except in special cases). Henderson also provided the graphic interpretation of these measures using utility curves, amount she would be willing to pay to avoid the change. This can be expressed as follows:

$$EV = e(\mathbf{p_0}, u_0) - e(\mathbf{p_0}, u_1) \tag{3-37}$$

where again the subscripts refer to time. Both CV and EV are defined here as having the same sign as the welfare impact of the price and income changes[1].

Graphic interpretation: Both willingness-to-pay measures can be divided into an income effect and a relative price effect. The relative price effect can be interpreted as the area to the left of the compensated (Hicksian) demand curve. To see this, we add and subtract $e(\mathbf{p_1}, u_1)$ to equation 3-37:

$$\begin{aligned} EV &= e(\mathbf{p_0}, u_1) - e(\mathbf{p_0}, u_0) = e(\mathbf{p_0}, u_1) + e(\mathbf{p_1}, u_1) - e(\mathbf{p_1}, u_1) - e(\mathbf{p_0}, u_0) \\ &= e(\mathbf{p_0}, u_1) + x_1 - e(\mathbf{p_1}, u_1) - x_0 \\ &= \Delta x + e(\mathbf{p_0}, u_1) - e(\mathbf{p_1}, u_1) \end{aligned} \tag{3-38}$$

The first term is the change in income, while the second two terms represent the change in income which is equivalent to the relative price changes. If we take the derivative and the integral of the second two terms with respect to p and then apply Shephard's lemma, we get:

$$\begin{aligned} EV &= \Delta x + e(\mathbf{p_0}, u_1) - e(\mathbf{p_1}, u_1) \\ &= \Delta x + \int_{p_1}^{p_0} \sum_{i=1}^{N} \frac{\partial e(\mathbf{p_1}, u_1)}{\partial p_i} dp_i \\ &= \Delta x - \int_{p_0}^{p_1} \sum_{i=1}^{N} h_i(\mathbf{p_1}, u_1)\, dp_i \end{aligned} \tag{3-39}$$

By similar manipulation of equation 3-36, compensating variation can be divided into income and relative price terms and expressed in terms of the Hicksian demand function:

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1. Some authors define CV and EV with opposite signs from the definitions provided here, but it is convenient to have the sign of CV and EV equal to the direction of welfare change.

$$CV = \Delta x - \int_{p_0}^{p_1} \sum_{i=1}^{N} h_i(\mathbf{p}_0, u_0)\, dp_i \tag{3-40}$$

Thus, the relative price effect of both willingness-to-pay measures can be interpreted as the area to the left of the Hicksian demand curve over the relevant price range. In the case of CV, the original Hicksian demand curve is used, while for EV the final Hicksian demand curve is used. This is illustrated in Figure 3-1 for a single price increase from p_0 to p_1. The Marshallian demand curve is represented by D, while the original and final Hicksian demand curves are h0 and h1, respectively.

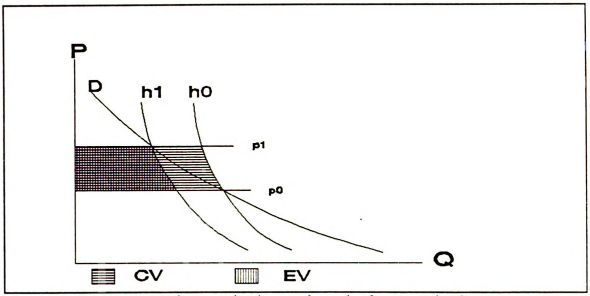

Figure 3-1: Compensating variation and equivalent variation

<u>Comparison of measures</u>: These two willingness-to-pay measures are superior to consumer surplus in that they are well defined for a consumer with consistent preferences. For CV and EV, the conditions for path independence are that compensated (Hicksian) price effects be symmetric. This, of course, is the same symmetry discussed in section 3.3.1, which is required under consistent ordering of preferences (see McKenzie, 1983 and Johansson, 1987).

The choice between CV and EV must be based on the situation being analyzed. If actual compensation is planned or if the "compensation principle" is adopted as a criteria for social choice, then the compensating variation is appropriate. On the other hand, if no compensation is planned or if the goal is to minimize the welfare effect on consumers, then the equivalent variation is appropriate. Some have argued that this decision corresponds to the assumptions made about property rights: if consumers have a "right" to the prior situation, then compensating variation should be used, while equivalent variation is more correct if they are assumed to have a right to the post-change situation.

Because of its relationship to the compensation principle, CV has been more often used than EV. On the other hand, McKenzie and Pearce (1982) and McKenzie (1983) make a strong case for EV, arguing that it allows multiple scenarios to be compared to the initial period since the base period prices are used to evaluate all the alternatives. By comparison, alternative outcomes cannot be compared using CV because the prices differ. Thus, EV is a better measure of utility because it is ordinally related to utility while CV is not.

The willingness-to-pay measures have been extended in various ways. Blackorbry, Donaldson, and Maloney (1984) consider intertemporal measurement of welfare. They show that the sum of discounted instantaneous surpluses cannot be an exact measure of welfare change, but it can provide bounds on the true value. Helms (1985) discusses willingness to pay in the context of risk, demonstrating that expected CV is a valid measure of welfare only under highly restrictive conditions. Johansson (1987) reviews a wide body of literature on the use of welfare measures to evaluate environmental benefits. And de Borger (1989) adapts the concepts of CV and EV to the case of government programs which provide in-kind transfers to consumers.

In spite of the theoretical superiority of CV and EV, many practitioners continue to use consumer surplus as a welfare measure in spite of its problems. For example, in a review of the trade literature, Jeon and von Furstenberg (1986) were not able to find a single case of CV or EV being used in calculations of the cost of protection. One reason for this is that:

> there appears to be a widespread impression in the literature that computation of CV or EV is intrinsically more difficult or requires more information than calculating the area under Marshallian demand functions... In fact, this is not so... (Deaton and Muelbauer, 1980a: 188-189)

This brings us to the methods of estimating compensating variation and equivalent variation.

3.4.4 Methods of estimating willingness to pay

There are essentially four strategies which have been proposed to estimate willingness to pay, given observable Marshallian (1) demand equations. The first is to derive an explicit form of the expenditure function from the demand functions. The second method is to use a Taylor-series expansion to estimate the indirect utility function. The third approach uses a Taylor-series expansion to estimate the (3) expenditure function. And the fourth strategy is to numerically (2) integrate the Hicksian demand function. Each of these is described briefly below.

Haussman method: The most obvious strategy is to derive an explicit form of the expenditure function. Hausman (1981) demonstrates how to do this with a single price change. The first step is to combine Roy's identity and the observed demand function to form a differential equation, the solution of which is the indirect utility function. Solving the indirect utility function for income yields the expenditure function, which can be used to calculate EV and CV exactly. Unfortunately, this procedure has limited applicability. De Borger (1989: 216) notes that:

> [Hausman's method] is difficult to generalize to a many-commodity world, and even in a two-good framework it will not always be useful as for many demand functions the corresponding differential equation will not have a close-form solution.

Obviously, these steps are unnecessary if the demand function is derived from an explicit expenditure function, as is the Almost Ideal Demand System. The fact remains, however, that only a few demand functions correspond to explicit expenditure functions.

<u>McKenzie method</u>: The second approach involves a Taylor-series expansion of the indirect utility function (McKenzie and Pearce, 1982 and McKenzie, 1983). The money-metric function, $M(\mathbf{p_1},x;\mathbf{p_0})$, defined as the cost of reaching the level of satisfaction, $v(\mathbf{p_1},x)$, at base prices, $\mathbf{p_0}$. Thus, equivalent variation is simply the change in the money metric function resulting from income and price changes. This change is approximated using the Taylor-series expansion (shown here expanded to the second order):

$$\begin{aligned}\Delta M(\boldsymbol{p},x;\boldsymbol{p}_0) = {} & \sum_{i=1}^{N}\frac{\partial M}{\partial p_i}dp_i + \frac{\partial M}{\partial x}dx \\ & + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{\partial^2 M}{\partial p_i \partial p_j} + \sum_{i=1}^{N}\frac{\partial^2 M}{\partial p_i \partial x}dp_i dx + \frac{1}{2}\frac{\partial^2 M}{\partial x^2}(dx)^2\end{aligned} \tag{3-41}$$

where M = money metric function
x = income or total expenditure
p_i = price of good i

By defining the money metric appropriately, this equation can be converted into a function of observed demand parameters (shown again to the second order):

$$\begin{aligned}\Delta M(\boldsymbol{p},x) = {} & -\sum_{i=1}^{N} q_i dp_i + dx \\ & + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left(q_i\frac{\partial q_j}{\partial x} - \frac{\partial q_i}{\partial p_j}\right)dp_i dp_j - \sum_{i=1}^{N}\frac{\partial q_i}{\partial x}dp_i dx\end{aligned} \tag{3-42}$$

where qi = quantity of good i

The third-order terms are rather involved, and McKenzie (1983: 48) admits that it "may appear to be a highly tedious procedure." He correctly notes that computer procedures can simplify the task, but higher-order derivatives of the demand function must be derived by hand, the order increasing with the desired level of precision. Furthermore, as discussed later, Dumagen and Mount (1991) show that McKenzie's approximation of the money metric may not be as accurate as alternative approaches.

Hicks method: The third method is to approximate the expenditure function using a Taylor-series expansion. Deaton (1980) and McKenzie (1983) illustrate this approximation up to the second-order approximation, although the idea is attributed to Hicks. Dumagen and Mount (1991) extend the expression to include the third-order term.

The first step is to decompose the two willingness-to-pay measures into income and price effects, as shown in equation 3-38. The difference between the two expenditure function terms can then be approximated as a Taylor-series expansion. In this way, the first-order approximations of EV and CV can be expressed as:

$$\begin{aligned} EV &= \Delta x + \frac{1}{1!}\sum_{i=1}^{N} \frac{\partial e(\mathbf{p}_1, u_1)}{\partial p_i}(p_{0i}-p_{1i}) = \Delta x - \sum_{i=1}^{N} q_{1i}\Delta p_i \\ CV &= \Delta x + \frac{1}{1!}\sum_{i=1}^{N} \frac{\partial e(\mathbf{p}_0, u_0)}{\partial p_i}(p_{0i}-p_{1i}) = \Delta x - \sum_{i=1}^{N} q_{0i}\Delta p_i \end{aligned} \qquad (3\text{-}43)$$

by applying Shephard's lemma and defining $\Delta p = p_1 - p_0$. From this expression, it is clear that Laspeyres and Paasche price indexes are first-order approximations of CV and EV, respectively[1] (see Deaton, 1980).

Figure 3-2 illustrates the first-order approximations of compensating variation (CV_1) and equivalent variation (EV_1) for a single price increase. The graph shows that the first-order approximations are more accurate when the Hicksian demand is highly inelastic. It also demonstrates that, in absolute value, EV_1 is a lower bound for equivalent variation, and CV_1 is an upper bound for compensating variation.

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1. Specifically, if nominal income (x) is constant, then the Laspeyres index is $100(x-CV_1)/x$ and the Paasche index is $100(x-EV_1)/x$.

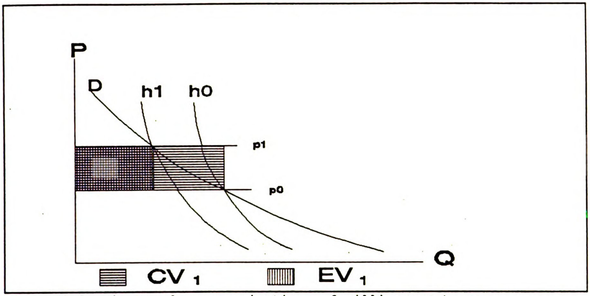

Figure 3-2: First-order approximations of willingness to pay

The Taylor-series can be expanded further to obtain a second-order approximation of equivalent variation as follows:

$$EV = \Delta x + \frac{1}{1!}\sum_{i=1}^{N}\frac{\partial e(\mathbf{p}_1, u_1)}{\partial p_i}(p_{0i}-p_{1i})$$

$$+ \frac{1}{2!}\sum_{i=1}^{N}\sum_{j=1}^{N}\frac{\partial^2 e(\mathbf{p}_1, u_1)}{\partial p_i \partial p_j}(p_{0i}-p_{1i})(p_{0j}-p_{1j}) \qquad (3\text{-}44)$$

$$= \Delta x - \sum_{i=1}^{N} q_{1i}\Delta p_i + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} S_{1ij}\Delta p_i \Delta p_j$$

where S_{1ij} is the Hicksian substitution term evaluated at the final position. Similarly, the second-order approximation of the compensating variation can be expressed as:

$$CV = \Delta x - \sum_{i=1}^{N} q_{0i}\Delta p_i - \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} S_{0ij}\Delta p_i \Delta p_j \qquad (3\text{-}45)$$

The only difference between these two equations is that the expression for EV is based on demand parameters evaluated at the end point (after the price and income changes), whereas the CV equation is based on parameters evaluated at the initial point (before the changes).

Figure 3-3 illustrates the second-order approximations of EV and CV for a single price increase (labeled EV_2 and CV_2, respectively). The slope of the right-hand edge of each area is equal to the slope of the compensated (Hicksian) demand curve at the respective reference points.

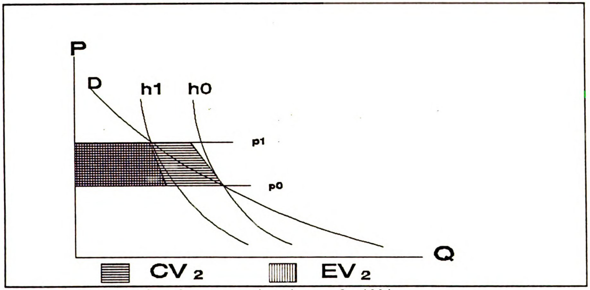

Figure 3-3: Second-order approximations of willingness to pay

The expenditure function approximation, like the approximation of the money metric, yields estimates of any desired degree of accuracy, although increasing precision requires increasingly higher-order derivatives of the demand function. However, the expenditure function approximation is easier to derive because there is only one income term; the money metric approximation involves various income-price interaction terms. In addition, Dumagen and Mount (1991) show that a third-order approximation of the expenditure function is generally more accurate than a third-order money metric approximation, at least when tested using a two-good model with quasi-linear demand.

Vartia method: The fourth approach to estimating willingness-to-pay, proposed by Vartia (1983), uses numerical integration of the compensated (Hicksian) demand curve. This method uses the fact that willingness to pay can be interpreted as the area "under" the compensated demand curve as price changes. Although the compensated demand curve is not directly observed, Vartia suggests an iterative procedure: the price change is divided into small increments and for each increment, consumer income is adjusted by an amount to compensate for the price change, leaving utility constant. This compensation increases the demand for the good (provided it is normal), so that with each iteration we trace the steeper compensated demand curve rather than the uncompensated demand curve.

The amount to compensate the consumer for each price increment can be estimated "crudely" (using CV_1) cause as the change in price approaches zero, the difference between various approximations also approaches zero. If we start at the initial point, utility is held at its original level so the sum of the adjustments to income is the compensating variation. Likewise, if we start at the final point and work backwards, the utility is held constant at its final level, so that the equivalent variation is calculated.

The Vartia method has a distinct computational advantage over the two Taylor-series approaches: once the computer routine has been written, increasing the level of precision is just a matter of raising the number of iterations (hence diminishing the size of the price increments). Unlike the Taylor expansions, no additional (human) effort is needed to improve accuracy.

3.4.5 Summary

Consumer surplus remains the most common welfare measure in applied economic research, in spite of the fact that it is not well defined for multiple price changes due to the problem of path-dependence. Although the two willingness-to-pay measures, compensating variation and equivalent variation, are well defined, they have not enjoyed widespread adoption.

Although the willingness-to-pay measures are based on unobserved compensated demand functions, they do not require more information than is needed to calculate consumer surplus. Several estimation approaches have been suggested. In cases where the demand function corresponds to an explicit expenditure function or indirect utility function, willingness to pay can be calculated exactly. When this is not possible, the indirect utility function or the expenditure function can be approximated using a Taylor-series expansion. The result is an expression for willingess to pay in terms of observed demand parameters. Finally, willingness to pay can be estimated through a numerical integration of the estimated compensated demand function.

CHAPTER 4

RESEARCH METHODS

4.1 Overview of research approach

The research approach of this study can be divided into three phases. In the first phase, data from the Rwandan National Budget and Consumption Survey (ENBC) is used to model household behavior. Section 4.2 describes the data collection and processing methods of the ENBC. In section 4.3, the procedures for estimating demand as a function of income, prices, and household characteristics using the ENBC are reviewed. Section 4.4 describes the modeling of the supply side of household behavior, relying on both ENBC data and outside estimates of agricultural supply elasticities.

In the second phase of the study, the impact of devaluation on prices will be modeled using 1) hypothetical prices based on the distinction between tradeable and non-tradeable goods and 2) historical prices for the seven months after devaluation. This phase is described in section 4.5.

The third phase combines the price changes and the model of household behavior to estimate the effect of devaluation on different types of households. The impact on demand, on nutritional intake, and on household welfare are simulated. The methods used in this phase of the study are described in section 4.6.

4.2 Data sources

The National Household Budget and Consumption Survey (ENBC) was carried out over the period 1983 to 1985 by the Ministry of Planning of the Republic of Rwanda. Technical and financial assistance during the data collection was provided by French agency for development assistance, while the data analysis and publication of results was supported primarily by the U.S. Agency for International Development, with additional contributions by the Cooperation Française, the Food and Agriculture Organization of the United Nations, and UNICEF.

The objectives of the survey were to provide information on household economic activities to government organizations and international agencies in order to improve policy making and project design. Two specific goals of the ENBC were 1) to provide more accurate weights (based on the composition of expenditures) for the construction of price indices and 2) to improve national accounts, particularly with regard to agricultural production for own consumption in the rural areas.

4.2.1 Survey sample

The ENBC sampling method makes use of the administrative units of Rwanda. The country is divided into ten *préfectures*, 149 *communes*, and roughly 1500 *secteurs*. The ENBC defined 36 *secteurs* as urban, following their designation as "predominantly urban" by the 1981 Demographic Survey. Only one *commune*, Nyarugenege, which contains the city of Kigali, is entirely urban.

For the rural sample, 90 of the 148 rural *communes* were selected using a complex system of multiple stratification: repeated samples were drawn until one of them was "representative" according to several agro-ecological variables. A few *communes* in the Zaire-Nile Ridge were reportedly excluded because of their remoteness. In spite of these manipulations, Scott (1985) recommended treating it as a random sample in devising the weighting system.

In each selected *commune*, one *secteur* was randomly chosen, and in each *secteur*, one census district was selected. An exhaustive list of households in each district was assembled and three randomly selected households were interviewed for the full set of questionnaires. Thus, the sample size in the rural area is 270 households[1].

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1. A subset of the questionnaires was administered to a larger sample, but the budget data were too incomplete to use.

The urban area was separated into two strata: the *commune* of Nyarugenge (including Kigali proper) and the rest of the urban area (including Butare, Ruhengheri, Gisenyi, and some outskirts of Kigali). In the first stratum, 15 of 49 "Observation Zones" were selected with probability proportional to the population as estimated by the National Fertility Survey of 1983. Ten households were randomly selected from an exhaustive list of households in each "Observation Zone." These households would receive the full set of questionnaires. In the second stratum, 20 of the 60 census districts were selected with equal probability. An exhaustive list of households in each district was prepared and between two and ten households were randomly selected, depending on the total number in each district[1].

4.2.2 Data collection methods

The data collection in the rural areas took place from November 1982 to December 1983, while the urban data collection covered the period October 1984 to January 1986. In both the rural and urban areas, the data collection was conducted in four rounds, each one involving two weeks of daily visits.

The survey used six main questionnaires, as well as some smaller supplemental questionnaires. These questionnaires are described briefly below (more complete descriptions can be found in Ministère du Plan, 1987 and 1988).

Daily transactions: This questionnaire recorded all transactions carried out by members of the household during the day of the interview. The transactions included purchases and sales (including those of labor), loans made and received, and transfers given and received. Both cash and in-kind transactions were included. The data collected included the quantity, value, place of transaction, which member of the household carried it out, and with whom the transaction took place.

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1. As in the rural survey, a larger sample was used for a few of the questionnaires, but the budget data for these households was too incomplete to allow analysis.

This information was collected daily for two weeks each round, making 56 days per household.

Retrospective transactions: This questionnaire was almost identical to the daily transaction questionnaire, but it was administered differently. The interview was carried out only once each round, but the respondent was to recall all "large" transactions since the last interview three months before.

Food consumption: The components of every meal consumed by members of the household were recorded in this questionnaire. In theory, the enumerator was to weigh each component during preparation. Since this was not always possible, recall was used on occasion. Also recorded were the origin of the food (purchased, gift, or own production), the number of people present, and food consumed by family members away from home. These data were collected over seven days during each round for a total of 28 days per household.

Structure and activities of the household: This questionnaire provided information on the various members of each household surveyed, including age, sex, level of education, and occupation. This information was collected in one visit per round.

Daily activities of the household: Each activity occupying more than 15 minutes carried out by each member of the household was recorded in this questionnaire. This information was collected daily for two weeks during each of the four rounds of the survey.

Household assets: This questionnaire recorded a variety of types of physical assets including livestock, farm tools, furniture, kitchen equipment, and other household effects. Information on the size, layout, and construction of the house and any other buildings was also collected. This questionnaire was completed in one visit.

Supplemental questionnaires were also used. For example, surveys of local markets were used to collect information on prices and the size of traditional units of measure.

4.2.3 Data processing methods

In order to make the budget and consumption data useable, several processing tasks were necessary. These included cleaning, weighting, and valuing transactions in kind. These tasks are briefly described in this sub-section.

Cleaning the data: The data cleaning phase involved the usual tests of logical coherence between different variables. The data were checked for inconsistencies between product and unit (e.g. liters of cloth), between product and quantity (e.g. 5,000 kg of spices), between product and price (e.g. one potato costing $ 10), and between product and type of transaction (e.g. a sale of a watch from "own production"), among others.

In addition, careful attention was devoted to matching business expenses and types of revenue generated. It was discovered that many purchases of bananas and sorghum for beer brewing were mistakenly classified as "commercial purchases" rather than "production expenses." At a higher level, the transactions of households with serious imbalances between cash revenue and cash expenditures were verified in the questionnaires. In a number of cases, it was found that business expenses were wrongly classified as consumption expenses.

In all the cleaning efforts, however, a conservative approach was adopted, in which corrections were limited to cases in which an obvious data-entry mistake had occurred or an unambiguous case could be made that the enumerator miscoded certain transactions. Thus, although the correspondence between income and expenditure is quite close on average, there are a few households with no reported sources of income and a handful of merchants with apparently large operating losses.

Designing the weighting system: The spatial weighting (or expansion) factors were calculated to allow extrapolation from the sample to the universe. These were calculated as the inverse of the probability of selection of a given household. This, in turn, is the product of the proportion of households selected in the district, the proportion of districts selected in the sector, and so on. In the urban area, the formula varies between the two strata, but the principle is the same. Throughout this study, weighted averages and percentages are used, with the sole exception of the regression analysis where weighting observations is not appropriate (see Deaton and Case, 1988).

The temporal weighting is used to extrapolate from sample data to annual estimates. This factor is the inverse of the proportion of days in the year which were covered by the survey recall period. Thus, it is based on the proportion of days for which data exist in a given quarter and the proportion of quarters for which data exists (normally four). For small transactions, the daily transaction questionnaire is used, so the temporal weight is generally around 6.5 (365 days per year divided by 56 days covered). For large transactions, both the daily and retrospective budget questionnaires are used, covering most of the year, so the weight is around 1.0 in most cases. The threshold between small and large transactions was set at 200 FRw (about US $2.00) for the rural areas and 500 FRw for the urban areas. In both cases, the bulk of transactions are recorded in the daily budget questionnaire.

<u>Valuing transactions in kind</u>: Budget data invariably includes various types of non-monetary transactions such as gifts, barter, and consumption of own production. In theory, one would like to value these transactions according to their opportunity cost, as reflected in the prices perceived by the household for those same goods. In practice, there are two complications in applying this procedure.

The first issue is whether to measure opportunity costs by purchase prices or by sale prices (the two differ significantly due to transportation and transaction costs). In principle, the purchase price is a better measure of the opportunity cost for a household which is a net buyer of the good in question, while the sales price is more appropriate for a net seller. Nonetheless, the purchase price was adopted to value all in-kind transactions for two practical reasons: 1) purchase price data are more abundant since purchases are smaller and more frequent than sales, and 2) valuing home production with purchase prices allows more direct comparison with the cash expenditures.

The second issue is at what level of geographic and temporal aggregation to calculate the average purchase prices to be used in valuing transactions in kind. After some experimentation, it was decided to adopt a system with the following priorities:

1. Average purchase price within the same region and round of the survey, provided 10 transactions are available;
2. Average purchase price within the same region over the year of the survey, provided 10 transactions are available;
3. Average purchase price in the sector (urban or rural) over the year of the survey, provided 10 transactions are available;
4. Average sale price in the sector (urban or rural) over the year of the survey multiplied by 1.1;
5. A "plausible" price based on experience.

In the rural sector, the "region" refers to the geographic zone, of which there are five. In the urban area, "region" refers to the city, of which the four largest are covered by the survey. The largest number of transactions in kind were valued at the first level. Less than 10% of the transactions had to be valued using the fourth and fifth methods. The use of "plausible" prices at the fifth level was only necessary for such unusual items as the gift of a dog and the loss of a dugout canoe. These represented a very small portion of the total value of transactions.

4.3 Household as consumer

4.3.1 Assumptions about preferences

Any effort to estimate consumer demand must rely on assumptions, whether explicit or implicit, about the structure of preferences. Although in theory, these assumptions should be based on *a priori* knowledge, in practice, it is often necessary to impose restrictions on preferences to compensate for deficiencies in the data.

Nonetheless, it is important to 1) avoid unnecessary restrictions, 2) ensure that the restrictions are not seriously contradicted by the data, and 3) make explicit the assumptions behind the restrictions.

It is assumed that households are a single decision-making unit which maximizes utility subject to time constraints, production technology, and market prices. Household utility is assumed to be an increasing function of the quantity of goods and services it consumes and of non-material qualities of life such as leisure time and health. In the absence of data on these "quality of life" variables, it is necessary to assume that leisure and other "quality of life" characteristics are weakly separable from the consumption of goods and services. This allows the demand for goods and services to be modeled without reference to other determinants of utility.

Price variables for non-food categories are also unavailable. The categories are too broad to be represented by a single price, and the small number of observations for any specific good make it impossible to construct a price index for each category. In order to obtain estimates of non-food price elasticities, we assume strong separability between food and non-food categories, as well as between the various non-food categories. This procedure satisfies the argument that strong separability be limited to broad categories of goods (Phlips, 1983:70), although Deaton (1974) argues that it is not justified even in this case[1].

These separability assumptions can be summarized in terms of the form of the direct utility function.

1. On the other hand, Deaton (1987b: 100) appears to accept additive preferences as a plausible restriction in applied demand analysis.

$$U = U\left\{ \phi\left[f(q_{f1}, q_{f2} \ldots q_{fm}) + \sum_j g_j(q_{nj}) \ , \ k(z) \right] \right\} \quad \text{(4-1)}$$

where $U(\cdot)$ = utility
$\phi(\cdot)$ = any monotonic increasing function
$f(\cdot)$ = the food sub-utility function
q_{fi} = quantity of food i
$g_j(\cdot)$ = the sub-utility function for non-food category j
q_{nj} = quantity of non-food category j
$k(\cdot)$ = the sub-utility function for non-material characteristics
z = vector of non-material characteristics of household which affect utility

The arbitrary monotonic increasing function, ϕ, is necessary to ensure that utility is represented ordinally and not cardinally.

The functional form of the sub-utility function f is directly related to the functional form of the food demand equations. Rather than start with an explicit sub-utility function and derive the corresponding demand function, a demand function is adopted which, when estimated in restricted form, satisfies the demand properties discussed in section 3.3.1. By duality theory, we know that this corresponds to a well-behaved utility function, although in this case the utility function cannot be expressed in an explicit form.

4.3.2 Functional form of demand equations

The functional form used to estimate consumer demand for food is the quadratic extension of the Almost Ideal Demand System (AIDS) with Stone's price index to deflate total expenditure. The food equation thus takes the following form:

$$w_i = \beta_{i0} + \beta_{i1}\ln\left(\frac{X}{P}\right) + \beta_{i2}\left[\ln\left(\frac{X}{P}\right)\right]^2 + \sum_{k=1}^{3} \gamma_{ik} Z_k + \sum_{j=1}^{gf} \alpha_{ij} \ln(p_j) \quad \text{(4-2)}$$

where w_i = budget share of good i
x = total expenditure of the household
P = Stone's index, defined by
$\ln(P) = \Sigma\, w_i \log(p_i)$
Z_k = household characteristic k
gf = number of food equations in model
p_j = price of good j where there are N goods
ß γ α = estimated parameters

The functional form used to estimate the demand for non-food categories is the same except that the price terms are dropped for the reasons described in section 4.3.1.

It is worth describing briefly each of these variables. The dependent variable, w_i, is the budget share: the annual value of consumption of good i divided by total expenditure over the year (defined below). The assumption behind this model is that the quantities consumed (including consumption of own-produced food) are influenced by the level of total expenditure (including home production), market prices, and the demographic composition of the households.

Total expenditure, x, is the sum of cash expenditures on final consumption, the value of home produced agricultural products, the value of gifts received in kind for consumption, and the value of goods and services received through barter. Two types of expenditure were intentionally excluded: 1) business expenses such as seed, hoes, bananas for making wine, hired labor for production activities, and goods purchased for resale, and 2) large durable expenditures such as the purchase of land, buildings, and vehicles. Excluded for lack of data was the value of non-agricultural home production. Evidence from the rural household asset questionnaire indicates that home production of baskets, mats, and wood utensils averages less than 0.5 % of total expenditure. On the other hand, the value of wood collected for household use in the rural sector may be on the order of 10% of total expenditure (see Ministere du Plan, 1988: 34).

Total expenditure is deflated using Stone's price index, P, which is essentially a geometric weighted average with budget shares as the weights. The index is based on prices for a set of 35 food and non-food items. The weights used to calculate the urban and rural indices are based on the average budget shares in the urban and rural areas, respectively.

The three demographic variables, Z_k, are the number of household members aged 16 or older, the number of members under 16 years of age, and a dummy variable to identify the sex of the head of household. Although the definition of the "head of household" was originally intended to reflect the division of labor, in practice the enumerators named the husband/father as the head whenever one was present. Thus, a female head of household represents a woman who is single, divorced, or widowed, or a woman whose husband lives elsewhere for whatever reason.

Finally, the food prices, p_j, are a combination of unit values, when the household reported buying the good in question, and imputed values, where no purchases were reported by the household. The imputed prices are based on the system described in section 4.2.3. As mentioned above, prices are not included in the equations that estimate non-food demand.

4.3.3 Estimation of demand

Based on the discussion in section 3.3.3, several decisions were made regarding the estimation methods. First, the model will be estimated both in unrestricted form and under the symmetry restrictions in order to compare results. Second, quality and measurement error effects will be investigated, but will not be the primary focus of the analysis (see section 4.3.5). Third, a Tobit model will be estimated on part of the data for the purposes of comparison, but the welfare analysis will be based on the linear models (see section 4.3.5). Fourth, the variables used will be annual averages, ignoring across-round variation. And finally, the cross-equation correlation of error terms will be tested and, if indicated, the seemingly unrelated regression (SUR) model will be adopted.

This section describes the methods used to estimate demand using single-equation OLS and using the SUR model, as well as the methods to impose symmetry on the SUR model and to test hypotheses. The derivation of demand elasticities from the estimated coefficients is discussed in section 4.3.4.

Single-equation OLS estimation: We start by converting the functional form of the food demand equation, equation (4-2), into a statistical relationship by adding an error term to represent the effect of missing variables and the measurement error in the dependent variable. Then, it can be put into matrix notation as follows:

$$w_i = \beta_{0i} + \beta_{i1}\ln\left(\frac{x}{P}\right) + \beta_{i2}\left[\ln\left(\frac{x}{P}\right)\right]^2 + \sum_{k=1}^{3}\gamma_{ik}Z_k + \sum_{j=1}^{gf}\alpha_{ij}\ln(p_j) + e_i$$

$$= \left[1 \;\; \ln\left(\frac{x}{P}\right) \;\; [\ln\left(\frac{x}{P}\right)]^2 \;\; Z_1 \;\; Z_2 \;\; Z_3 \;\; \mathbf{p}\right]\begin{bmatrix}\beta_{i0}\\ \beta_{i1}\\ \beta_{i2}\\ \gamma_{i1}\\ \gamma_{i2}\\ \gamma_{i3}\\ \alpha_{ij}\end{bmatrix} + e_i \qquad (4\text{-}3)$$

where w_i = budget share of good i
x = total expenditure of the household
P = Stone's index, defined by
$\ln(P) = \Sigma\, w_i \log(p_i)$
p_j = price of good j where there are g goods
gf = number of food equations in system
Z_k = household characteristic k
β γ α = estimated parameters

The dimensions of these matrices can be described in terms of the number of observations (N), the number of food categories in the system (g_f), and the number of independent variables (k_f=g_f+6)[1]. The first set of brackets represents the independent variables, where each element is an N×1 vector except **p** which is an N×g_f matrix. The second set of brackets

1. In the rural model, N=270, g_f=17, and k_f=23, while in the urban model, N=297, g_f=21, and k_f=27.

contains the coefficients, each element being a scalar except for α which is a $g_f \times 1$ vector.

The non-food demand equations can be expressed in a similar way except that prices are omitted from the independent variables:

$$w_i = \beta_{i0} + \beta_{i1}\ln\left(\frac{X}{P}\right) + \beta_{i2}\left[\ln\left(\frac{X}{P}\right)\right]^2 + \sum_{k=1}^{3}\gamma_{ik}Z_k + e_i$$

$$= \left[1 \;\; \ln\left(\frac{X}{P}\right) \;\; [\ln\left(\frac{X}{P}\right)]^2 \;\; Z_1 \;\; Z_2 \;\; Z_3\right]\begin{bmatrix}\beta_{0i}\\ \beta_{1i}\\ \beta_{2i}\\ \gamma_{1i}\\ \gamma_{2i}\\ \gamma_{3i}\end{bmatrix} + e_i \qquad (4\text{-}4)$$

where the notation is the same as in equation (4-3). Each element in the first set of brackets is an N×1 vector, while those in the second set are scalars. The number of estimated parameters in the non-food equations, k_n, is six.

The independent variables can be combined into one N×k matrix called X, while the parameters can be represented by a k×1 vector called B_i ($k=k_f$ for food equations and $k=k_n$ in the non-food equations). The demand equation can be expressed as follows:

$$w_i = XB_i + e_i \qquad (4\text{-}5)$$

The ordinary least squares (OLS) estimate of B_i can be written as:

$$\hat{B}_i = (X'X)^{-1}X'w_i \qquad (4\text{-}6)$$

Ordinary least squares provides the best unbiased linear estimate under the classical regression assumptions discussed in section 3.3.3. However, single-equation OLS estimation does not allow cross-equation restrictions or hypothesis tests. Furthermore, it is not efficient if the error terms are correlated across equations. In this case, we need to use seemingly unrelated regression (SUR).

Seemingly unrelated regression: The seemingly unrelated regression model combines g equations into one regression model in order to use information about 1) cross-equation correlation of the error terms or 2) cross-equation restrictions on the parameters. The variables and coefficients are assembled as follows:

$$\begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \cdot \\ \cdot \\ w_g \end{bmatrix} = \begin{bmatrix} X_1 & 0 & 0 & \cdot & \cdot & 0 \\ 0 & X_2 & 0 & & & 0 \\ 0 & 0 & X_3 & & & 0 \\ \cdot & & & \cdot & & \cdot \\ \cdot & & & & \cdot & \cdot \\ 0 & 0 & 0 & \cdot & \cdot & X_g \end{bmatrix} \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ \cdot \\ \cdot \\ B_g \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ \cdot \\ \cdot \\ e_g \end{bmatrix} \tag{4-7}$$

The subscript identifies the commodity equation; for example, X_i refers to the N×k matrix of independent variables for equation i. The system can be rewritten more concisely as:

$$w = \overline{X}B + e \tag{4-8}$$

where w = a Ng×1 vector of budget shares for g goods and N households
$\overline{X}$ = an Ng×gk block diagonal matrix with an N×k matrix, X_i, in each block
B = an gk×1 vector of parameters for g goods and k variables
e = an Ng×1 vector of error terms for g goods and N households

The standard assumptions concerning the error terms in the SUR model are that:

$$E(e)=0 \quad and \quad E[ee']=\Sigma\otimes I_N \tag{4-9}$$

where Σ = a g×g matrix, each element of which represents the covariance between the error terms of equations i and j for the same household
I_N = an N×N identity matrix

In other words, the demand equation for each good has a different variance, and there is a positive covariance between equations for the *same* household but zero covariance between equations across households.

The SUR model is estimated in two steps. First, the OLS residuals are used to estimate the Σ matrix. Specifically, each element of the Σ matrix, denoted σ_{ij}, is consistently estimated by $(\hat{e}_i'\hat{e}_j)/(N-k^*)$, where $\hat{e}_i$ is an $N\times1$ vector of OLS residuals from equation i and k^* is the average number of estimated parameters per equation[1]. In the second step, the estimated covariance matrix is used in a feasible generalized least squares format to calculate the SUR estimate of B:

$$\tilde{B} = \left[\, \bar{X}' \,(\hat{\Sigma}^{-1}\otimes I_N)\,\bar{X}\,\right]^{-1} \bar{X}' \,(\hat{\Sigma}^{-1}\otimes I_N)\, w \qquad (4\text{-}10)$$

The estimated covariance matrix of this estimate, designated $\hat{C}$, is:

$$\hat{C} = cov(\tilde{B}) = \left[\, \bar{X}' \,(\hat{\Sigma}^{-1}\otimes I_N)\,\bar{X}\,\right]^{-1} \qquad (4\text{-}11)$$

The Breusch-Pagan test can be used to determine whether the cross-equation correlation of error terms is significant, which would suggest the use of the SUR model even for models without cross-equation restrictions. This test is described at the end of section 4.3.3.

Imposing symmetry: Symmetry requires that the compensated effect of the price of good j on the demand for good i be equal to the compensated effect of the price of good i on demand for good j. In other words, the Hicksian substitution matrix must be symmetric. The symmetry restriction can be expressed in terms of the estimated parameters as follows:

---

1. The adjustment for degrees of freedom in the denominator is not necessary for consistent estimation of σ_{ij}, but this adjustment may reduce bias in finite samples (see Judge *et al.*, 1988: 450).

$$S_{ij} = S_{ji}$$

$$\frac{q_i}{p_j}\epsilon^*_{ij} = \frac{q_j}{p_i}\epsilon^*_{ji} \tag{4-12}$$

$$\frac{q_i}{p_j}\left(\frac{\alpha_{ij}}{w_i} + w_j - \delta\right) = \frac{q_j}{p_i}\left(\frac{\alpha_{ji}}{w_j} + w_i - \delta\right)$$

where δ is the Kronecker delta (equal to 1 when i=j and 0 otherwise) and ϵ^*_{ij} is the Hicksian elasticity of demand for good i with respect to the price of good j. The expression for the Hicksian elasticity is derived in section 4.3.4. Because we are interested in the case where i is not equal to j, the Kronecker delta, δ, is equal to zero. Using the definition of budget share, $w_i=p_iq_i/x$, we can write the condition for symmetry as:

$$\frac{q_i}{p_j}\left(\frac{\alpha_{ij}}{w_i} + w_j\right) = \frac{q_j}{p_i}\left(\frac{\alpha_{ji}}{w_j} + w_i\right)$$

$$\frac{q_i}{p_j}\frac{x}{p_iq_i}\alpha_{ij} + \frac{q_i}{p_j}\frac{p_jq_j}{x} = \frac{q_j}{p_i}\frac{x}{p_jq_j}\alpha_{ji} + \frac{q_j}{p_i}\frac{p_iq_i}{x} \tag{4-13}$$

After canceling terms, this expression reduces to the following:

$$\alpha_{ij} = \alpha_{ji} \tag{4-14}$$

In other words, symmetry of the matrix of price coefficients, α, is necessary and sufficient for symmetry of the Hicksian substitution terms.

Because symmetry involves restrictions involving parameters in different equations, imposing or testing symmetry must be carried out within a seemingly unrelated regression (SUR) model. A set of m linear restrictions can be written in the form RB-r=0, where R is an m×k matrix, B is the k×1 matrix of parameters, and r is an m×1 vector. Using the notation of equations 4-10 and 4-11, the restricted SUR estimator can be written in terms of the unrestricted SUR parameters as follows:

$$\tilde{B}^{*} = \tilde{B} + \hat{C}\,R'\,(R\,\hat{C}\,R')^{-1}(r-R\tilde{B}) \tag{4-15}$$

Imposing symmetry on the $g_f \times g_f$ matrix of price coefficients, α, involves $g_f(g_f-1)/2$ restrictions on the parameters.

<u>Hypothesis testing</u>: It is useful to test various hypotheses concerning the estimated coefficients. These tests are based on the assumption that the error terms are normally distributed. If the errors are not normally distributed, then the tests will hold "approximately" for large samples, making use of the central limit theorem (see Judge *et al.*, 1988: 268-270).

A group of m linear hypotheses can be expressed as RB-r=0, where R is an m×k matrix of constants, B is the k×1 vector of parameters, and r is an m×1 vector of constants. For single-equation linear hypotheses in the context of single-equation OLS estimation, we can use the standard F test:

$$\frac{(R\hat{B}-r)'[R(X'X)^{-1}R']^{-1}(R\hat{B}-r)/m}{(\hat{e}'\hat{e})/(N-k)} \sim F_{(m,N-k)} \tag{4-16}$$

To test linear hypotheses in the SUR model of the demand system, we can use the following Wald test where the estimated covariance matrix, $\hat{C}$, is defined in equation 4-11:

$$(R\hat{B}-r)'(R\hat{C}R')^{-1}(R\hat{B}-r) \sim \chi^2_m \tag{4-17}$$

This expression is only *asymptotically* distributed as chi squared because the covariance matrix, C, is not known and must be estimated. Judge *et al.* (1988) recommend an extended F-test as being somewhat more cautious than the chi-squared test. It is similar to the single-equation F-test except that the numerator includes the cross-equation covariance matrix, Σ (within $\hat{C}$), and the denominator collapses to 1.0.

$$\frac{(R\hat{B}-r)'(R\hat{C}R')^{-1}(R\hat{B}-r)}{m} \sim F_{(m,Ng-gk^*)} \quad (4\text{-}18)$$

By defining the R matrix and the r vector appropriately, these tests can be used to test the single-equation null hypotheses presented in Table 4-1. Similarly, the cross-equation hypotheses in Table 4-2 can be tested in the context of the SUR model using the latter two tests.

Table 4-1: Single-equation hypotheses to be tested

Parameter restrictions	Number of restrictions	Explanation
$ß_{i1}=ß_{i2}=0$	2	Total household expenditure has no effect on budget share of good i
$ß_{i2}=0$	1	Budget share of good i is linear in log expenditure
$\gamma_{i1}=0$	g	Sex of head of household has no effect on the budget share for good i
$\alpha_{ij}=0$ for all j	g_f	Prices have no effect on the budget share for good i

Finally, in order to determine whether the SUR is appropriate for the unrestricted version of the model, we need to determine the statistical significance of the off-diagonal elements of Σ. The Breusch-Pagan test uses the fact that, under the null hypothesis that Σ is a diagonal matrix, the following asymptotic distribution is true:

$$N\sum_{i=2}^{g}\sum_{j=1}^{i-1}\frac{\sigma_{ij}^2}{\sigma_{ii}\sigma_{jj}} \sim X^2_{g(g-1)/2} \quad (4\text{-}19)$$

The test expression is the number of observation times the sum of cross-equation correlation coefficients for each pair of equations. If the value of this expression exceeds the appropriate critical value, the null hypothesis is rejected and the SUR model should be adopted.

Table 4-2: Cross-equation hypotheses to be tested

Parameter restrictions	Number of restrictions	Explanation
$\beta_{i1}=\beta_{i2}=0$ for all i	2g	Total expenditure has no effect on budget share of all goods
$\beta_{i2}=0$ for all i	g	Budget share is linear in log expenditure for all goods
$\gamma_{i1}=\gamma_{i2}=0$ for all i	2g	Household size has no effect on the budget share for all goods
$\gamma_{i1}=0$ for all i	g	Sex of head of household has no effect on budget share for all goods
$\alpha_{ij}=0$ for all i,j	g_f^2	Prices have no effect on the budget share for all goods
$\alpha_{ij} = \alpha_{ji}$ for all i,j	$(g_f^2-g_f)/2$	Hicksian (compensated) price effects are symmetric

4.3.4 Derivation of elasticities of demand

In the previous section, the methods for estimating the demand coefficients was discussed. In this section, the price and expenditure elasticities of demand are expressed in terms of these coefficients. The expenditure (income) elasticities and food price elasticities are calculated directly from estimated parameters. Non-food price elasticities are derived from the other elasticities and the assumption of additivity in preferences. Finally, the demand elasticities for the excluded category, "other food," are derived using the homogeneity and adding up from consumer theory. Each of these are discussed below.

Elasticity of demand with respect to expenditure: The elasticity of demand with respect to income (total expenditure) can be derived by noting that:

$$\ln(w_i) = \ln\left(\frac{p_i q_i}{x}\right) = \ln p_i + \ln q_i - \ln x \qquad (4\text{-}20)$$

Taking the partial of equation (4-20) with respect to ln x, we get:

$$\frac{\partial \ln w_i}{\partial \ln x} = \frac{\partial \ln p_i}{\partial \ln x} + \frac{\partial \ln q_i}{\partial \ln x} - \frac{\partial \ln x}{\partial \ln x} = 0 + \epsilon_i - 1 \qquad (4\text{-}21)$$

where ϵ_i is the income elasticity for good i. Rearranging terms and using equation (4-2), we obtain the expression for the income elasticity:

$$\epsilon_i = 1 + \frac{\partial \ln w_i}{\partial \ln x} = 1 + \frac{\partial w_i}{\partial \ln x}\frac{1}{w_i} = 1 + \frac{\beta_{i1}}{w_i} + \frac{2\beta_{i2}}{w_i}\ln\left(\frac{x}{P}\right) \qquad (4\text{-}22)$$

Since the expenditure elasticity varies with the budget share and the level of total expenditure, it is normally evaluated at the mean values of these variables.

<u>Elasticity of food demand with respect to prices</u>: The compensated (or Hicksian) elasticity of demand for good i with respect to the price of good j can be similarly derived. First, we take the partial of equation (4-20) with respect to p_j:

$$\frac{\partial \ln w_i}{\partial \ln p_j} = \frac{\partial \ln p_i}{\partial \ln p_j} + \frac{\partial \ln q_i}{\partial \ln p_j} - \frac{\partial \ln x}{\partial \ln p_j} = \delta + \epsilon_{ij}^{*} - \frac{\partial \ln x}{\partial \ln p_j} \qquad (4\text{-}23)$$

where δ is the Kroenecker delta (equal to 1 if i=j and 0 otherwise) and ϵ_{ij}^* is the compensated price elasticity of demand. The last term in equation (4-23) is not zero because nominal income (x) must change to compensate for the price change. Using the definition of Stone's index and the fact that real income (x/P) must remain constant:

$$0 = \frac{\partial \ln\left(\frac{x}{P}\right)}{\partial \ln p_j} = \frac{\partial \ln x}{\partial \ln p_j} - \frac{\partial \sum_{i=1}^{N} w_i \ln p_i}{\partial \ln p_j} = \frac{\partial \ln x}{\partial \ln p_j} - w_j \qquad (4\text{-}24)$$

Therefore,

$$\frac{\partial \ln x}{\partial \ln p_j} = w_j \qquad (4\text{-}25)$$

Solving equation (4-23) for ϵ_{ij}^* and substituting in equation (4-25), we get the following:

$$\epsilon_{ij}^{*} = \frac{\partial \ln w_i}{\partial \ln p_j} + w_j - \delta = \frac{\partial w_i}{\partial \ln p_j}\frac{1}{w_i} + w_j - \delta \tag{4-26}$$

Using the expression for w_i in equation (4-2):

$$\epsilon_{ij}^{*} = \frac{\alpha_{ij}}{w_i} + w_j - \delta \tag{4-27}$$

where δ is the Kroenecker delta. By substituting equations (4-22) and (4-27) into the Slutsky equation, we obtain the uncompensated (Marshallian) own-price elasticity:

$$\begin{aligned}\epsilon_{ii} = \epsilon_{ii}^{*} - w_i\epsilon_i &= \frac{\alpha_{ii}}{w_i} + w_i - 1 - w_i\left[1 + \frac{\beta_{i1}}{w_i} + \frac{2\beta_{i2}}{w_i}\ln\left(\frac{X}{P}\right)\right] \\ &= \frac{\alpha_{ii}}{w_i} - 1 - \beta_{i1} + 2\beta_{i2}\ln\left(\frac{X}{P}\right)\end{aligned} \tag{4-28}$$

The uncompensated cross-price elasticity is derived in a similar way:

$$\begin{aligned}\epsilon_{ij} = \epsilon_{ij}^{*} - w_j\epsilon_i &= \frac{\alpha_{ij}}{w_i} + w_j - w_j\left[1 + \frac{\beta_{i1}}{w_i} + \frac{2\beta_{i2}}{w_i}\ln\left(\frac{X}{P}\right)\right] \\ &= \frac{1}{w_i}\left[\alpha_{ij} - w_j\beta_{i1} - 2w_j\beta_{i2}\ln\left(\frac{X}{P}\right)\right]\end{aligned} \tag{4-29}$$

Green and Alston (1990) suggest that the above method for deriving the price elasticities is incorrect. Specifically, they argue that the partial of Stone's index with respect to p_j is not simply w_j, as shown in equation (4-24). Rather, it should also include the influence of p_j on w_j because the budget share is itself a function of prices. Because they view the price index and the budget share as functions of each other, Green and Alston hold that it is necessary to solve a system of simultaneous equations to derive the elasticities.

This argument appears to overlook the fact that the budget share in the Stone's price index is not a function of prices, but rather a constant base-period weight for averaging the prices in the index. Just as the base-period quantities in the (arithmetic) Laspeyre index do not change, so the base-period shares in the (geometric) Stone's index are constant. Indeed, a price index with variable weights would not be well-defined: if demand were sufficiently price elastic, price *increases* for a set of goods could reduce their budget shares enough to result in a *decrease* in the price index.

Derived non-food price elasticities: The price elasticities of non-food categories are approximated by assuming strong (or additive) separability both among non-food categories and between food and non-food categories. As discussed in section 3.3.1, strong separability implies the following relationship between income and price elasticities:

$$\epsilon_{ij} = \delta \, \phi \, \epsilon_i - \epsilon_i w_j (1 + \phi \epsilon_j) \tag{4-30}$$

where ϵ_{ij} = price elasticity of good i with respect to the price of j
δ = the Kronecker delta (equal to one if i=j and zero otherwise
ϕ = $-\mu/x$
ϵ_i = income elasticity of good i
w_i = budget share of good i

This implies a fixed relationship, which depends on the parameter ϕ, between the income and price elasticities of each strongly separable category[1]. Setting i=j, this equation can be solved for ϕ to get the following expression:

$$\phi = \frac{\epsilon_{ii} + \epsilon_i w_i}{\epsilon_i (1 - w_i \epsilon_i)} \tag{4-31}$$

Following the procedure used by Newberry (1987), we can obtain an estimate of ϕ using equation (4-31) with the estimated price and income elasticities of food. Then, this parameter and the non-food income elasticities can be combined in equation (4-30) to derive values for the non-food price elasticities under the assumption of strongly separable preferences.

---

1. Additive preferences imply symmetry among separable groups and price homogeneity of non-food demand equations.

<u>Derived coefficients for "other food"</u>: The coefficients for "other food" are derived by using some of the restrictions of consumer theory: adding up and homogeneity. Adding up requires that the budget shares add up to one. Given the functional form used in this study, adding-up is ensured when the sum of each coefficient across equations is zero. Thus, the expenditure and household composition coefficients of "other food" are each defined as minus the sum of the corresponding coefficients in the g modeled equations. From these coefficients, the elasticity of demand for "other food" with respect to household expenditure can be calculated (Phlip, 1983).

Homogeneity requires that a proportionate increase (or decrease) in all prices and incomes not affect the estimated budget shares. Such a change will affect equally the numerator and denominator of (x/P), leaving deflated expenditure unchanged. Thus, the only parameter restrictions necessary for homogeneity are on the price terms, α_{ij}. In particular,

$$\sum_{j=1}^{g} \alpha_{ij} = 0 \tag{4-32}$$

is necessary and sufficient for homogeneity.

The price terms associated with "other foods" are derived as follows. Starting with the homogeneity condition, we separate the coefficient representing the effect of the price of "other foods" on the demand for good i, α_{io}, and move the summation of the remaining terms to the right side:

$$\alpha_{io} = -\sum_{j=1}^{g-1} \alpha_{ij} \tag{4-33}$$

(the subscript o refers to "other foods"). The coefficients representing the effect of other prices on the demand for "other food" are obtained by assuming a limited symmetry: $\alpha_{oi}=\alpha_{io}$. Finally, the own-price term for "other foods" can be obtained by again applying homogeneity:

$$\alpha_{oo} = -\sum_{i=1}^{g-1} \alpha_{oi} \qquad (4\text{-}34)$$

It should be noted that the price parameters for "other food" can be derived only after all the other price parameters, both food and non-food, have been obtained.

4.3.5 Additional issues in demand estimation

In Chapter 3, two sources of bias in the estimation of household demand were discussed. In this section, we describe some methods to evaluate the importance of these problems in the context of the present model. The first topic is the potential bias of using unit values in place of true prices as independent variables. The second is the effect of zero-expenditures on the estimated income and price elasticities.

Quality and measurement error effects: Deaton (1987a, 1988) points out that the use of unit values (the value of a transaction divided by the number of units purchased) to estimate price elasticities may generate biased estimates of price and income elasticities. As discussed in section 3.3.3, the biases are caused by quality effects and measurement error. The correction methods devised by Deaton are complex and this is not the focus of the present study. Nonetheless, it is worth investigating the magnitude of these biases in the case of the Rwandan budget data.

The method suggested by Deaton relies on the assumption that true prices do not vary within the "cluster" of nearby households into which the samples of many household surveys are organized. First, measurement error effects can be detected by estimating the impact of "price" on demand within the cluster. Second, the income elasticity of quality can be estimated by regressing unit values on total expenditure within each cluster. These two tests can be implemented with the Rwandan ENBC data since it was collected using cluster sampling (there are 90 rural clusters of three households each and 35 urban clusters averaging 8.5 households each).

In order to look for "price" effects on demand within the cluster, the basic food demand equation is modified by replacing the constant term with a set of dummy variables, one for each cluster in the sample:

$$w_i = G + \beta_{i1}\ln\left(\frac{X}{P}\right) + \beta_{i2}\left[\ln\left(\frac{X}{P}\right)\right]^2 + \sum_{k=1}^{3}\gamma_{ik}Z_k + \sum_{j=1}^{gf}\alpha_{ij}\ln(p_j) + e_i \qquad (4\text{-}35)$$

where G = an Nxc matrix of c dummy variables, each one representing a cluster
c = the number of clusters

Because we are not interested in the numerous coefficients on the dummy variables, the estimation can be simplified by subtracting the cluster means from each variable. The "within cluster" estimates are obtained by:

$$\hat{B}_{wi} = (X'M_GX)^{-1}X'M_Gw_i \qquad (4\text{-}36)$$

where B_{wi} = a kx1 vector of "within" parameter estimates for food commodity i
M_G = an NxN matrix = $I_N - G(G'G)^{-1}G'$

As Deaton (1988: 420) explains:

> Since the model is supposedly one of spatial price variation, and the since price variation within clusters should be absent, the subtraction of the cluster means should make estimation of a price elasticity impossible.

Thus, the presence of measurement error effects is tested by the significance of the price coefficients in this regression.

The second test focuses on the quality effect. Since true prices are assumed constant within each cluster, any within-cluster relationship between unit value and the level of income (total expenditure) must be a reflection of quality differences. The following regression identifies this relationship:

$$\ln(p_i) = G + \beta_{i1}\ln\left(\frac{x}{P}\right) + \beta_{i2}\left[\ln\left(\frac{x}{P}\right)\right]^2 + \sum_{k=1}^{3}\gamma_{ik}Z_k + e_i \qquad (4\text{-}37)$$

where G = an Nxc matrix of dummy variables for the clusters
c = the number of clusters

The elasticity of quality with respect to income can be derived by taking the partial of unit values (p) with respect to income (x):

$$\frac{\partial \ln p_i}{\partial \ln x} = \beta_{i1} + 2\beta_{i2}\ln\left(\frac{x}{P}\right) \qquad (4\text{-}38)$$

The null hypothesis that the expenditure coefficients are zero (H_0: $\beta_{i1}=\beta_{i2}=0$) is equivalent to the hypothesis of no quality effects for good i. If a quality elasticity is significantly different than zero, we would expect it to be positive.

Zero-expenditure observations: For reasons discussed in section 3.3.3, a censored dependent variable model was not adopted for this study. Nonetheless, it is worth comparing the price and income elasticities derived from the standard linear regression model and those derived from a limited dependent variable model which explicitly incorporates zero-expenditures.

The Tobit model, discussed in section 3.3.3, is based on the following log likelihood function:

$$\ln L = \sum_{y=0}\ln\left[F(-x_i'B,\sigma^2)\right] + \sum_{y>0}\left[-\frac{1}{2}\ln\sigma^2 - \frac{1}{2\sigma^2}(y_i-x_i'B)^2\right] \qquad (4\text{-}39)$$

where $F(\cdot)$ = the cumulative normal distribution function
$x_i'B$ = the predicted value of the dependent variable (y) for observation i
y_i = the actual value of the dependent variable

The first summation is over observations where the dependent variable is zero, assuming that probability of such an observation is equal to the probability of the latent variable being negative. The second summation is over observations where the dependent variable takes a positive value and follows the form of a standard likelihood function.

Because the likelihood function is non-linear, it must be maximized using iterative techniques. The software package, LIMDEP, performs this non-linear maximization, generating estimates of the parameters, B, and their corresponding standard errors.

The coefficients of this model must be interpreted carefully since a change in an independent variable alters both the probability of the dependent variable being positive and the expected value conditional on its being positive. In order to derive the partial of y with respect to x_j, we start with the unconditional expected value of the i^{th} observation of dependent variable:

$$E(y_i) = F(x_i'\beta/\sigma)\,E(y_i \mid y>0) \tag{4-40}$$

The first term on the right side is the probability that y is positive, while the second is the expected value of y given that it is positive. Taking the derivative with respect to an independent variable, x_j, we get:

$$\frac{\partial E(y_i)}{\partial x_{ij}} = F(x_i'\beta/\sigma)\frac{\partial E(y_i \mid y>0)}{\partial x_{ij}} + E(y_i \mid y>0)\frac{\partial F(x_i'\beta/\sigma)}{\partial x_{ij}} \tag{4-41}$$

McDonald and Moffitt (1980) show that this can be expressed in terms of estimated parameters as follows:

$$\begin{aligned}\frac{\partial E(y_i)}{\partial x_j} &= F_i\beta\left(1-z_i\frac{f_i}{F_i}-\frac{f_i^2}{f_i^2}\right) + \left(x_{ij}'\beta + \sigma\frac{f_i}{F_i}\right)f_i\frac{\beta}{\sigma}\\ &= \beta\left[F\left(1-z_i\frac{f_i}{F_i}-\frac{f_i^2}{F_i^2}\right) + f_i\left(z_i + \frac{f_i}{F_i}\right)\right]\end{aligned} \tag{4-42}$$

where $F_i = F(z_i)$ = the cumulative normal density function evaluated at z_i
$f_i = f(z_i)$ = the normal density function evaluated at z_i
$z_i = x_i'ß/\sigma$

The standard income and price elasticities can thus be calculated by substituting this expression into the corresponding coefficients (ß and α) in the elasticity equations 4-22, 4-28, and 4-29. These elasticities can then be compared to the results obtained using the standard linear model.

4.4 Household as producer

As discussed in section 3.3.4, household-firm models incorporate the impact of agricultural price changes on household income, and thus on consumption and marketed output. This "profit effect" tends to dampen, or even make positive, the elasticity of food consumption with respect to own price. The elasticity of marketed output, although reduced, usually remains positive.

4.4.1 Effect of prices on income

In the household-firm model, prices affect the income level of the household. In section 3.4.1, it was shown that this effect can be calculated using first- or second-order approximations of producer surplus. These approximations may be considered the short- and long-term effects of prices on income, respectively, since the first-order approximation does not incorporate any change in output, as would be appropriate in the short term.

There are three practical complications in using these equations. First, the concept of "quantity" is not meaningful for many income categories such as "commerce" and "other artisanal activity." Fortunately, the expressions for the short- and long-run effect of prices on income can be rewritten in terms of values, the proportional change in price, and (for the long-run effect) the proportional change in output:

$$\Delta x = \sum_{i=1}^{N} q_i \Delta p_i = \sum_{i=1}^{N} q_i p_i \frac{\Delta p_i}{p_i} \tag{4-43}$$

$$\Delta x = \sum_{i=1}^{N} \frac{1}{2}(q_{0i}+q_{1i})\Delta p_i = \sum_{i=1}^{N} \frac{1}{2}\left[q_{0i}p_{0i}\left(1 + \frac{q_{1i}}{q_{0i}}\right)\right]\frac{\Delta p_i}{p_{0i}} \tag{4-44}$$

A second issue concerns the assumptions about business expenses. In this study, we assume these costs change in the same proportion as revenue (this is done by replacing gross revenue in these equations with net revenue). This may be somewhat unrealistic in the case of agriculture, although variable costs are relatively minor in this case, representing only 9% of the value of agricultural output (Ministère du Plan, 1988). This assumption is more realistic for commerce, a sector in which intermediate expenses are quite important.

The third issue is how to deal with imbalances between net income and total expenditure at the household level. Although income and expenditure are highly correlated, there are important differences due to saving and dissaving, transfers, and measurement error. Perhaps the most conservative approach is to assume that a given change in net income results in a change in expenditure of the same proportion.

Under these assumptions, the short-run effect of prices on income is simulated using the proportion of net income for each household obtained from each type of activity. This information is available from the ENBC data. Urban income was classified into 15 categories, while rural income was divided into 24 groups.

4.4.2 Supply response of agriculture

Simulating the long-run effect of prices on income requires data on the supply response, particularly for agricultural commodities. The ENBC data set is not appropriate for estimating agricultural supply elasticities because land, labor, and input use are not available at the level of individual crops.

In this study, we make use of agricultural price supply elasticities estimated for Rwanda by Ansoanuur (1991). The estimates are based on time-series data covering the period 1971-1989. Production data were assembled from the Ministry of Agriculture and the export marketing boards, while price information was obtained from Ministry of Planning sources. The double-log functional form was used in most cases, although the semi-log form was adopted in a few cases where it yielded a closer fit.

The dependent variable was the volume of production in most cases, although the number of trees was used in the coffee equation. The independent variables (expressed in log form) included the price of the commodity, the legal minimum wage deflated by the consumer price index, the real price of hoes, and the level of rainfall. In the case of coffee and tea, three years of lagged prices were added to reflect the lag between new planting and new production. The price of other crops was also added in the case of a few pairs of close substitutes (white potatoes and pyrethrum, bananas and coffee, and beans and sorghum).

There are a number of limitations of this approach to modeling the household as producer: 1) labor-leisure decisions are not explicitly modeled, 2) estimates are based on single-equation regressions using only a few prices, and 3) few of the estimated elasticities are significantly different from zero, perhaps reflecting the low quality of the original data.

On the other hand, the supply elasticities are well within the range of those estimated for the same crops in other less developed countries (see Askari and Cummings, 1976). Furthermore, the direct price effect on income, which is estimated more accurately, is likely to be more important than the output effect.

4.5 Price changes associated with devaluation

The next phase involves adopting some set of price changes associated with devaluation. This information is combined with the model of household behavior described in sections 4.3 and 4.4 to simulate the impact on household welfare and nutritional intake, as described in section 4.6. Both historical and hypothetical prices are used, each with their own advantages and limitations. Each is discussed in turn.

4.5.1 Historical price data

The historical prices are based on monthly data collected by the Ministry of Planning in the capital city of Kigali during the year before and the six months after the October 1990 devaluation. This data source has the obvious advantage of simulating the actual price trends in the country.

There are, however, several drawbacks to using these data. The most important complication is that an unsuccessful military invasion of the country took place in October 1990, making it difficult to isolate the effect of each event on prices. The invasion has resulted in significant security measures within the country and strained relations with neighboring countries, particularly Uganda and Burundi. The security measures have affected prices in various ways, particularly by impeding the internal flow of people and goods with checkpoints. The strained relations with Uganda have restricted trade between the two countries, as well as international trade which normally flows through Uganda to and from the coast.

A second problem is that only five months of post-devaluation price data from Kigali are available. A longer time series and a sample of rural prices would be desirable. To the extent that the proportional change in prices varied across the country, this simulation may be biased.

4.5.2 Hypothetical prices

The alternative approach is to adopt hypothetical prices according to *a priori* knowledge of the impact of devaluation and the nature of different goods and services in Rwanda. The literature on devaluation, reviewed in Chapter 3, focuses on the distinction between tradeable and non-tradeable goods. The rural component of the Rwandan household budget survey contains codes for 405 goods and services, while the urban component has codes for 825 goods and services. Each product was classified as tradeable or non-tradeable based on a judgement as to whether the price of the product is determined by international markets or by domestic demand and supply. Although the judgement is somewhat arbitrary, in most cases the appropriate choice was obvious.

Most of the staple food crops were considered non-tradeable because their low value/bulk ratio prevents any significant amount of international trade in these commodities. Export crops such as coffee, tea, and pyrethrum are obviously tradeable, as are imported foods such as rice, wheat flour, vegetable oil, and most processed items.

Beans represent perhaps an intermediate case. First, imports represent around half of all marketed volume but only 15% of domestic consumption. Second, beans are imported informally so that the price is partly a function of the parallel exchange rate. In this study, it is assumed that the price increase for beans is one quarter that of pure tradeables (see Appendix A).

All services were considered to be non-tradeable, while most manufactured goods were considered tradeable. Although a number of manufactured goods are produced in Rwanda, as described in Chapter 2, many of them compete directly or indirectly with imported products.

Since the demand analysis is done at a much more aggregated level, with only 17 to 20 food categories and nine non-food groups, it was necessary to aggregate the tradeable-nontradeable information to this level. The price change for a given category is set equal to the weighted average of the assumed price change of tradeables and non-tradeables, with the weights equal to the tradeable and non-tradeable components of the category.

The relationship between nominal devaluation and the relative price of tradeables and non-tradeables is studied by Edwards (1989). Using pooled time-series data for 12 less developed countries and a fixed-effect model, he estimates coefficients between 0.49 and 0.68, meaning that "with all other things as given, a nominal devaluation has been transferred in a less than one-to-one real devaluation in the first year" (p. 141). Using a different specification and 29 devaluation episodes, he obtains an estimate of 0.60 for the year after devaluation (p. 268). In this study, we will adopt the latter figure. Thus, the November 1991 increase of 67% in the Rwandan exchange rate (expressed in francs per US dollar) would result in a 40% increase in the relative price of tradables within a year of devaluation.

Although this study focuses on the effect of price changes associated with devaluation, the same methods could be used to simulate the effect of other hypothetical price changes. For example, changes in the administratively-set rates for water and electricity or variations in the price of individual food commodities could be modeled. Of course, the price changes would have to be at the level of aggregation of the budget categories used in the demand model.

4.6 Effect of price changes

At this point, we have described the methods for estimating a model of consumer demand, an approach for incorporating the effect of prices on income, and the use of both historical and hypothetical prices. In this section, we describe the methods for measuring the welfare impact and the nutritional impact of price changes on households.

4.6.1 Effect of price changes on demand

Because the functional form being used in this study does not have the property of exact aggregation, we cannot simulate the change in demand using a single demand equation of a representative household. Instead, the demand must be calculated for each household and then summed. For household h and good i, the quantity consumed can be written as follows:

$$q_{hi} = w_{hi}\left(\frac{x_h}{P}, p_h, z_h\right)\frac{x_h}{p_{hi}} \qquad (4\text{-}45)$$

where q_{ih} = quantity of good i consumed by household h
$w_{ih}(\cdot)$ = demand function describing budget share for good i and household h
x_h = total expenditure for household h
P = Stone's price index to deflate expenditure
p_h = gx1 vector of prices for household h
z_h = 3x1 vector of household characteristics for household h
p_{hi} = price of good i for household h

The quantities can then be summed over households for each good to obtain the aggregate quantities. Prices affect demand in three ways: 1) directly through the price vector, p_h, 2) indirectly through the price index, P, and 3) indirectly through total expenditure, x_h, since income is a function of the prices of output. These three types of influence represent the substitution effect, the income effect, and the profit effect, respectively.

4.6.2 Effect of price changes on nutrition

The impact of price and income changes on nutritional intake is calculated by combining simulated changes in food consumption with the nutritional coefficients for each category of food. This can be expressed as follows:

$$\Delta C_h = \sum_{i=1}^{g} c_i \, \Delta q_{hi} \qquad (4\text{-}46)$$

where Dc_h = change in caloric or protein intake for household h
c_i = coefficient relating the caloric or protein content per unit of good i
dq_{hi} = change in consumption of good i by household h

The precision of this method is related to the degree of disaggregation of the food categories. In this study, we use 17 food categories in the rural areas and 21 in the urban areas. Although the degree of disaggregation is quite high for a demand analysis, it does contain some heterogeneous categories such as "other meats" and "prepared meals."

A more finely disaggregated analysis of the Rwandan ENBC food consumption data was carried out using 180 food categories (see Ministère du Plan, 1988). Although the demand analysis cannot be carried out at this level of disaggregation, we can use these results to obtain average nutritional coefficients for the broader categories. Thus, the nutritional coefficient for "other meat" is based on a quantity-weighted average of 20 types of meat other than beef.

Once again, the nutritional impact is calculated for each household, based on the diet of that household, the sources of income, and the estimated food demand elasticities for that household. This allows us to make full use of the diversity of household behavior as reflected in the survey sample.

4.6.3 Effect of price changes on household welfare

In section 3.4, a number of approaches to measuring welfare impact were compared. In this study, we make use of seven measures: consumer surplus, three approximations of compensating variation, and three approximations of equivalent variations. They are summarized in Table 4-3.

The first-order approximation of compensating variation (CV_1) is the simplest and most commonly used welfare measure. It is the only measure which does not require any knowledge of the shape of the demand curve, relying entirely on the price and quantity data at the original position before the price change. The first-order approximation of the equivalent variation (EV_1) is similar, but it uses the "after" quantity rather than the "before" quantity. The expressions for CV_1 and EV_1 are given in equations 3-43. Graphically, these measures may be considered "rectangular" approximations of EV and CV, as shown in Figure 3-2.

Consumer surplus (CS) is approximated as a trapezoid, that is, as a second-order approximation of the "true" consumer surplus. Although

Table 4-3: Selected welfare measures

Symbol	Measure	Approximation method
CV_1	Compensating variation	First-order approximation
CV_2	Compensating variation	Second-order approximation
CV_n	Compensating variation	Vartia method (n iterations)
CS	Consumer surplus	Second-order approximation
EV_n	Equivalent variation	Vartia method (n iterations)
EV_2	Equivalent variation	Second-order approximation
EV_1	Equivalent variation	First-order approximation

this measure is not well-defined for multiple price and income changes, as discussed in the previous chapter, it is calculated in this study as a basis of comparison with the willingness-to-pay measures. Equation 3-34 is used to calculated consumer surplus.

The two second-order approximations (EV_2 and CV_2) are calculated using the Hicks method which involves a Taylor-series expansion of the expenditure function. The expressions for these two welfare measures are given in equations 3-44 and 3-45. Graphically, these may be thought of as "trapezoidal" approximations of CV and EV, as illustrated in Figure 3-3.

The Vartia approximation of compensating variation (CV_n) and equivalent variation (EV_n) involve an interactive procedure, as described in section 3.4.4, so it cannot be expressed as an equation. In this study, twenty iterations are used to calculate this welfare measure, although some experimentation is done with 50 iterations.

Each of these measures includes a term for the change in net income (or profit) due to changes in output prices. This term (Δx) can be calculated using short-term producer surplus or long-term producer surplus, given in equations 3-31 and 3-32 respectively. Because of uncertainty regarding the supply elasticities, most of the results are calculated using the short-term producer surplus which assumes no supply response. However, sensitivity analysis is used to explore the impact of incorporating supply response in the model.

Consumer surplus and the two "willingess-to-pay" measures are expressed in monetary terms, yet clearly the utility derived from one Rwandan franc is not the same across households. No attempt is made to measure or assume a relationship between the marginal utility of money and household income. Nonetheless, in order to incorporate, at least in a rough way, the idea that the marginal utility of money declines with income, the results are presented as a percentage of household expenditure.

For example, substituting equation 3-31 into 3-45, we can write CV_1 as a proportion of expenditure as follows:

$$\begin{aligned} \frac{CV_1}{x} &= \sum_{i=1}^{N} \frac{F_{0i}}{x} \Delta p_i - \sum_{i=1}^{N} \frac{q_{0i}}{x} \Delta p_i \\ &= \sum_{i=1}^{N} f_{0i} \frac{\Delta p_i}{p_i} - \sum_{i=1}^{N} w_{0i} \frac{\Delta p_i}{p_i} \end{aligned} \qquad (4\text{-}47)$$

where f_{0i} is the base-period share of net income from good i and w_{0i} is the base-period share of total expenditure allocated to good i[1]. This is the measure used by Sahn and Sarris (1991). As they note, this measure overestimates the welfare loss of consumer price increases and underestimates the welfare gain from output price increases because it does not incorporate household response to price changes.

Expressing the welfare impact as a percentage of household expenditure allows for an intuitively simply interpretation of the results. EV/x is the percentage change in real income equivalent to the price changes being simulated. Similarly, CV/x is the percentage of

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1. Strictly speaking, this interpretation requires the assumption that expenditure is equal to net income.

real income which would be necessary to compensate the household for the price changes.

Each of these welfare measures is calculated for each household in the sample, based on the sources of net income, the structure of consumption, and the demographic composition of the individual households. Only then are the welfare measures averaged over different groups of households defined by region, occupation, or income. In this way, the full diversity of households in the sample is exploited.

CHAPTER 5

HOUSEHOLD BUDGET PATTERNS IN RWANDA

In this chapter, the basic results of the National Household Budget and Consumption Survey (ENBC) are presented to provide context for the discussion in the chapters to follow. Section 5.1 reviews the characteristics of Rwandan households. In section 5.2, the composition of household income is described. Section 5.3 analyzes the level of total expenditure which is used as an indicator of household welfare and the composition of expenditure across different types of households. Finally, section 5.4 provides additional analysis of the agricultural economy of Rwanda.

5.1 Characteristics of Rwandan households

This sections presents a brief overview of the basic demographic characteristics of Rwandan households. For the purposes of the ENBC, the household is defined as a group of people, generally related, that live and eat together. Under this definition, semi-permanent "guests" and domestic employees are included in the household, but family members who live elsewhere are not.

The average household in Rwanda has 4.9 people, including 2.7 adults and 2.3 children, as shown in Table 5-1. The heads of household average somewhat less than 48 years of age, and about one fifth of the heads of household are female. These national averages are determined primarily by the rural sector, which accounts for about 95% of the total. It is useful to compare urban and rural households.

Urban households tend to be younger than rural households, as shown in Table 5-1. Less than a tenth of the urban heads of household are over 60 years of age, whereas almost a quarter of the rural heads of household are. As a consequence, urban households are more likely to be in the child-bearing years: 57% of the heads of household in the cities are 40 years or less in age, while only 36% of the rural heads are in this age group.

Table 5-1: Characteristics of rural and urban households

	Rural	Urban	Total
Avg age of head of household	48.2	40.4	47.8
Pct of households by age			
30 or under	16.8 %	29.3 %	17.4 %
31-40 years	19.3 %	27.3 %	19.7 %
41-50 years	22.1 %	22.4 %	22.1 %
51-60 years	17.3 %	12.1 %	17.2 %
Over 60 years	24.5 %	9.0 %	23.7 %
Total	100.0 %	100.0 %	100.0 %
Average size of household	4.9	5.6	4.9
Number of adults	2.7	2.4	2.7
Number of children	2.3	3.2	2.3
Pct households by size			
1-3 people	26.2 %	28.2 %	26.3 %
4 people	13.8 %	18.4 %	14.0 %
5 people	12.5 %	15.3 %	12.6 %
6 people	10.6 %	15.0 %	10.8 %
7 or more people	36.9 %	23.1 %	36.2 %
Total	100.0 %	100.0 %	100.0 %
Pct of households with female head of household	20.6 %	16.6 %	20.4 %

Source: Rwandan ENBC.

Urban households are also larger than rural households, on average. As shown in Table 5-1, this difference is due to the larger number of children in urban households. One explanation for this pattern is that a higher proportion of urban households are in child-bearing years, as discussed above. Another factor is that children and adolescents from rural households often migrate to the city, staying with relatives while attending school or looking for work.

Urban households are somewhat less likely to be female-headed. In both urban and rural areas, female heads of household are, on average, older and have smaller households than their male counterparts.

About 38% of urban female head are 40 years or under in age, and just 12% of rural female heads are in this age group. This may reflect the importance of widows among the female-headed households, particularly in the rural sector.

5.2 Composition of household income

5.2.1 Definition of net income

For the purposes of this study, net income is the value of production minus the value of business expenses. Production includes agricultural home production, cash sales of goods and services, goods and services "sold" through barter, and goods and services offered as transfers. The sale or transfer of household assets is excluded intentionally, while the value of non-agricultural home production is excluded for lack of data. Business expenses include the value of labor, raw materials, inputs, and land rental, whether purchased in cash or through barter. In the case of merchants, it also includes the goods purchased for resale. The purchase of vehicles, land, or commercial property is excluded from business expenses[1].

Net income is less suitable than total expenditure as an indicator of household welfare for three reasons. First, welfare is a function of material well-being (among other factors) and is thus more directly measured by expenditure than income. Second, net income is calculated as the difference between two estimated values (gross income and business expenses), so it is less accurately measured than expenditure. Third, households probably "smooth" expenditure relative to income by means of saving and dissaving. Seasonal smoothing implies that annual expenditure is more accurately measured than annual income, while year-

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1. These transactions would properly be included in a capital account category. However, because infrequent transactions are not well measured in this type of survey, no analysis of capital accounts was attempted.

to-year smoothing implies that expenditure is an estimate of "permanent income" as perceived by the household.

Given the fact that net income is less appropriate for measuring household welfare, household welfare and distributional issues will be discussed in the context of household expenditure in section 5.3. This section concentrates on the sources of income for Rwandan households.

5.2.2 Proportion of income from different activities

The agricultural sector, which includes both crop and animal production, is the most important source of net income in Rwanda. It represents 55% of the net income of Rwandan households, according to the ENBC data presented in Table 5-2. Of course, most of this production is in the rural areas, where agriculture represents 62% of net income, but agriculture exists on a small scale in the cities as well.

The importance of agriculture would be even greater under a broader definition. In Table 5-2, beer income is calculated by implicitly including the value of the raw materials (bananas and sorghum), when they are grown by the same household that brews the beer. Reclassifying this banana and sorghum production as agriculture would raise the share of agriculture to approximately 74% of rural net income (Ministry of Planning, 1988: Annex D).

Manufacturing and services includes the output of self-employed non-agricultural producers and service providers such as beer brewers, tailors, wood- and metal-workers, masons, mechanics, bar and restaurant owners, and truck drivers. The importance of this sector does not vary much between the rural and urban areas (24% and 30%, respectively), but these figures mask important differences in composition. In the countryside, beer brewing is the dominant activity within this sector. Banana beer alone accounts for over 60% of the value of rural manufacturing and services. In the cities, by contrast, beer brewing is a minor activity compared to construction, repair work, transportation,

Table 5-2: Sources of net income for rural and urban households

Source of income	Rural	Urban	Total
TOTAL	100.0 %	100.0 %	100 %
Agricultural production	62.1 %	5.3 %	55.1
Manufacturing and services	23.7 %	30.4 %	24.5
Beer brewing	17.5 %	2.3 %	15.6
Other	6.2 %	28.0 %	8.9
Commerce	5.4 %	20.4 %	7.3
Wage employment	8.7 %	44.0 %	13.1
Agricultural wages	4.0 %	0.7 %	3.6
Public sector	2.9 %	19.2 %	4.9
Other	1.8 %	24.0 %	4.6

Source: Rwandan ENBC.

food preparation, and wood working.

This pattern of locational specialization in manufacturing can be attributed, in part, to the geographic distribution of demand. As a result of higher urban income and the consequent larger shares allocated to non-food items, real non-food expenditure per household in the urban areas is 6.2 times higher than in the rural areas. According to the ENBC data, urban households represent just 5% of the population, but account for over a quarter of the non-food demand.

Another factor in the geographic distribution of manufacturing is that banana beer brewing is a weight-reducing process. On average, three kilograms of bananas are needed for one kilogram of banana beer. Thus, transportation costs are reduced by brewing the beer on the farm where the bananas are grown. Indeed, over 90% of the bananas used in rural beer production are grown by the brewer household.

By contrast, sorghum beer brewing is a weight-adding activity, with less than 100 grams of sorghum being needed for one kilogram of sorghum beer. This helps explain why only half of the sorghum used in rural sorghum beer production is grown by the brewer household. It also explains the fact that rural brewing activity is dominated by banana beer, while urban beer production is primarily in the form of sorghum beer (Ministry of Planning, 1988: Annex D).

Commerce refers to the purchase and resale of goods with little or no physical transformation of the product. This category includes the entrepreneurial income of all types of traders, from large-scale diversified importer-wholesalers to small-scale retailers without employees. As presented in Table 5-2, commerce is almost four times as important as a source of household income in the urban sector as in the rural sector. This is not surprising given the fact that much of rural production is not marketed. The level of commercial income as a proportion of the value of *cash* expenditures is similar in rural and urban sectors (15% and 21% respectively).

Wage income is defined as income earned on a per-hour or per-month basis. Table 5-2 demonstrates that this is an important source of income in the urban areas, representing 44% of the total. Somewhat more than half of urban wage income is earned through non-agricultural private sector employment, while public sector employment accounts for almost all the remainder. By contrast, wage income is much less important in the rural areas, contributing less than 9% of the total. Almost half of this take the form of agricultural wage labor.

5.2.3 Proportion of households by primary occupation

Another way to evaluate the importance of different sources of income is to look at the distribution of households according to the primary source of income, defined as that which contributes over 50% of household net income. Table 5-3 indicates that almost three-quarters of all Rwandan households derive most of their income from farming. In absolute terms, by this definition, there are approximately 800,000 farm households in Rwanda[1]. About 10% of Rwandan households are self-employed in manufacturing and services, while the remaining 16%

1. To fully appreciate the farming intensity in Rwanda, it is worth noting that by a similar definition there are approximately 600,000 farm households in the United States (Tweeten, 1989).

of the households are more or less equally divided among commerce, wage employment, and "diverse" (i.e. households for which no single source of income accounts for over half the total). Overall, about 88% of Rwandan households obtain at least half of their net income from self-employment.

Table 5-3: Distribution of households by primary occupation

Principal occupation	Rural	Urban	Total
TOTAL	100.0 %	100.0 %	100.0 %
Agriculture	76.9 %	14.0 %	73.7 %
Manufacturing and services	8.7 %	28.6 %	9.7 %
Commerce	3.7 %	11.5 %	4.1 %
Wage employment	4.4 %	35.3 %	5.9 %
Diverse	6.3 %	10.5 %	6.5 %

Source: Rwandan ENBC.

In the rural sector, 77% of the households depend primarily on agriculture to earn their living. Furthermore, the proportion would be even higher if the banana and sorghum production of brewers were counted as agriculture. Nonetheless, it is important to note that even in this semi-subsistence low-income rural economy, almost one quarter of the households derive most of their income from non-agricultural activities.

In the cities, wage employment is the most common primary occupation, but only 35% of the households fall into this category. This statistic highlights the danger of using wage rates as an indicator of well-being in Rwanda, even among the urban population. Furthermore, as discussed below, households whose primary source of income is wage income tend to have higher-than-average incomes. Over half (54%) of the urban households derive most of their income from self-employment in agriculture, manufacturing and services, and commerce. For the remaining 10% of the households, no one activity accounts for over half of net income.

5.2.4 Proportion of households involved in different activities

Having reviewed the distribution of households according to the primary source of income, it is useful to consider supplemental sources of income. Table 5-4 shows the proportion of households obtaining *any* income from each source. The ENBC data indicate that all the rural households and three-quarters of the urban households have some agricultural production. The latter figure may seem high, but it should be recalled that households with a garden, fruit trees, or a plot outside the city are included. Virtually all rural households and about half the urban household brew banana or sorghum beer, whether or not it is marketed. Although wage employment is a secondary source of income for most rural households, about 44% of them obtain some income from agricultural wage labor.

Table 5-4: Proportion of households earning any income from each source

Source of income	Rural	Urban	Total
Agricultural production	100.0 %	75.5 %	98.7 %
Manufacturing and services	97.7 %	83.2 %	97.0 %
Beer brewing	96.5 %	49.3 %	94.1 %
Other	42.3 %	70.4 %	43.7 %
Commerce	27.3 %	51.0 %	28.5 %
Wage employment	52.1 %	67.3 %	52.9 %
Agricultural wages	44.1 %	13.3 %	42.5 %
Public sector	5.0 %	24.6 %	6.0 %
Other	14.9 %	48.2 %	16.6 %

Source: Rwandan ENBC.

An index of the diversity of income sources is the sum of the percentages of households obtaining income from each source. If the list of sources is exclusive and exhaustive, this sum represents the average number of sources of income per household. Dividing the sources into five categories (agriculture, brewing, other manufacturing and services, commerce, and wage employment), the sum is over 300% in both urban and rural sectors. This means that Rwandan households, on average, obtain income from slightly more than three of these five income sources.

5.3 Composition of household expenditure

5.3.1 Definition of expenditure

For the present purposes, total expenditure is defined as the sum of cash consumption expenditures and the imputed value of agricultural home production, gifts received in kind, and goods received in barter transactions. Cash consumption expenditures includes current consumption expenditures (e.g. food) and expenditure on durables (e.g. household effects), but excludes purchases of vehicles, land, and buildings. It also excludes goods purchased to be used as gifts for other households to avoid double counting[1]. Non-agricultural home production was not recorded in the ENBC, although estimates derived from the Household Asset questionnaire indicate that this is negligible, even in the rural areas. The collection of firewood, on the other hand, may be a significant type of non-agricultural home production (see Ministère du Plan, 1988).

Household expenditures need to be adjusted for household size and composition in order to more accurately reflect the average standard of living in the household. For the present purposes, we use both expenditure per capita and expenditure per adult equivalent (ae), where the latter is defined on the basis of caloric requirements[2]. The

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1. In the rural areas, "product use" codes allowed the exclusion of goods purchased to be used as gifts. In the urban areas, the value of gifts given was subtracted from consumption expenditures for the appropriate budget category.

2. Each member of the household is assigned a value, based on age and gender, to reflect his or her caloric requirements as a fraction of those of an adult male. For example, a five-year-old girl

estimation of adult-equivalence scales based on the budget data is a more theoretically justifiable approach, but there is little agreement on the correct method (see Deaton and Case, 1988).

And finally, nominal figures need to be adjusted for the price level in each region. Price indices were calculated based on the prices recorded in the ENBC of 32 products, representing about 70% of the value of household expenditures nation-wide. A price index was calculated for each of the five geographic zones in the rural areas and each of the four urban centers. Kigali is used as the base region.

5.3.2 Average expenditure and size distribution

The average level of expenditure in Rwanda according to the ENBC is 13,422 Rwandan francs (FRw) per person per year at current prices (1983 for rural expenditure and 1985 for urban) or 18,670 FRw per capita at Kigali prices of 1985. Given the 1985 official exchange rate of 100 Frw per U.S. dollar, nominal expenditure is equivalent to $ 134 per capita. The World Bank estimate of 1982 per capita gross national product is $ 260 (World Bank, 1984). The difference is partly due to the fact that gross national product includes several categories excluded from this estimate, such as savings and government expenditure. One study compared over a dozen household budget surveys and found that survey estimates of income (or expenditure) were almost always lower that those of national accounts (Brown *et al.*, 1978).

As shown in Table 5-5, the level of real expenditure per capita is about 2.4 times higher in the urban areas than in the rural areas. When household size is measured using adult equivalents, the ratio is almost the same. The urban/rural ratio of real expenditure per capita (2.4) is considerably lower than that of nominal expenditure per household (almost 4.0) for two reasons. First, the average household size in the cities (5.6 persons) is greater than that in the country (4.9). Second,

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is given a value of 0.76 since her caloric needs are roughly three quarters those of an adult male (see Appendix A for the equivalence scale).

prices are about 50% higher in the urban areas, particularly those of domestically produced food. These results highlight the importance of adjusting for prices and household size when comparing urban and rural expenditure.

Table 5-5: Mean level of expenditure in rural and urban areas

	Rural average	Urban average	Urban/ rural ratio	National average
Nominal expenditure				
FRw/household/year	54,360	214,807	3.95	62,543
FRw/person/year	11,763	44,302	3.77	13,422
FRw/ae/year	13,095	49,026	3.74	14,934
Real expenditure				
FRw/household/year	80,245	210,706	2.63	86,923
FRw/person/year	17,396	42,285	2.43	18,670
FRw/ae/year	19,352	46,846	2.42	20,759

Note: "ae" refers to adult-equivalent, where the number of adult equivalents in the household reflects the caloric requirements of the household, based on the age and sex of its members

Source: Rwandan ENBC.

A brief examination of the distribution of expenditure among households demonstrates that the gap between the urban and rural averages is not just the result of a few high-income households in the urban areas. Table 5-6 shows, for example, that scarcely one quarter of the rural households reach the level of 20,000 FRw/person/year, whereas almost three quarters of the urban households exceed this level. Another illustration of the generally higher incomes in the cities is that 73% of the urban households have per capita expenditure levels above that of the national median (18,250 FRw/person/year).

According to various measures of concentration, expenditure is more concentrated in the urban areas than in the rural areas. For example, the poorest 20% of the rural households account for 14% of

Table 5-6: Cumulative distribution of households by expenditure level

Real expenditure (FRw/person/year)	Rural	Urban	National
5,000 - 9,999	13.9 %	4.6 %	13.4 %
10,000 - 14,999	51.7 %	12.9 %	49.9 %
15,000 - 19,999	72.4 %	26.3 %	70.0 %
20,000 - 24,999	82.9 %	39.4 %	81.9 %
25,000 - 29,999	90.0 %	49.0 %	87.9 %
30,000 - 34,999	95.2 %	56.0 %	93.2 %
35,000 - 39,999	97.9 %	63.3 %	96.1 %
40,000 and above	100.0 %	100.0 %	100.0 %

Source: Rwandan ENBC.

total expenditures in the rural areas, whereas the poorest 20% of the urban households represent just 7% of the urban total. Similarly, the Gini coefficient for the rural areas is 0.27, while the urban coefficient is 0.42.

Because the overwhelming majority (roughly 95%) of the Rwandan population is rural, the distribution of expenditure is largely determined by the rural patterns. Thus, the poorest 20% of the households in Rwanda, according to the ENBC, represent 13% of total household expenditures and the Gini coefficient is 0.29. This indicates that Rwanda has one of the least concentrated expenditure distributions in the world, albeit at one of the lowest levels of average expenditure (income) in the world.

5.3.3 Expenditure for different types of households

The level of per capita expenditure varies as a function of a number of household characteristics, most importantly occupation, size of household, and sex of head of household. The households in the ENBC were divided into different five occupations depending on the most important source of net income: agriculture, manufacturing and services, commerce, wage employment, and "diverse" (the last category was for households for which no one source represented at least 50% of the total).

In both urban and rural areas, the wage earners have the highest incomes and expenditures, as shown in Table 5-7. Although there are some day laborers and other low-income wage earners, most of the wage earners are teachers, civil servants, and other relatively well-paid occupations. Artisans and merchants tend to have expenditure levels close to the average of their regions. Although merchants are perceived in Rwanda as wealthy, the ENBC results imply that there are a large number of small-scale (lower-income) merchants. Farmers and "diversified earners" have the lowest level of expenditure and income. Although these patterns hold in both urban and rural areas, urban households have higher levels of expenditure within the same occupational category.

The level of per capita expenditure is also correlated with the size of household, as shown in Table 5-7. In both urban and rural areas, larger households have lower average per capita expenditure. Deaton and Case (1988) note that this pattern exists in most household budget surveys and caution against interpreting this as a sign that household welfare falls with larger families. First, there may be economies of scale in household size. Second, larger households usually have a larger proportion of children, for whom expenditure requirements are lower. This issue cannot be solved without more in-depth analysis, but it is worth noting that, if adult-equivalents are defined by caloric requirements, then expenditure per adult-equivalent also falls with larger households.

Third, the sex of the head of household is a determinant of expenditure per capita. As shown in Table 5-7, male-headed households in the urban areas have per capita expenditure levels substantially higher than those of female-headed households. Part of this is due to the fact that female-headed households in the urban areas tend to be involved in less remunerative occupations, such as farming and small-scale commerce. This in turn could be the result of lower education and

Table 5-7: Real expenditure of different types of households

	Real expenditure (Frw/person/year)		
	Rural average	Urban average	National average
Principal occupation			
Agriculture	16,491	19,740	16,523
Manuf./services	20,583	46,208	24,443
Commerce	18,251	37,994	21,073
Wage employment	24,668	53,509	33,444
Diverse	18,517	28,691	19,363
Household size			
1-3 members	21,742	56,356	23,393
4 members	17,250	46,820	18,399
5 members	16,193	38,375	17,133
6 members	14,930	36,912	15,737
Over 6 members	14,597	33,465	16,095
Sex of head of hh			
Male	17,247	44,888	18,729
Female	17,967	29,243	18,437
Overall mean	17,396	42,285	18,670

Note: Expenditure is evaluated at 1985 Kigali prices.

Source: Rwandan ENBC.

literacy levels, limited access to credit, discrimination by employers, and/or social norms against participation in some occupations.

Interestingly, there is no gap between the expenditure levels of male- and female-headed households in the rural areas. Perhaps this is because, although rural women probably face the same problems as urban women, education, credit, and discrimination are less constraining in farming, which is the predominant activity in the rural sector[1].

5.3.4 Composition of expenditure

Household expenditures in Rwanda are dominated by food, particularly tubers, plantains, and beans. Nationwide, over three quarters of household expenditures (including the value of home

1. The use of purchased inputs, and hence the need for credit, is very limited in Rwanda. Expenditure on all agricultural inputs including labor is only 8% of the gross value of crop production.

production) are devoted to food products, as shown in Table 5-8. Tubers and bananas represent fully one quarter of expenditures, while legumes (primarily beans) account for almost one fifth. The next most important category is beverages, primarily traditional beers, which account for 15% of the value of expenditure. Animal products and grains, by contrast, are relatively minor items in the Rwandan budget, representing about 7% and 4% respectively. Only 22% of expenditure is allocated to non-food categories, the most important of which are housing (8%) and clothing (5%).

Table 5-8: Composition of expenditure in rural and urban areas

Expenditure category	Rural	Urban	National
Total	100.0	100.0	100.0
Food	80.7	54.2	77.4
Grains	3.4	5.0	3.6
Tubers and plantains	27.2	12.6	25.4
Legumes	21.3	6.9	19.5
Fruits and vegetables	3.4	3.1	3.3
Meat, eggs, and dairy	6.7	8.5	6.9
Beverages	15.9	11.2	15.4
Other	2.7	6.9	3.3
Non-food	19.3	45.9	22.6
Clothing	5.0	4.9	5.0
Housing	7.1	14.3	8.0
Household equipment	1.9	3.9	2.1
Energy and water	1.0	5.7	1.6
Health and hygiene	1.6	3.4	1.8
Education	0.5	1.4	0.6
Transportation	1.1	7.8	1.9
Tobacco	0.6	1.1	0.7
Leisure and services	0.5	3.3	0.8

Source: Rwandan ENBC.

Naturally, the composition of expenditure varies sharply between urban and rural areas. In the urban areas, barely one half (54%) of expenditures are allocated to food, whereas over four fifths (81%) of rural expenditures are on food. This difference is almost entirely due to the significantly larger shares of the rural budget allocated to tubers, bananas, and legumes. These food categories account for 48% of the rural budget, but less than 20% of the urban budget. In contrast, the urban households allocate a larger share of their expenditures to housing, transportation, and energy and water than do rural households.

In interpreting these figures, it is important to recall that real per capita expenditure is about 2.4 times greater among urban households than among rural households. Thus, even when the urban budget *share* is smaller than the rural share, the absolute *level* of expenditure on a given item is often higher in the urban areas. For example, the only category for which rural households spend more in absolute terms than urban households is legumes.

5.4 Agriculture in the rural sector

5.4.1 Land

Given the overwhelming importance of agriculture in Rwanda and the high population density, access to arable land is obviously an important factor in the well-being of rural households. Data on the farm size is available for the rural sample of the ENBC[1]. These data indicate that the average farm size in the ENBC sample was 1.28 hectares. Almost 60% of the households in the sample had less than one hectare. Furthermore, the situation today is undoubtedly worse: in the decade since these measurements were made, the population of Rwanda has probably grown by roughly 40%.

The Gini coefficient of the distribution of land in the rural sector of Rwanda is 0.48. This coefficient means that the degree of concentration of land ownership in Rwanda is somewhat above the African average, but far below that of most Latin American countries. In more

1. In 1982, the pilot survey of the Agricultural Census measured land area for 450 rural households. The following year, a subsample of 270 households was used for the rural portion of the ENBC. However, no land area information is available for four of the households in the rural ENBC sample. Thus, the farm size figures presented here are based on the remaining 266 rural households.

concrete terms, 52% of the farm land is farmed by one fifth of the rural households.

Surprisingly, there no clear positive relationship between total farm size and household well-being, whether the latter is measured in caloric intake or expenditure per adult equivalent. Table 5-9 shows that the relationship is, if anything, curvilinear, with the smallest and largest farms being better off.

Table 5-9: Rural expenditure and caloric intake by farm size

Farm size (hectares)	Real expenditure (FRw/person/yr)	Caloric intake (kcal/ae/day)
Under 0.38	17,898	2,546
0.38 to 0.65	16,808	2,455
0.66 to 1.07	15,955	2,351
1.08 to 1.90	18,923	2,309
Over 1.90	17,832	2,573

Note: Farm size categories represent quintiles (each contains 20% of the rural households).

Source: Rwandan ENBC/Rural sector.

Three factors can be cited to explain this result. First, part of the variability in farm size is due to life-cycle patterns. Average farm size increases and then decreases with the age of the head of household, tracking the growth and later decline of household size, as shown in Table 5-10. In other words, land ownership *per capita* is somewhat more equal than land ownership per household. The Gini coefficient for farm size per adult equivalent is 0.45, compared to 0.48 for total farm size.

Table 5-10: Life cycle patterns in farm size in the rural sector

Age of head of household (years)	Average size of household	Average size of farm (hectares)
Under 30 years	3.9	0.7
31-40 years	5.4	1.5
41-50 years	6.0	1.4
51-60 years	5.8	1.7
Over 60 years	3.7	1.1

Source: Rwandan ENBC/Rural sector.

Second, the land is more intensively cultivated on small farms. Although net agricultural income[1] per *household* rises with farm size, it does not increase proportionately. As shown in Table 5-11, the agricultural return per *hectare* is over six times as great on the smallest 20% of farms compared to the largest 20%. Much of the reason for this is related to soil fertility, which is probably inversely related to farm size. Average farm size is the greatest in the drier and less fertile eastern lowlands and the lowest in the fertile volcanic zones to the northwest. In addition, small farms tend to have more family labor per hectare of farmland (see Table 5-11). Thus, they are able to plant more labor-intensive crops and use more labor-intensive techniques to increase return to the scarce factor, land.

A third factor which reduces the importance of unequal land distribution is the fact that small farms rely more heavily on non-agricultural income. The last column in Table 5-11 indicates that the

1. Net agricultural income is the value of agricultural production (including home production) minus agricultural operating expenses, such as seed, hoes, chemicals, and hired labor.

Table 5-11: Factors which ameliorate the disparity in farm size

Farm size (hectares)	Avg size household (persons)	Persons per hectare	Ag return per hect (Frw/ha)	Pct income from non-ag source
Under 0.38	3.6	17.5	104,731	35.5 %
0.38 to 0.65	4.6	9.6	56,631	19.6 %
0.66 to 1.07	4.8	5.9	39,634	23.8 %
1.08 to 1.90	5.6	3.9	26,584	17.6 %
Over 1.90	6.2	2.1	17,126	9.6 %

Note: Farm size categories represent quintiles.

Source: Rwandan ENBC/Rural sector.

importance of income *other* than from agriculture and beer brewing[1] increases from less than 10% among the largest 20% of farms to over 35% among the smallest 20% of farms. It seems likely that farm size and non-agricultural income influence each other: small farmers are forced to supplement their income with non-farm activities *and* households with non-farm income are more likely to sell farm land they cannot adequately tend.

Although total farm size is not related to household welfare, farm size per adult equivalent is positively related to welfare. As shown in the first pair of columns in Table 5-12, the mean expenditure level of the rural quintile under the least land pressure is 33% higher than that of the rural quintile under the greatest land pressure. Similarly, the mean caloric intake of the first group of households is 24% higher than that of the second.

If we restrict our attention to rural households which obtain at least half of their net income from agriculture and beer brewing, then the relationship between farm size per adult equivalent and household welfare becomes stronger. This is particularly true if we use caloric

1. Since virtually all banana beer producers grow their own bananas, beer brewing is closely linked to banana production and thus to the availability of land.

Table 5-12: Rural expenditure and caloric intake by farm size

Farm size per adult equivalent (hect/ae)	Among rural households		Among rural agricultural households	
	Real expenditure (FRw/person/ year)	Caloric intake (kcal/ae/ day)	Real expenditure (FRw/person /year)	Caloric intake (kcal/ae/ day)
Under 0.10	15,725	2,230	14,538	2,151
0.11 to 0.18	16,089	2,352	15,568	2,319
0.19 to 0.27	17,209	2,594	17,025	2,596
0.28 to 0.47	18,194	2,389	17,173	2,398
Over 0.47	20,997	2,772	20,267	2,802

Note: Farm size categories represent quintiles. "Agricultural" households are those that obtain at least 50% of net income from agriculture and beer brewing.

Source: Rwandan ENBC/Rural sector.

intake as the welfare indicator. One implication is that the situation of agricultural households under the greatest land pressure is especially acute, as shown in second pair of columns in Table 5-12.

In summary, there is no relationship between total farm size and household welfare because 1) small farms tend to be operated by small households, 2) small farms have a higher economic return per hectare, and 3) small farms rely more on non-farm income. On the other hand, there is a positive relationship between farm size per adult equivalent and welfare, particularly for households which rely primarily on agriculture for their income.

5.4.2 Purchased inputs

Purchased inputs, as defined here, refer to goods and services bought, either in cash or through barter, for agricultural production (including livestock production). This category includes seeds, hoes, agricultural chemicals, agricultural labor, livestock[1],

1. Livestock were counted as a purchased input only when the household appeared to have a regular business of buying animals to fatten them for resale.

and rental of land. Although the vast majority of rural households (92%) purchase agricultural inputs, the value of these purchases is equivalent to only 9% of the value of agricultural production. This represents about US$ 34 per household per year.

Of the amount spent on purchased inputs, the largest share (40%) goes toward hired labor[1]. This is equivalent to about 17 days of hired labor per rural household per year. Since less than half the rural households (44%) hire labor, the average number of days of hired labor among those households is greater, about 39 days. Slightly less than half of rural households (46%) had members who worked as agricultural laborers for someone else.

Livestock purchases are the second largest component, representing about 19% of the value of purchased inputs. The remaining 41% is split more or less evenly among seeds and planting material, hoes and chemicals, and land rental. In spite of the land pressure in Rwanda, less than one quarter of the rural households purchase manure, fertilizer, or other chemicals. The average expenditure among users is roughly US$ 6 per year.

5.4.3 <u>Agricultural production and marketing</u>

As described in section 5.2, agriculture represents 62% of net income in the rural sector, and 77% of rural households earn over half their net income from crop and livestock production. Table 5-13 shows the percentage contribution of each commodity to the gross value of agricultural production[2]. According to the ENBC data, the most important crops in terms of the value of production are bananas, beans, sweet potatoes, cassava, and white potatoes. It is interesting to note

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1. This category also includes payment for specialist services such as veterinarians, but this component is negligible.

2. It is "gross" in the sense that the cost of purchased inputs has not been subtracted. The contribution of each commodity to *net* income cannot be calculated because the ENBC data do not allow the input costs to be allocated among different crops.

that coffee, the predominant export commodity in Rwanda, is not among the top five crops.

Table 5-13: Composition of agricultural production and sales

Commodity	Pct of value of agricultural production	Pct of value of agricultural sales
Sorghum	4.4	6.5
Cassava	7.0	4.8
Sweet potatoes	12.7	3.8
White potatoes	6.2	7.9
Bananas	21.9	7.7
Beans	20.4	5.0
Fruits and vegetables	4.2	2.7
Coffee	4.3	21.7
Livestock	11.6	29.3
Other	7.3	10.6
TOTAL	100.0	100.0

Source: Rwandan ENBC/Rural sector.

However, most of the agricultural output is retained on the farm for own-consumption. In value terms, more than three quarters (76%) of agricultural output is not marketed (the importance of home production is discussed further in section 5.5.1). The composition of agricultural sales is quite different, as shown in the second column in Table 5-13. Coffee and livestock alone account for one half of the value of agricultural sales by Rwandan households. Bananas, beans, and sweet potatoes, which represent 55% of the value of agricultural output, account for barely 16% of the cash revenue from agriculture. At the same time, it is worth pointing out that "food crops" as a whole contribute almost half of agricultural cash income, while "cash crops" barely account for one quarter.

The proportion of the staple food production which is marketed varies considerably from one commodity to another, as shown in Table 5-14. Less than 10% of the sweet potatoes, bananas, and beans produced in

Rwanda reach the market. The marketed shares of sorghum, cassava, white potatoes, and fruits and vegetables are greater but still less than one third of production.

Table 5-14: Agricultural production and marketed share

Commodity	Production (kg/hh/yr)	Pct of output which is sold
Sorghum	125.8	31.0
Cassava	306.3	20.5
Sweet potatoes	888.3	7.8
White potatoes	271.6	31.1
Bananas	1590.8	0.8
Beans	361.1	6.3
Fruits and vegetables	102.1	15.2
Coffee	16.8	100.0
Livestock	77.7	40.8

Source: Rwandan ENBC/Rural sector.

Concerning sorghum and bananas, it should be noted that a portion of the "non-marketed" output is used by the same household to manufacture traditional beer, which may in turn be sold. Based on the volume of beer production, it appears that around 1,150 kilograms of bananas per household per year may be used directly in beer brewing by the producer. Roughly two thirds of the banana beer is marketed. Similarly, about 75 kilograms of sorghum per household per year are used to manufacture traditional beer by the grower. Slightly over half the sorghum beer production is sold.

5.5 Effect of price changes on households

In this section, we begin to examine the impact on households of the price changes associated with devaluation. Although a more rigorous model of household-level impact is developed in Chapter 7, the descriptive statistics presented in this section will facilitate the interpretation of the results of that chapter.

The effect on a given household of a price changes associated with devaluation can be crudely measured by considering the proportionate change in price, the composition of expenditure, and the sources of income. This type of analysis does not incorporate the effect of the adjustment of households as consumers and as producers, but it may serve as a first-round approximation. Thus, the absolute impact of a price increase of a given commodity would be the proportionate change in price times the difference between the value of production of that good and the value of consumption of the good[1]. Of course, in subtracting the value of consumption (including home production) from the value of production (including home production), the result is the net cash sales of the good. The *relative* impact of the price increase can be approximated by the net cash sales as a proportion of total expenditure (including home production).

This discussion suggests that the effect of price changes associated with devaluation on a given household depends on 1) the level of participation in the market economy, 2) the net sales position of the household with respect to agricultural commodities, and 3) the tradeable component of cash expenditure and cash income. Each of these topics is explored in the following subsections.

5.5.1 Participation in the market

The portion of total expenditure which is in the form of purchases (both cash and barter) clearly influences the vulnerability of the household to price changes. In other words, the larger the home produced component of expenditure (income), the more insulated the household is from fluctuations in prices[2].

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1. This is the first-order estimate of compensating variation, i.e. the amount by which nominal income would have to be increased to restore the initial level of utility if (compensated) demand were completely inelastic (see equation 4-47).

2. The appropriate treatment for gifts and other transfers is not clear. In this section, we have included the value of transfers received with home production, since both are non-market acquisitions.

The first column of Table 5-15 indicates that, not surprisingly, home production represents a much larger share of rural food consumption than urban. Rural households produce over three quarters of their own food, as measured in terms of monetary value. The rate of food self-sufficiency in the urban sector is barely 20%, although this seems fairly high compared to the conventional view of urban life.

Table 5-15: Importance of cash expenditure in rural and urban sectors

Sector	Home production as a pct of food expenditure	Food consumption as a pct of total expenditure	Home production as a pct of total expenditure	Cash purchases as a pct of total expenditure
Rural	75.9	83.7	64.8	35.2
Urban	21.2	66.7	16.9	83.1
Rwanda	73.1	82.8	62.4	37.6

Source: Rwandan ENBC.

The second column provides the mean share of total expenditure allocated to food consumption. The food share is, of course, higher in the rural areas, reflecting Engle's Law and the lower levels of expenditure in the countryside. Food represents five sixths of the average rural budget, but only two thirds of the average urban budget.

The product of these two ratios at the household level is the share of home-produced food in total expenditure, the average of which is presented in the third column of Table 5-15. Since data on non-food home production are not available from the survey data, this is our measure of the overall importance of home production. The portion of total expenditure in the form of cash purchases is thus one minus the home production share, as shown in the fourth column. Thus, purchases represent 35% of the expenditure of an average rural household and 83% of the expenditure of an average urban household.

The same information is disaggregated by expenditure quintile in Table 5-16. This table demonstrates that the role of home production in food consumption declines as income (expenditure per adult equivalent) rises. Similarly, the food share in the budget falls from 87% in the poorest fifth of households to 63% in the richest. These two factors together explain the sharp drop in the importance of home production from 62% of the budget in the first quintile to 19% in the fifth. Examined from another perspective, the importance of market purchases rises from somewhat more than one third to over four fifths of the total expenditure.

Table 5-16: Importance of cash expenditure by expenditure quintile

Expenditure quintile	Home production as a pct of food expenditure	Food consumption as a pct of total expenditure	Home production as a pct of total expenditure	Cash purchases as a pct of total expenditure
1st	70.1	87.4	62.5	37.5
2nd	68.2	84.2	58.6	41.4
3rd	62.5	82.0	53.2	46.8
4th	55.8	80.0	46.8	53.2
5th	24.5	63.2	18.9	81.1
Rwanda	73.1	82.8	62.4	37.6

Source: Rwandan ENBC.

The largest change in Table 5-16 occurs between the fourth and fifth quintiles. This raises the question as to whether the observed decline in the importance of home production is simply the result of urban households being clustered in the fifth quintile or whether this pattern exists separately in rural and urban sectors. In order to address this issue, Table 5-17 disaggregates the variables by rural quintile and urban quintile.

Table 5-17 reveals that the rate of food self-sufficiency does not vary appreciably across expenditure quintiles within the rural sector. In other words, relatively better off households in the rural sector are no more food self-sufficient than their poorer neighbors, nor do they depend any more on market purchases to obtain food. At the same time, the value of food consumption as a percentage of total expenditure does decrease as income rises, although the decline is fairly modest. The food share falls from 86% among the richest quintile to 80% in the poorest.

Combining these two patterns, the share of home production in total expenditure declines gradually across expenditure quintiles. The importance of market purchases correspondingly rises from 32% among the poorest rural households to 38% among the richest.

Table 5-17: Importance of cash expenditure by rural and urban expenditure quintiles

Expenditure quintile	Home production as a pct of food expenditure	Food consumption as a pct of total expenditure	Home production as a pct of total expenditure	Cash purchases as a pct of total expenditure
Rural sector				
1st	77.1	86.0	67.8	32.2
2nd	74.8	85.3	64.3	35.7
3rd	77.4	83.7	65.9	34.1
4th	75.1	83.1	63.5	36.5
5th	74.9	80.0	62.0	38.0
Urban sector				
1st	38.0	80.7	32.4	67.6
2nd	24.2	73.2	19.5	80.5
3rd	18.3	66.0	13.7	86.3
4th	14.3	59.3	11.5	88.5
5th	9.6	53.7	6.2	93.8

Source: Rwandan ENBC.

Turning our attention to the urban section, it is important to recall that the quintiles are defined relative to the income distribution in each sector. For example, 60% of the urban households would qualify to be in the fifth rural quintile. Similarly, over half the rural households would be classified in the poorest urban quintile (see Table 5-6).

According to Table 5-17, the patterns in the urban sector are much more marked than those in the rural sector. The importance of home production in food consumption drops sharply across expenditure quintiles, from 38% for the poorest fifth of urban households to under 10% for the richest. Likewise, food shares fall from almost 81% to 54%. As a result, the share of market purchases in total expenditure rises from two thirds among the poorest urban households to almost 94% among the richest.

In summary, the importance of market purchases in total expenditure is positively related to the level of expenditure per adult equivalent. Furthermore, this pattern exists in both rural and urban areas. In the rural sector, the pattern is weak and is determined solely by the falling food share. In the cities, the pattern is strong and is determined by both a falling food share and falling food self-sufficiency as expenditure rises. As a result of these patterns, we can expect a given price change to have an effect on urban households at least twice as great as that on rural households. Furthermore, other things being equal, the impact will be fairly similar across rural households, but it will vary considerably among urban households.

5.5.2 Net position in agricultural commodities

Even if two households have the same proportion of expenditure in the form of home production, the impact of a given price change will vary depending on the degree to which the households are net sellers (or net buyers) of the good in question. Until recently, it was generally believed that rural households benefited from higher agricultural prices, with the possible exception of landless households that rely on wage-labor. However, recent research in Senegal (Goetz, 1990), Mali (Dioné, 1989), and Rwanda (Loveridge, 1989) indicated that significant numbers of farmers are net buyers of staple crops (this research is summarized in Weber *et al*, 1988). This unexpected diversity in the rural sector indicates the need for more careful consideration of the net sales position of rural households. In particular, the welfare impact of various types of agricultural policy depends greatly on the distribution of households by their net sales position in different commodities. This applies to agricultural price policy, agricultural research priorities, and trade policy (including devaluation), among others.

In the case of Rwanda, Loveridge (1989) found that 73% of Rwandan farmers were net buyers of beans and that 6% of the farmers accounted for over half of the net sales. Net buyers of beans depended more heavily on coffee and tea sales than net sellers. Furthermore, based on the imbalance between purchases and sales, he estimated that 15% of the national consumption of beans (and 60% of purchases) must have been imported. The survey data also indicated the existence of informal imports of sorghum. These conclusions were based on agricultural surveys of some 1000 farm households in 1985-86.

Although the ENBC data set is older (1983) and based on a smaller sample (270 households) than that used by Loveridge, the breadth of the ENBC survey allows it to address some additional issues. In this section, we examine the net sales position for six principal crops, the degree of correlation in net position across crops, and the relationship between net sales and standard of living.

Average net sales in the rural sector: Table 5-18 presents information on rural production, marketing, and consumption for seven crops, expressed in kilograms per rural household per year (kg/hh/yr). These results support the finding of Loveridge (1989) that rural purchases exceed sales for beans and sorghum. The ENBC figures imply that bean imports represent 10% of rural consumption and 64% of rural market purchases, estimates generally in line with those of Loveridge. In the case of sorghum, the calculation is complicated by the fact that a large portion of sorghum output is used in beer production, frequently by the same household. Based on ENBC estimates of traditional beer output and accepted transformation coefficients, self-supplied sorghum for beer brewing represents 75 kg/hh/yr on average (see Ministry of Planning, 1988, Appendix D). Taking this into account, apparent imports are 19% of rural usage (including that for beer brewing) and 43% of market purchases.

Table 5-18: Rural production, marketing, and consumption of six crops

Commodity	Production (kg/hh/yr)	Consumption of own production (kg/hh/yr)	Sales (kg/hh/yr)	Purchases (kg/hh/yr)	Net sales (kg/hh/yr)	Consumption (kg/hh/yr)
Sorghum	121	8	38	67	-29	150
Manioc	298	236	62	30	32	266
Sweet pot.	854	790	64	48	16	838
White pot.	260	177	83	24	59	201
Banana	1691	520	115	77	38	1653
Beans	354	333	21	59	-38	392
Coffee	17	0	17	0	17	0

Note: Production is the sum of home production and sales. Consumption is the sum of home production and purchases. In the case of sorghum and banana, both production and consumption figures include the amounts used by the grower in the manufacture of traditional beer. This represents an estimated 1056 kg of bananas and 75 kg of sorghum per household per year. No allowance for self-stored seed is made in these calculations.

Source: Rwandan ENBC/Rural sector.

In contrast, rural sales of the other staple food crops exceed rural purchases, according to the ENBC data. The surpluses (positive net sales) range from 16 to 59 kg/hh/year, depending on the crop. In order to assess the hypothesis that these surpluses are the volumes shipped to the urban areas of Rwanda, Table 5-19 presents the estimated rural surpluses (net sales) and urban market demand, both expressed in total tonnage. These figures are based on the extrapolation of ENBC figures to the national level.

Table 5-19: Rural net sales and urban demand

Commodity	Rural mkt demand (1000 mt)	Rural surplus (1000 mt)	Urban mkt demand (1000 mt)	National surplus as % of cons.
Sorghum	69.4	-30.1	8.5	-23 %
Cassava	31.2	33.2	10.2	8 %
Sweet potatoes	49.9	16.6	7.3	1 %
White potatoes	24.8	61.2	37.2	10 %
Bananas	80.0	39.4	11.8	2 %
Beans	61.6	-39.4	9.6	-12 %

Source: Rwandan ENBC.

The national surplus (rural surplus minus urban market demand) is under 10% of national consumption for manioc, sweet potatoes, and bananas[1]. This is probably within the margin of error for these estimates. In the case of white potatoes, the results may indicate exports to neighboring countries. This result confirms the conclusions of Ngirumwami (1989) who found frequent references to potato exports in interviews with Rwandan traders (see also Scott, 1988: 77).

Table 5-19 also illustrates the fact that the bulk of the *market* demand for the basic staple crops is by rural households. It is often assumed that, because rural households rely on the market for only a small portion of their food consumption, agricultural sales must be destined for urban markets. For all the basic staples except white potatoes, rural market demand is three to eight times are great as urban demand. Thus, the principal agricultural marketing channels are rural-rural, with only relatively small volumes being siphoned off to meet urban demand.

1. These calculations do not take into account agricultural sales by urban households. The value of urban agricultural sales indicates that the total volume for all crops is probably around six thousand metric tons.

White potatoes are the exception in that the cities account for 60% of the national market demand. This is related to the fact that white potatoes are a relatively expensive source of calories and are actually a "luxury" good in the rural sector (see Tables 6-4 and 6-5).

Distribution of households by net sales: Until now, the discussion has been confined to the net sales of different commodities for the "average" household. In this section, we explore the distribution of rural households according to their net sales position and examine the characteristics of net buyers and net sellers.

Table 5-20 shows the percentage of rural households according to the type of participation in the markets for the six principal commodities. The proportion of rural households that participate in one way or another is around half for most commodities, but in the case of beans it is over 90%. The bean market is also unusual for the large percentage of rural households that are only purchasers (54%) and for the relatively small numbers of households that only sell (14%).

Table 5-20: Distribution of households by market participation

	Percentage of households by market participation			
Commodity	Only buy	Only sell	Buy and sell	Neither buy nor sell
Sorghum	32.7	23.7	5.8	37.8
Cassava	28.0	18.6	9.3	44.1
Sweet potatoes	26.8	22.2	2.6	48.4
White potatoes	32.2	11.9	2.1	53.9
Bananas	13.2	29.7	3.8	53.2
Beans	54.4	13.8	22.4	9.3

Only a small proportion of rural households both purchase and sell the same commodity: with the exception of beans, each commodity is both purchased and sold by less than 10% of rural households. This contradicts the common belief that many farmers are forced to sell their crop at low harvest prices, only to buy some of it back at high prices later in the season. Even in the case of beans, there is no evidence from the ENBC that households that buy and sell beans are poor households forced to make "distress" sales[1].

More detailed information on net sales is provided in Figures 5-1 through 5-7 which show the cumulative percentage of rural households according to net sales of the six staple crops and coffee. Figure 5-1 provides the distribution for net sales of sorghum. Roughly half of the rural households are net buyers and one quarter are net sellers. The sharp "point" in the lower left portion of the graph indicates that net purchases are highly concentrated among a small number of households. This is due to the influence of relatively large-scale sorghum beer brewers who purchase their raw materials. The area above the curve and below the center line represents the total volume of net purchases, while the area under the curve and above the center line represents net sales. The fact that former exceeds the latter reflects the excess of purchases over sales in Rwanda, presumably made possible by informal sorghum imports.

The distribution of households by net sales of cassava is quite different, as shown in Figure 5-2. About 30% of rural households are net buyers and 25% are net sellers, with close to half of the households having no net sales or net purchases. Purchases of cassava are less concentrated than those of sorghum, which is expected since most cassava purchases are for direct consumption.

Sweet potatoes follow a similar pattern, as shown in Figure 5-3. One quarter of the rural households are net sellers, one quarter net buyers, and the remainder do not participate in the sweet potato market. Since virtually all rural households (94%) grow sweet potatoes, most of these non-participants grow sweet potatoes for their own consumption.

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1. Households that both buy and sell beans in the rural sector tend to have average levels of expenditure and caloric intake and above-average levels of home production of beans.

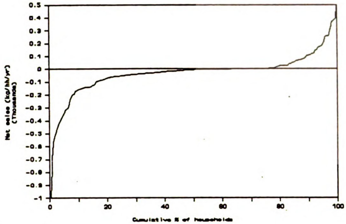

Figure 5-1: Distribution of households by net sales of sorghum

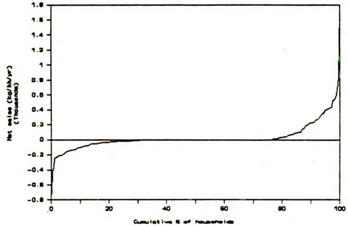

Figure 5-2: Distribution of households by net sales of cassava

According to Figure 5-4, white potatoes have a relatively even distribution of purchases among the 25% of rural households that buy them, but only 15% of rural households have net sales. Among the net sellers, a small proportion of households account for a large portion of the total volume. This concentration of production is due to the agro-

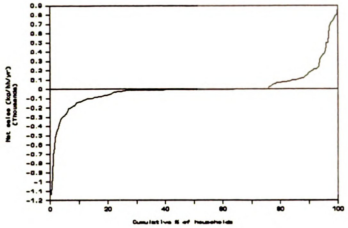

Figure 5-3: Distribution of households by net sales of sweet potatoes

climatic requirements of potatoes which restrict them to fields above 1800 meters. In addition, there are a number of relatively large-scale commercial growers in the northwest (Scott, 1988: 61, 68). The overall rural surpluses in white potatoes is reflected in the greater area above the center line than below it.

The distribution of rural households by net sales of bananas is shown in Figure 5-5. A relatively large portion of households (30%) have net sales. On the other hand, the net purchases of bananas are highly concentrated. As in the case of sorghum, this is the result of large-scale banana beer producers who need to purchase large quantities of raw materials.

The net sales of beans are shown in Figure 5-6. There are several distinctive aspects of the pattern of net beans sales. First, the total volume of net purchases exceeds by a considerable margin the volume of net sales. As noted in the previous section, this appears to indicate informal imports of beans. Second, a large majority of rural households (70%) are net buyers of beans. Perhaps only one quarter of rural households have net sales. And third, unlike the other staple crops,

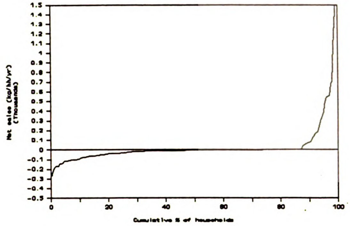

Figure 5-4: Distribution of households by net sales of white potatoes

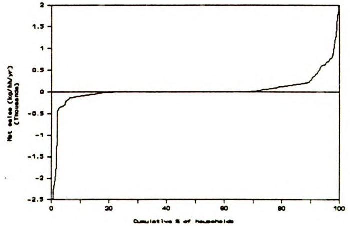

Figure 5-5: Distribution of households by net sales of bananas

beans are bought and/or sold by almost all rural households. About 20% of all rural households have net purchases over 100 kg/yr, a quantity that represents roughly one quarter of the average household consumption.

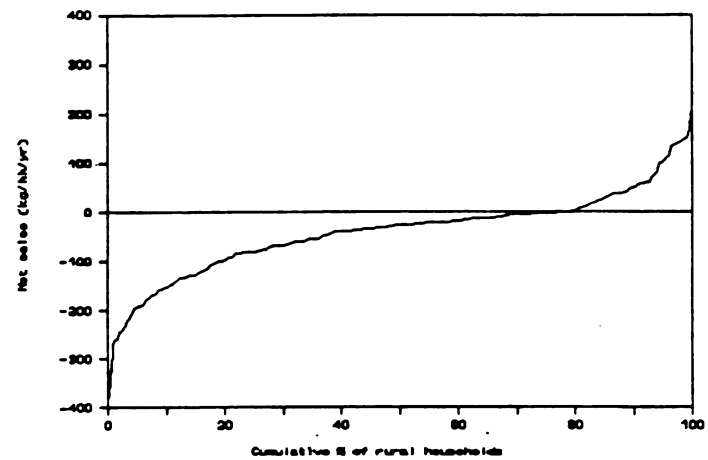

Figure 5-6: Distribution of households by net sales of beans

Finally, the distribution of rural households by the volume of coffee sales is presented in Figure 5-7. According to the ENBC data, about one third of the rural households sold coffee. Most coffee growers sell less than 100 kg/yr, but about five percent of rural households sell more than this amount. However, the ENBC may have underestimated coffee sales. The 1984 Agricultural Census, using a much larger sample, estimated that 44% of rural households were producing coffee. The Agricultural Census also estimated coffee production to be almost twice as high (32 compared to 17 kg/household/yr).

These graphs have several implications for the impact of price changes on rural households. First, an increase in the price of beans will harm a large majority of rural households (70%), benefiting only one quarter of them. Second, changes in the price of the other staple crops (sorghum, cassava, sweet potatoes, white potatoes, and bananas) will generally benefit one quarter of the households, hurt another quarter, and not directly affect half of the rural households. Third, the impact (both positive and negative) will be relatively concentrated among a small number of households. This is particularly true in the

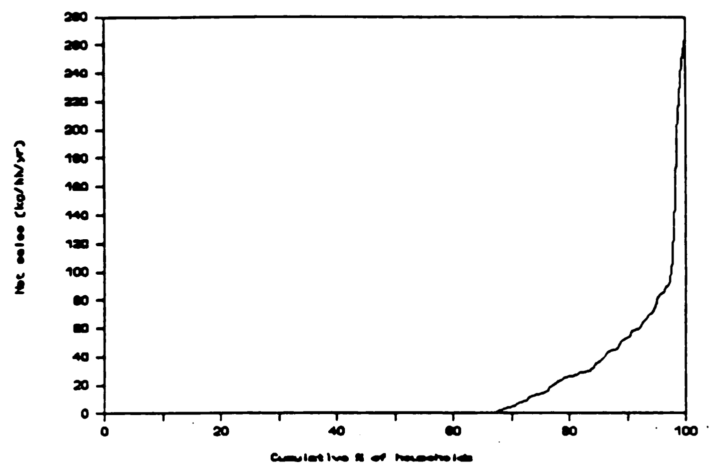

Figure 5-7: Distribution of households by coffee sales

case of net sellers of white potatoes and the beer brewers who are net buyers of bananas and sorghum.

Correlation of net sales across crops: The results in the previous section raise the question whether net buyers of one commodity tend to be net buyers of other commodities as well. One approach to answering this question is to consider the correlation of net sales, in volume terms, across commodities, shown in Table 5-21. In general, the correlation coefficients are fairly low: only three of the commodity pairs have net sales correlations greater than 0.15 in absolute value. The highest coefficient is that between net sales of beans and net sales of sorghum, although even this correlation is relatively weak (0.168).

Another way to address this question is to consider the distribution of households according to their net sales of staple crops as a group. For this purpose, net sales of the six staple food crops, expressed in calories per adult equivalent (ae), have been summed for

Table 5-21: Correlation of net sales of different commodities

	Sorghum	Cassava	Sw pot	Wh pot	Banana	Beans	Coffee
Sorghum	1.000						
Cassava	.056	1.000					
Sw pot	-.052	.044	1.000				
Wh pot	-.155	-.040	-.006	1.000			
Banana	.076	.135	-.164	.006	1.000		
Beans	.168	.133	.128	-.033	.147	1.000	
Coffee	.064	.125	-.003	-.089	-.008	.014	1.000

Source: Rwandan ENBC/Rural sector.

each household[1]. Sorghum and banana purchases for beer brewing have been excluded in order to focus on food consumption. Figure 5-8 shows the cumulative distribution of households by the net sales (in kcal/ae/day) of the six staple food crops.

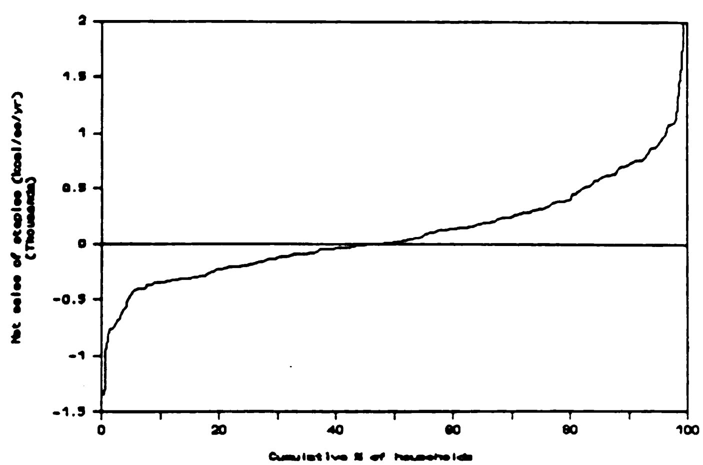

Figure 5-8: Distribution of households by net sales of six staple crops expressed in caloric terms

This graph reveals that fully 45% of the rural households are net buyers of the six staple goods. However, many of the net buyers are

1. Net sales are expressed in calories to reflect more accurately the importance of each kilogram of the different crops and in per-adult-equivalent terms to adjust for household size.

purchasing relatively small amounts of these crops. Only about 5% of the rural households purchase more than 500 kcal/ae/day worth of the six staple crops. As a basis for comparison, the mean level of caloric intake in the rural sector is 2444 kcal/ae/day, according to the ENBC data.

Characteristics of net buyers: The distributional impact of a change in the price of an agricultural commodity obviously depends on the characteristics of net buyers and net sellers. It seems plausible that net buyers could include poor households with insufficient land to meet their own food needs and/or households with relatively well-paying non-agricultural occupations. Table 5-22 provides some figures to help address these questions.

With respect to net sales of sorghum, it appears that households selling more than 100 kg/yr are relatively well-off. On the other hand, net buyers are better off in terms of expenditure and caloric intake than small-scale net sellers. This may be due to the influence of sorghum beer producers among the net buyers[1].

In the case of cassava and sweet potatoes, there is some evidence that the 15-20% of households with net purchases over 50 kg/yr have lower levels of food self-sufficiency, caloric intake, and expenditure.

Net buyers of cassava tend to have smaller farms, but this is not the case for net buyers of sweet potatoes. However, it should be recalled that even among net buyers, home production is more important than purchases as a source of the commodity.

White potatoes present a quite different pattern in which net buyers tend to be, if anything, better off than the 54% of rural household that neither buy nor sell potatoes. Large-scale net sellers (those with net sales of more than 100 kg/yr) have even higher levels of

1. The home production figures in this section of the table refer only to consumption of own production, excluding production retained for the manufacture of sorghum beer.

Table 5-22: Characteristics of rural households by net sales position

	Pct hh	Expend (F/ae)	Nbr pers	Farm size (ha)	Pct food self suff	Kcal /ae	Sales (kg)	Purch (kg)	Home prod (kg)
Net sales of sorghum									
< -100 kg	16.0	13,551	5.3	1.5	66	2,502	3	292	10
-100 to -50 kg	9.3	13,933	4.6	.7	71	2,709	4	73	7
-50 to -1 kg	25.6	13,313	5.0	1.1	67	2,473	4	30	8
0 kg	24.5	11,907	3.9	1.1	64	2,279	0	0	4
1 to 100 kg	13.6	11,857	5.7	1.6	70	2,262	53	15	11
> 100 kg	10.9	15,418	5.9	2.1	74	2,659	268	32	14
Net sales of cassava									
< -100 kg	9.9	11,597	6.0	1.1	61	2,135	5	194	217
-100 to -50 kg	5.9	9,651	5.6	1.1	54	1,872	13	82	186
-50 to -1 kg	16.6	13,212	4.5	.9	65	2,523	4	26	173
0 kg	44.1	13,933	4.5	1.4	71	2,622	0	0	141
1 to 100 kg	10.0	14,415	5.0	1.4	68	2,244	62	7	419
> 100 kg	13.5	11,833	5.6	1.6	70	2,387	402	7	520
Net sales of sweet potatoes									
< -100 kg	12.9	10,799	6.1	1.4	67	2,092	3	306	905
-100 to -50 kg	7.9	10,049	5.4	1.3	71	2,210	0	77	685
-50 to -1 kg	6.5	14,478	5.5	1.0	65	2,480	0	24	494
0 kg	48.4	13,651	4.6	1.3	67	2,497	0	0	624
1 to 100 kg	9.8	14,313	4.8	1.4	66	2,471	84	9	757
> 100 kg	14.4	13,514	4.6	1.2	70	2,671	387	0	1,457
Net sales of white potatoes									
< -100 kg	8.7	13,701	5.9	1.5	59	2,435	2	141	75
-100 to -50 kg	8.8	14,458	5.5	1.3	70	2,558	1	71	60
-50 to -1 kg	15.7	14,691	4.9	1.3	69	2,509	1	30	47
0 kg	53.9	12,020	4.7	1.3	67	2,344	0	0	43
1 to 100 kg	3.7	12,263	5.4	1.1	73	2,519	71	9	793
> 100 kg	9.3	15,111	5.0	1.3	71	2,782	865	4	1,137
Net sales of bananas									
< -100 kg	9.3	15,466	5.9	1.0	59	2,386	1	664	580
-100 to -50 kg	5.4	9,997	5.4	1.3	65	2,283	19	91	353
-50 to -1 kg	8.7	13,792	5.0	1.2	60	2,430	5	21	297
0 kg	45.1	11,907	4.7	1.2	68	2,380	0	0	208
1 to 100 kg	9.5	11,797	4.6	1.0	65	2,503	72	20	454
> 100 kg	22.0	15,582	5.0	1.8	74	2,617	488	32	1,294
Net sales of beans									
< -100 kg	18.8	11,814	6.1	1.5	59	2,281	8	176	315
-100 to -50 kg	17.8	11,751	5.2	1.2	68	2,381	5	77	303
-50 to -1 kg	33.3	13,356	4.4	.9	68	2,504	6	30	291
0 kg	9.3	13,241	4.2	1.5	63	2,260	0	0	251
1 to 100 kg	15.2	13,098	4.8	1.7	75	2,539	54	15	450
> 100 kg	5.6	19,923	4.9	1.9	72	2,881	150	5	553
Sales of coffee									
0 kg	67.2	13,354	4.7	1.2	68	2,593	0	0	0
1 to 100 kg	30.0	12,296	5.3	1.4	66	2,138	35	0	0
> 100 kg	2.8	15,427	6.9	1.8	68	2,143	205	0	0
Rural means	100.0	13,095	4.9	1.3	67	2,444	115	77	520

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expenditure and caloric intake. The characteristics of net buyers are explained by the fact that potatoes are a relatively costly source of calories.

Concerning the net position in bananas, large-scale net buyers are relatively well off, in spite of the small average farm size and low level of food self-sufficiency. As in the case of sorghum, this is probably due to the presence of important banana beer producers among the net buyers. Large-scale net sellers are also relatively well-off, although they tend to have above average farm sizes and rates of food self-sufficiency.

Beans present the clearest case in which net sales are correlated with the level of expenditure per adult equivalent, caloric intake, and food self-sufficiency. Households buying over 50 kg/yr do not have particularly small farms, but they are larger in number than the average rural household.

Finally, Table 5-22 seems to indicate that "large-scale" coffee growers (those selling over 100 kg/yr) are better off than the average rural household in terms of expenditure (though not in terms of caloric intake), but small-scale coffee growers are less well off. This is plausible, but the sample size for the "large-scale" growers is too small to draw firm conclusions. Interestingly, the rate of food self-sufficiency is the same between growers and non-growers.

5.5.3 Tradeable component of expenditure and income

In this section, we concentrate on the composition of cash expenditure and cash income with particular emphasis on the tradeable and nontradeable components. As discussed in section 4.5.2, the rural budget survey used a system of 405 codes for goods and services, while the urban survey relied on an even more disaggregated system of 825 codes. Each code was classified as tradeable or non-tradeable, based on a judgement as to whether the domestic price is determined by international prices or by domestic supply and demand.

Tradeable goods include export crops, rice, cooking oil, wheat products, sugar, processed foods, and most manufactured consumer items. Most staple food crops, building materials, and other bulky low-value products were considered non-tradeable, as were all services. As discussed earlier, factory beer is considered 50% tradeable, while beans are counted as 25% tradeable (see Appendix A).

Table 5-23 gives the proportion of tradeable goods in cash expenditure on each budget category. For example, tradeable goods account for 16% of rural cash expenditure on food, but tradeables represent almost twice as high a percentage of urban cash food expenditure (30%). Part of this difference is due to the fact that non-tradeable categories, such as tubers/bananas, play a larger role in the cash budget of rural households than urban. In addition, the composition of each category is more heavily weighted toward tradeable goods in the urban sector, particularly in the case of grains, animal products, and beverages. With respect to grains, rural households purchase primarily (nontradeable) sorghum and maize, while urban households buy mostly (tradeable) rice and wheat products. With regard to beverages, the differences is due to the fact that factory beer is much more important in the cities. Non-tradeable traditional beers dominate beverage purchases in the countryside.

Among non-food categories, rural cash expenditure has a larger tradeable component (57%) than does urban cash expenditure (47%). This is primarily due to the composition of energy/water, education, and leisure/services. In general terms, this is because urban spending is more concentrated on services (e.g. water, electricity, school fees, and leisure services), while rural spending tends to have a larger share of goods, including tradeable goods (e.g. kerosene, school uniforms, and consumer goods). In addition, a much larger share of rural non-food spending is allocated to clothing, which is almost entirely tradeable.

Table 5-23: Tradeable component of rural and urban cash expenditure

Budget category	Rural	Urban
Total	36.6	39.2
Food	16.0	29.6
Grain	36.1	85.9
Tubers/bananas	.0	.0
Legumes	23.0	22.2
Fruits/vegetables	1.0	4.5
Animal products	2.2	17.9
Beverages	7.3	37.7
Other	47.0	52.3
Non-food sub-total	56.9	47.3
Clothing	96.4	94.0
Housing	14.1	15.7
Household equipment	64.2	76.2
Energy/water	82.1	26.8
Health/hygiene	50.4	72.9
Education	33.7	15.5
Transportation	51.2	84.0
Tobacco	.0	.0
Leisure/services	50.7	29.8

Interestingly, the tradeable share in overall spending is almost the same in rural and urban areas (37% and 39%, respectively). This is somewhat surprising given the conventional wisdom that imported goods play a much larger role in urban (and high-income) household budgets.

If the prices of all tradeable goods increase in the same proportion, which price increases will have the greatest effect on household budgets? In order to address this question, we need to examine the composition of tradeable goods spending, as shown in Table 5-24. The most striking aspect of this table is that almost half (46%) of all tradeable goods spending in the rural sector is on clothing. The ENBC data indicate that imported used clothing accounts for roughly one third of rural clothing expenditure. Bolts of cloth and African print wraps, also imported for the most part, represents another third (see Ministry of Planning, 1988: 33).

Household equipment and "other food" represent the second and third largest categories of rural tradeable spending. Each of these

Table 5-24: Composition of rural and urban tradeable cash expenditure

Budget category	Rural	Urban
Total	100.0	100.0
Food	21.6	34.5
Grain	3.3	9.7
Tubers/bananas	.0	.0
Legumes	5.9	2.5
Fruits/vegetables	.0	.3
Animal products	.4	3.6
Beverages	3.4	9.5
Other	8.5	8.9
Non-food	78.4	65.5
Clothing	46.2	13.9
Housing	5.5	7.5
Household equipment	8.7	7.5
Energy/water	5.4	3.9
Health/hygiene	5.8	6.4
Education	1.0	.6
Transportation	4.3	23.2
Tobacco	.0	.0
Leisure/services	1.5	2.5

categories accounts for 8-9% of tradeable spending.

In the urban areas, transportation represents almost one quarter (23%) of tradeable spending. This includes taxi and bus fare, fuel, spare parts, and lubricants, but bus fares represent almost half of the total. Other important components of tradeable spending are grains (wheat products and rice) and beverages (primarily factory beer).

Having discussed the tradeable component in the *average* budget of rural and urban households, it is now worth examining how the tradeable component varies across households. Tables 5-25 and 5-26 give the proportion of cash expenditure and of net cash income which is associated with tradeable goods in the rural and urban sectors, respectively.

According to Table 5-25, the tradeable portion of rural cash expenditure does not show any consistent pattern with respect to total expenditure, although it is highest for the third quintile. The net cash income pattern is only somewhat more regular, with a "peak" in the second and third quintiles. This peak corresponds to a larger number of coffee producers in the third quintile, although this may be merely a characteristic of the sample.

Table 5-25: Importance of tradeables in rural income and expenditure by expenditure quintile

Rural quintile	Tradeable share in cash expenditure (%)	Tradeable share in cash net income (%)
1st	36.9	7.3
2nd	35.9	17.0
3rd	42.4	20.5
4th	38.8	7.5
5th	32.1	8.2

Table 5-26 gives the corresponding results for the urban sector. The importance of tradeable goods in urban cash expenditures rises from 31% in the first (poorest) quintile to over 40% in the last two quintiles. The pattern for net income is irregular, but it appears that the poorest 40% in the urban sector rely primarily on non-tradeable types of income. This would indicate that the urban poor would be hurt by devaluation, in spite of their relatively low spending on tradeables, because of their overwhelmingly non-tradeable sources of income.

Table 5-26: Importance of tradeables in urban income and expenditure by expenditure quintile

Urban quintile	Tradeable share in cash expenditure (%)	Tradeable share in cash net income (%)
1st	31.1	5.6
2nd	34.7	5.7
3rd	36.8	30.3
4th	43.6	16.2
5th	40.2	22.1

The results in Tables 5-25 and 5-26 should be regarded with some skepticism. It should be recalled that in the rural areas, cash transactions are modest in absolute terms and may be greatly influenced by a single large transaction. In addition, net income is subject to greater measurement error than expenditure, a fact which is more serious when the data are disaggregated. Finally, the classification of income sources into tradeable and nontradeable groups is more difficult than the classification of expenditure.

5.5.4 Summary

With regard to the impact of price changes on Rwandan households, three topics were examined: the importance of market transactions within the overall budget, the net sales position with respect to the principal crops, and the tradeable component of cash income and expenditure.

The importance of market purchases in total expenditure is positively related to the level of expenditure per adult equivalent in both rural and urban areas. As a result of these patterns, we can expect a given price change to have an effect on urban households at least twice as great as that on rural households. Furthermore, other things being equal, the impact will be fairly similar across rural households, but it will vary considerably among urban households.

The net sales information indicate that the rural sector of Rwanda purchases more beans than it sells, implying the existence of informal imports. Almost three quarters of the rural households are net buyers. The data also imply the existence of sorghum imports. For the other staple food crops, as a rule of thumb, price increases will benefit the 25% of rural households who are net sellers, harm another quarter of the households, and leave unaffected the remaining 50% of rural households who do not have market transactions in that commodity.

A household with net sales in one commodity shows no significant tendency to have net sales in other commodities. In the case of beans and possibly cassava and sweet potatoes, net purchases are correlated with reduced caloric intake and expenditure levels.

The proportion of cash expenditure spent on tradeable good is roughly the same in rural and urban sectors. In the rural sector, clothing accounts for almost half of cash expenditure on tradeables, while transportation is the most important type of tradeable spending among urban households. The tradeable share in cash expenditure is greater among high-income urban households than low-income, but it shows no strong trend in the rural sector.

Thus, the impact of devaluation is expected to be less among rural households and among the poor, not because they purchase fewer tradeables, but because purchases are a smaller part of their overall expenditure. However, these results are only suggestive in that the analysis has not combined the various factors into one welfare measure, nor does the analysis incorporate the adaptation of households as consumers and as producers. This is the task of the next two chapters.

CHAPTER SIX

MODEL OF HOUSEHOLD DEMAND

In this section, we describe the results of the estimation of rural and urban food demand as a function of total expenditure (income), household characteristics, and prices. Sections 6.1 describes several aspects of model selection: whether to estimate separate rural and urban models or combine them, what commodity categories to use, and whether single-equation ordinary least squares (OLS) or the seemingly unrelated regression (SUR) model is more appropriate. Sections 6.2 and 6.3 describe the results of the rural model with and without imposing symmetry, while 6.4 and 6.5 provide the corresponding results from the urban model. The final two sections digress somewhat to cover two topics: 1) a comparison of OLS and Tobit results in estimating rural food demand and 2) an analysis of the possible influence of quality and measurement error in the elasticity estimates.

6.1 Selection of the appropriate model

6.1.1 Treatment of rural and urban samples

The first question to address is whether urban consumer behavior is sufficiently different from rural behavior to justify separating urban and rural samples to estimate demand from each. Statistically, the question is whether there are variables missing from the demand equations (such as tastes and assets) which vary between rural and urban households and are correlated with the independent variables, thus biasing the combined-sample parameter estimates.

We can use the F test (see equation 4-16) to statistically test the joint null hypothesis that all rural coefficients are equal to the corresponding urban coefficients (this is also called a Chow test). The test is carried out equation-by-equation using ordinary least squares.

Table 6-1: Test of equality of urban and rural coefficients

Category	F stat	Prob
SORGH	1.41	0.10
RICE	1.17	0.27
SWPOT	3.67	0.00
WHPOT	3.03	0.00
BANAN	5.43	0.00
BEANS	2.67	0.00
PEAS	1.46	0.09
BEEF	1.57	0.05
MEAT	1.72	0.02
BBEER	1.46	0.09
SBEER	3.99	0.00
FBEER	1.33	0.15
OIL	1.64	0.04
SALT	1.66	0.03
SUGAR	1.67	0.03
CLOTH	2.06	0.06
HOUSE	0.59	0.74
EQUIP	0.26	0.96
ENERG	14.33	0.00
HEALT	6.16	0.00
EDUCA	1.67	0.13
TRANS	4.30	0.00
TOBAC	8.89	0.00
LEISU	8.12	0.00

The results in Table 6-1 indicate that, at the 90% confidence level, we can reject the null hypothesis that rural and urban coefficients are equal for 20 out of the 24 budget categories tested. Only in the equations for rice, housing, education, and household equipment are the differences statistically insignificant at the 90% level. At the 95% level, we can reject the hypothesis of rural-urban equality for 16 out of the 24 equations (sorghum, peas, banana beer, and clothing).

Taking the commodities as a group, it is clear that urban and rural coefficients are significantly different. Thus, it is appropriate to estimate separately rural and urban demand.

6.1.2 <u>Commodity categories</u>

Twenty-one food categories were considered for inclusion in the rural model. The F statistic was used to test the joint null hypothesis that all the coefficients (other than the constant) were equal to zero. The hypothesis could not be rejected for several minor commodities. After some experimentation, it was decided to drop four goods from the rural model (eggplant, cabbage, onion, and prepared meals) and to combine goat meat and fish into an "other meat" category. The price of "other meat" was calculated as the weighted average of goat and fish prices. The impact of these changes is relatively minor since the four dropped goods account for only 1.7% of rural expenditures, while "other meat" represents 1.8%. The 17 food commodities included in the rural model are presented in Table 6-2. On average, they represent 74% of household expenditure and 87% of household food expenditure among rural households.

In the urban system, 26 food products were originally included. Based on the F-test of the joint significance of the independent variables, it was decided to combine four vegetables (eggplant, cabbage, tomatoes, and onions) into a "vegetables" category, to combine goat meat and fish into "other meat," and to collapse liquid and powder milk categories. Again, the prices of the combined categories were calculated as a weighted average of the various components of each.

The 21 food commodities in the urban model are briefly described in Table 6-2. On average, they comprise about 59% of total expenditure and 90% of food expenditure by households. The greater coverage of food expenditure in the urban model is due to the inclusion of three categories not in the rural model: bread, milk, and prepared meals. Other differences are that the urban model disaggregates cassava into cassava root and cassava flour and that it includes the category "vegetables," while the rural model has just "tomatoes."

In both the rural and urban models, non-food expenditure was divided into nine categories for the purpose of demand estimation. Although the joint significance of the independent variables was low for some non-food categories, all nine were retained in the final model to

Table 6-2: Description of food products in rural and urban models

Food Code	Rural model	Urban model	Description
SORGH	Yes	Yes	Sorghum in grain or porridge
RICE	Yes	Yes	Rice in grain or other form
BREAD	No	Yes	Bread, cake, or other wheat product
CASSA	Yes	Yes	Cassava root and, in rural model, cassava flour
SWPOT	Yes	Yes	Sweet potato
WHPOT	Yes	Yes	White potato
BANAN	Yes	Yes	Bananas and plantains
CASFL	No	Yes	Cassava flour
BEANS	Yes	Yes	Dry beans in any form
PEAS	Yes	Yes	Peas
TOMAT	Yes	No	Fresh tomatoes
VEGET	No	Yes	Cabbage, onion, tomato, & eggplant
BEEF	Yes	Yes	Beef and related products
OTHMT	Yes	Yes	Goat meat or any type of fish
MILK	No	Yes	Liquid milk or milk powder
BBEER	Yes	Yes	Banana beer
SBEER	Yes	Yes	Sorghum beer
FBEER	Yes	Yes	Factory beer
OIL	Yes	Yes	Palm oil, other oils and fats
SALT	Yes	Yes	Salt
SUGAR	Yes	Yes	Sugar, candy, and other sweets
MEALS	No	Yes	Prepared meals outside home
OTHER	No	No	Millet, yams, groundnuts, greens, other vegetables, fruit, other meat, other beverages, canned or processed goods

allow finer disaggregation between tradeable and nontradeable goods. Table 6-3 provides a brief description of the goods and services which comprise each non-food category.

6.1.3 Estimation method: OLS vs SUR

As described in Chapter 4, there are two situations in which the seemingly unrelated regression (SUR) model does not improve on the estimates obtained from single-equation ordinary least squares (OLS): 1) when all the equations in the model have the same independent variables and 2) when there is no correlation among errors in different equations. The first condition is not fulfilled because the food equations have price terms while the non-food equations do not. The

Table 6-3: Description of non-food categories in rural and urban models

Category	Rural model	Urban model	Description
CLOTH	Yes	Yes	Clothing, shoes, hats, accessories, cloth, sewing materials, tailor services
HOUSE	Yes	Yes	Building materials, construction labor (excludes rent and the purchase of buildings and land)
EQUIP	Yes	Yes	Furniture, kitchenware, bedding, floor mats, decorations
ENERG	Yes	Yes	Firewood, charcoal, water, kerosene, electricity, batteries
HEALT	Yes	Yes	Medication, clinic fees, traditional healers
EDUCA	Yes	Yes	School fees, school uniforms, school materials
TRANS	Yes	Yes	Buses, taxis, spare parts, operating cost of vehicles (excludes purchase of vehicles)
TOBAC	Yes	Yes	Cigarettes, tobacco leaf, tobacco powder
LEISU	Yes	Yes	Radios, cassettes, games, sporting equipment, domestic employees

second condition can be tested using the Breush-Pagan test of diagonality.

The first step in the test is to estimate food and non-food demand using single-equation OLS regression. The residuals are then used to estimate the covariance matrix of errors across equations and within households. The Breush-Pagan statistic tests the null hypothesis that the covariance matrix is diagonal (i.e. that there is no correlation in the error terms across equations).

The Breusch-Pagan test of the 26x26 cross-equation covariance matrix of the rural model indicates that we can reject the null hypothesis of diagonality at the 99.9% confidence level.

Null hypothesis: Cross-equation covariance matrix of residuals is diagonal in rural model.
Chi squared = 762.845 with d.f.= 325
Prob under Ho = 0.000

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In the presence of cross-equation correlation of error terms, the SUR model is more efficient than single-equation OLS because it uses information regarding the correlated error terms to improve the parameter estimates.

The Breusch-Pagan test was also applied to the 30x30 cross-equation covariance matrix of the urban model. Again, the chi-squared statistic was quite high, allowing us to reject the hypothesis of diagonality at the 99.9% confidence level.

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Null hypothesis: Cross-equation covariance matrix of
residuals is diagonal in urban model.
Chi squared   = 1572.461 with d.f.= 435
Prob under Ho =    0.000
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Thus, the SUR model is more appropriate for the urban demand system as well.

It should be noted, however, that in spite of the non-diagonality of the cross-equation covariance matrix, the parameter estimates obtained using SUR are quite similar to those obtained using OLS. For example, the expenditure and price elasticities at the mean differ by 0.02 or less for almost every food category. In the case of non-food categories, OLS and SUR estimates are identical because the non-food equations exclude prices and are thus over-identified. If the computational costs of SUR were high, single-equation OLS would be sufficiently accurate for most purposes.

6.2 Unrestricted SUR model of rural demand

The unrestricted SUR model of rural demand involves the simultaneous estimation of 445 parameters (six coefficients common to all 26 equation, plus 17 price terms in each of the 17 food equations). Because of the large number of coefficients and because many of them are not easily interpretable in original form, this section presents only selected results. A complete listing of the coefficients and their corresponding t statistics is found in Appendix C.

First, overall measures of the goodness-of-fit and significance of the equations are discussed. Then, we consider the impact of different groups of independent variables: the two expenditure terms, the three household composition variables, and the price terms.

6.2.1 Overall goodness-of-fit and significance

Table 6-4 presents the mean budget share[1], the correlation coefficient (R^2), the F statistic for the equation as a whole, and the probability corresponding to the F statistic. The correlation coefficient indicates the proportion of the variance in the dependent variable (budget share) which is "explained" by the set of independent variables. The value of R^2 varies from 0.01 for three non-food categories (health, tobacco, and leisure/services) to 0.39 for sweet potatoes. Although these values may seem low, this is normal for cross-sectional demand studies, particularly when budget share, rather than quantity, is the dependent variable.

The values of the correlation coefficient are generally higher for food categories than for non-food categories. The low correlation coefficients of non-food regression equations reflects the smaller number of independent variables (six compared to 23 in the food equations). In addition, non-food expenditure is probably less predictable than food expenditure because the budget shares are small and the purchases are often lumpy and infrequent. For example, a single $ 20 radio would represent ten times the mean expenditure per household on leisure and services.

The F statistic in Table 6-4 tests the hypothesis that all coefficients except the constant are equal to zero. In other words, the

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1. These budget shares do not agree exactly with those presented in Chapter 5 because of different calculation methods. First, these are unweighted averages, whereas the figures in Chapter 5 use the expansion factors based on the sampling method. Second, these figures are averages shares, while the figures in Chapter 5 represent the share of total expenditure allocated to each category. The latter figures give more weight to high-expenditure households.

Table 6-4: Summary of unrestricted SUR model of rural demand

Budget category	Mean budget share	R^2	F stat for all variab	Prob under Ho
SORGH	1.41	0.16	2.28	0.00
RICE	0.49	0.10	1.24	0.19
CASSA	5.92	0.13	1.65	0.03
SWPOT	12.54	0.39	7.93	0.00
WHPOT	4.02	0.30	4.82	0.00
BANAN	5.86	0.34	5.87	0.00
BEANS	21.61	0.28	4.25	0.00
PEAS	1.39	0.12	1.59	0.04
TOMAT	0.13	0.15	1.94	0.00
BEEF	1.39	0.14	1.87	0.01
MEAT	1.91	0.14	1.95	0.00
BBEER	10.15	0.17	2.49	0.00
SBEER	3.91	0.21	3.29	0.00
FBEER	0.80	0.20	3.07	0.00
OIL	0.96	0.20	2.97	0.00
SALT	1.02	0.18	2.81	0.00
SUGAR	0.31	0.12	1.76	0.01
CLOTH	6.30	0.06	3.37	0.00
HOUSE	3.31	0.18	10.87	0.00
EQUIP	1.54	0.04	2.08	0.05
ENERG	1.19	0.03	1.58	0.15
HEALT	1.68	0.01	0.52	0.79
EDUCA	0.42	0.03	1.44	0.20
TRANS	0.80	0.07	3.64	0.00
TOBAC	0.71	0.01	0.73	0.63
LEISU	0.36	0.01	0.67	0.67

null hypothesis is that the budget share does not vary with total expenditure, price, or household composition. The last column gives the probability of obtaining the corresponding value of F if the null hypothesis is true. The results show that the null hypothesis can be rejected at the 95% confidence level for 20 of the 26 equations (17 of these are significant at the 99% level). Rice is the only food commodity for which the coefficients are not significantly different from zero at the 95% level. This category, which represents only 0.5 % of the rural budget, was retained because it is one of a few tradeable foods and thus will be important in subsequent analysis.

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Among the non-food categories, the budget shares allocated to clothing, housing, household equipment, and transportation vary significantly with the five independent variables. In contrast, the shares allocated to the other non-food categories do not vary significantly with the independent variables. Health, tobacco, and leisure/services are the least predictable budget categories.

6.2.2 Effect of total expenditure

Engel's Law states that, as income rises, the budget share of food in general, and starchy staple foods in particular, falls. In other words, food should have an expenditure elasticity less than one, and the cheapest sources of calories should have the lowest elasticities. Table 6-5 presents the average cost (in Rwandan francs of 1983) per 100 kilocalories of the most important foods. This table demonstrates that sorghum, sweet potato, cassava, and bananas are the least expensive sources of calories. Rice, white potatoes, and banana beer are at least twice as costly on a per calorie basis, but are still considerably less expensive than beef, goat meat, and factory beer.

The impact of total household expenditure on rural budget shares, as estimated with the unrestricted SUR model, is shown in Table 6-6. The estimated coefficients on the expenditure terms, β_1 and β_2, are not easy to interpret by themselves. If both β_1 and β_2 have positive (negative) signs then budget share increases (decreases) with total expenditure, so the item is a luxury good (necessity or inferior good) at all levels of income. When β_1 and β_2 have different signs, as is generally the case, goods may change from luxury to necessity (or necessity to luxury) as household expenditure increases[1].

1. The transition from luxury to necessity (or vice versa) occurs when the budget share curve reaches a maximum (or minimum), that is, when the expenditure elasticity is 1.0. At this point, $\log(x/P) = -\beta_1/2\beta_2$. If β_1 and β_2 have different signs, then the extremum will be found at a positive level of expenditure, but it may still be outside the relevant range.

Table 6-5: Caloric cost of various food items

Product	Calories (kcal/100 g)	Price (F/kg)	Caloric cost (F/100 kcal)
SORGH	345	20.9	0.61
RICE	363	80.4	2.21
CASSA	130	10.5	0.81
SWPOT	96	6.0	0.63
WHPOT	71	12.9	1.82
BANAN	89	7.3	0.83
BEANS	323	29.6	0.92
PEAS	339	35.5	1.05
TOMAT	20	24.2	12.10
BEEF	237	116.8	4.93
GOAT	141	113.5	8.05
BBEER	87	30.5	3.51
SBEER	173	14.1	0.82
FBEER	43	123.7	28.77
OIL	884	154.9	1.75
SALT	0	47.0	not defined
SUGAR	380	97.3	2.56

The elasticity of demand with respect to total household expenditure is easier to interpret. These elasticities are calculated from $ß_1$ and $ß_2$ using the following expression (derived in section 4.3.4):

$$\epsilon_i = 1 + \frac{\beta_{i1}}{w_i} + \frac{2\beta_{i2}}{w_i} \ln\left(\frac{x}{P}\right) \tag{6-1}$$

The rural expenditure elasticities of demand for food were evaluated at the mean level of expenditure and are presented in the fifth column of Table 6-6. The sixth column provides the F statistic for the null hypothesis that $ß_1=ß_2=0$. Under the null hypothesis, budget share does not vary with household expenditure, so that the expenditure elasticity is equal to 1.0 at all levels of expenditure. The last column of Table 6-6 gives the probability of obtaining this value of F by chance if the null hypothesis is true.

The food elasticities conform, in general, to *a priori* expectations. First, the expenditure elasticity of food as a whole is 0.85 (this is calculated as the share-weighted average of individual elastic-

Table 6-6: Effect of household expenditure on rural demand

Budget category	ln(exp) β_1	t	ln(exp) sqrd β_2	t	expend elast	F stat for expend	Prob under Ho
SORGH	-16.19	-1.75	0.79	1.69	0.48	3.02	0.05
RICE	5.79	0.89	-0.28	-0.84	1.80	1.48	0.23
CASSA	22.14	0.69	-1.30	-0.80	0.45	5.24	0.01
SWPOT	-98.44	-2.64	4.41	2.33	0.02	40.99	0.00
WHPOT	68.33	2.33	-3.33	-2.24	1.83	5.95	0.00
BANAN	-15.77	-0.52	0.82	0.54	1.04	0.21	0.81
BEANS	70.83	1.47	-4.03	-1.65	0.63	14.99	0.00
PEAS	11.62	0.86	-0.59	-0.86	1.09	0.37	0.69
TOMAT	0.20	0.11	-0.01	-0.13	0.70	0.20	0.82
BEEF	-1.14	-0.12	0.11	0.22	1.66	4.10	0.02
MEAT	7.48	0.39	-0.30	-0.32	1.80	2.53	0.08
BBEER	4.32	0.11	-0.04	-0.02	1.34	2.97	0.05
SBEER	26.46	1.18	-1.30	-1.15	1.25	1.09	0.34
FBEER	-15.23	-1.39	0.86	1.54	2.85	10.49	0.00
OIL	10.71	1.58	-0.52	-1.52	1.58	2.96	0.05
SALT	3.55	0.99	-0.20	-1.13	0.56	8.22	0.00
SUGAR	3.55	0.71	-0.16	-0.64	2.24	2.23	0.11
CLOTH	2.63	0.12	-0.09	-0.08	1.15	0.80	0.45
HOUSE	-92.54	-2.95	5.04	3.17	2.77	26.07	0.00
EQUIP	6.74	0.39	-0.25	-0.29	2.17	4.68	0.01
ENERG	1.69	0.18	-0.10	-0.21	0.72	0.61	0.55
HEALT	3.30	0.37	-0.17	-0.38	0.96	0.12	0.88
EDUCA	4.30	0.62	-0.21	-0.61	1.25	0.22	0.80
TRANS	-5.33	-0.64	0.33	0.78	2.35	8.52	0.00
TOBAC	-0.41	-0.08	0.01	0.05	0.80	0.31	0.74
LEISU	3.34	0.47	-0.15	-0.42	1.97	0.96	0.38

ities). In other words, a 1% increase in total household expenditure is associated with a 0.85% rise in food expenditure. This implies, of course, that food is a "necessity" and that the budget share allocated to food declines with increasing total expenditure.

In addition, the highest expenditure elasticity (2.85) is that of factory beer, the most expensive source of calories among the products considered: compared to traditional beers, it is seven times as expensive on a calorie basis and four times as costly on a volume basis. Other foods with elasticities significantly greater than 1.0 are beef, white potatoes, banana beer, and cooking oil, all relatively expensive sources of calories in Rwanda (the elasticities of rice, other meat, and sugar are also high, but are not significantly greater than 1.0).

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By contrast, the three cheapest sources of calories (sorghum, sweet potatoes, and cassava) have expenditure elasticities below 0.5; all three are significantly less than 1.0. Beans and salt also qualify as "necessities" with elasticities significantly less than 1.0. It is worth noting that, at the mean expenditure level in the rural areas, there are no inferior goods. Sweet potatoes come the closest to being inferior with an expenditure elasticity of 0.02. This means that, at the mean level of expenditure, sweet potato expenditures remain practically constant as total household expenditure rises.

Among the non-food categories, the highest expenditure elasticities are those of housing (2.77), transportation (2.35), and household equipment (2.17). Although the expenditure terms in these three equations are significant at the 99% confidence level, none of the other non-food equations has statistically significant expenditure coefficients. In other words, we cannot reject the hypothesis that rural budget shares are constant across income for the other six non-food categories.

Looking at both food and non-food categories in Table 6-6, the F test indicates that the two expenditure terms are jointly significant at the 95% level in 13 of the 26 equations. A cross-equation test of all 52 expenditure coefficients in the rural model yields an F statistic of 5.4, which is significant at the 99% confidence level. Thus, we can reject the null hypothesis that rural budget shares are constant across household expenditure levels.

The t statistic on the quadratic term, β_2, is significant at the 95% level in only three equations (sweet potatoes, white potatoes, and housing) and at the 90% level for two more (sorghum and beans)[1]. A cross-equation test of the joint significance of all 26 quadratic terms

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1. The critical value of the t statistic with 246 degrees of freedom at the two-tailed 95% confidence level is 1.96. At the two-tailed 90% level, the critical value is 1.65.

rejects the null hypothesis only at the 90% level. When the test is restricted to the 17 food equations within the system, the quadratic terms are significantly different from zero at the 99% confidence level. This result indicates that using the standard AIDS (without the quadratic term) to model demand in rural Rwanda would not allow sufficient flexibility in the relationship between food budget share and total expenditure (income).

6.2.3 Effect of household composition

The three demographic variables are the number of adults, the number of children, and a dummy variable to indicate a female-headed household. The first two demographic coefficients (γ_1 and γ_2) in Table 6-7 indicate the effect on budget share of each additional member of the household, holding prices and real expenditure per adult-equivalent constant. The third demographic coefficient (γ_3) shows the change in budget share associated with a female-headed household.

Few of the demographic variables are statistically significant in the rural demand model, as indicated by the t-statistics in Table 6-7. Only seven of the 81 demographic coefficients are statistically significant at the 95% confidence level and nine more are significant at the 90% level.

The coefficients associated with household size (γ_1 and γ_2) which are significant at the 90% level provide weak support for the hypothesis of "economies of scale" in household size. In this case, large households with the same expenditure per adult equivalent consume more luxuries (oil, sugar, other meat, and housing) and relatively less of the necessities (sweet potatoes, beans, salt, and energy). This is a common pattern in household budget data and is generally attributed to economies of scale in non-food consumption such as housing (see Deaton and Case, 1987).

Not surprisingly, the number of children is negatively associated with the budget share allocated to tobacco. Contrary to expectations,

Table 6-7: Effect of household composition on rural demand

Budget category	number adults γ_1	t	number children γ_2	t	female head γ_3	t
SORGH	-0.04	-0.31	0.00	0.04	-0.37	-1.12
RICE	-0.05	-0.63	0.08	1.44	0.40	1.75
CASSA	-0.18	-0.46	-0.07	-0.23	0.56	0.49
SWPOT	-0.84	-1.78	-0.25	-0.74	0.88	0.66
WHPOT	0.20	0.55	0.30	1.13	0.12	0.11
BANAN	0.09	0.24	0.16	0.59	0.93	0.87
BEANS	-1.66	-2.73	-0.85	-1.95	1.47	0.86
PEAS	-0.17	-1.00	-0.12	-0.99	-0.24	-0.50
TOMAT	-0.02	-0.67	0.01	0.56	0.09	1.39
BEEF	0.09	0.78	0.04	0.47	0.28	0.83
MEAT	-0.10	-0.43	0.35	2.04	-1.11	-1.64
BBEER	0.15	0.29	-0.37	-1.00	-4.62	-3.20
SBEER	0.42	1.47	-0.11	-0.57	-0.61	-0.77
FBEER	0.07	0.54	0.03	0.33	-0.58	-1.48
OIL	0.15	1.71	0.05	0.83	-0.25	-1.04
SALT	-0.10	-2.20	-0.05	-1.54	-0.05	-0.36
SUGAR	0.05	0.75	0.08	1.72	0.17	0.94
CLOTH	0.93	3.46	-0.37	-1.93	-0.02	-0.03
HOUSE	0.74	1.90	0.82	2.93	1.55	1.41
EQUIP	0.08	0.39	0.12	0.80	-0.38	-0.62
ENERG	-0.07	-0.61	-0.23	-2.62	-0.11	-0.32
HEALT	0.15	1.37	-0.06	-0.74	0.03	0.11
EDUCA	0.14	1.60	0.10	1.62	-0.03	-0.10
TRANS	-0.03	-0.31	0.09	1.14	0.21	0.73
TOBAC	0.03	0.43	-0.08	-1.73	-0.19	-1.01
LEISU	-0.03	-0.28	0.02	0.31	-0.25	-0.99

the number of children is not significantly related to the portion of the budget allocated to beer. Perhaps the fact that children consume less beer is offset by the economies of household size since beer is a "luxury." With regard to the impact of children on education spending, although the sign is correct (positive), the coefficient is not quite significant at the 90% confidence level.

Testing the cross-equation hypothesis that the numbers of adults and of children do not affect budget shares in the rural sector ($\gamma_1=\gamma_2=0$), the F statistic indicates that we can reject the hypothesis at the 99% level of confidence. In other words, budget shares in the rural sector are influenced by the number of adults and children in the household, holding other variables constant.

The sex of the head of household is represented by a dummy variable which takes the value 1 for a female head and 0 for a male head. At the 95% confidence level, the results show that female-headed households allocate a significantly smaller portion of their budget (4.6 percentage points less) to banana beer. This finding probably reflects social norms against banana beer consumption by women. By contrast, sorghum beer is considered more appropriate for women (see Haggblade, 1988).

If we accept a 90% confidence level, then female-headed household allocate a somewhat larger share of the budget to rice and a smaller share to "other meat" (goat and fish). The former result may be related to the greater time pressure of female heads and the ease of rice preparation compared to alternative staples. It should be noted, however, that rice constitutes a very minor portion of the budget (less than 1%) in rural households, regardless of the gender of the household head. The weak tendency of female headed households to consume less of "other meat" may be due to traditional beliefs that discourage women from consuming goat meat[1].

Testing the cross-equation hypothesis that the sex of head of household does not affect budget allocations (γ_3=0 in all equations), the F statistic indicates that we can reject the null hypothesis only at the 90% confidence level. Further analysis reveals that the gender of the head of household is a significant determinant of food allocations but that it does not influence non-food budget shares.

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1. A common belief in Rwanda is that eating goat meat contributes to facial hair in women.

6.2.4 Effect of prices

The effect of food prices on the demand for food is estimated directly as part of the SUR model. Non-food price effects are not estimated but derived under the assumptions of strongly separable preferences. The results of each procedure are discussed in turn.

Estimated food price elasticities: The estimated price parameter, α_{ij}, represents the compensated effect of the log of the price of food item j on the budget share of food item i. The interpretation of these coefficients is complicated by the fact that even if a price increase in good j does not affect the budget *share* of good i (i.e. $\alpha_{ij}=0$), the compensated *demand* will increase slightly due to the adjustment in nominal income to maintain a constant real income[1]. Because the coefficients cannot be directly interpreted, they are relegated to Appendix C, and we will move directly to the discussion of price elasticities.

The uncompensated (Marshallian) price elasticities are calculated from the estimated parameters using the following equation (derived in section 4.3.4):

$$\epsilon_{ij} = \frac{\alpha_{ij}}{w_i} - \delta - \frac{w_j}{w_i}\beta_{i1} - 2\frac{w_j}{w_i}\beta_{i2}\ln\left(\frac{X}{P}\right) \qquad (6\text{-}2)$$

In general, we expect price elasticities (in absolute value) to be positively correlated with expenditure (income) elasticities. In other words, the demand for a good which is a "luxury" in the sense of being consumed disproportionately by high-income consumers is likely to be more sensitive to changes in price.

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1. If $\alpha_{ii}=0$, then the compensated own-price elasticity is w_i-1, where w_i is the budget share of good i. If $\alpha_{ij}=0$, then the compensated cross-price elasticity is w_j. These price elasticities correspond to the most plausible null hypothesis: that budget shares are not affected by prices. In a disaggregated system, the budget shares will be small and these elasticities will be close to -1 and 0, respectively.

A comparison of the expenditure elasticities in Table 6-6 and the price elasticities in Table 6-8 confirms this intuition. Factory beer, rice, and white potatoes, all luxuries in the rural sector, have price elasticities (in absolute value) of 2.0 or greater. Other luxuries with price elastic demand include traditional beers, "other meat," and sugar. Most of the necessities, such as bananas, beans, sorghum, salt, and sweet potatoes, are relatively unresponsive to price. The most counter-intuitive result is the low price elasticity of demand for beef (-0.20).

Although only three of the 17 own-price coefficients are significant at the 95% level, as shown in Table 6-7, the cross-equation joint

Table 6-8: Effect of prices on rural food demand

Budget category	own price coeff α_{ii}	t	own price elast	F stat for all prices	Prob under Ho
SORGH	0.23	0.24	-0.83	2.39	0.00
RICE	-0.76	-0.76	-2.53	1.34	0.16
CASSA	-0.56	-0.42	-1.06	1.41	0.12
SWPOT	-1.20	-0.73	-0.97	2.92	0.00
WHPOT	-5.75	-2.30	-2.46	5.46	0.00
BANAN	0.92	1.07	-0.85	7.35	0.00
BEANS	2.13	0.62	-0.82	4.06	0.00
PEAS	-0.69	-0.69	-1.50	1.85	0.02
TOMAT	-0.09	-1.19	-1.72	2.32	0.00
BEEF	1.12	1.36	-0.20	1.82	0.02
MEAT	-0.46	-0.26	-1.25	1.80	0.02
BBEER	-5.84	-2.60	-1.61	1.80	0.02
SBEER	-3.96	-1.94	-2.02	4.01	0.00
FBEER	-6.19	-2.09	-8.77	2.54	0.00
OIL	0.15	0.26	-0.85	3.32	0.00
SALT	0.38	0.95	-0.62	2.39	0.00
SUGAR	-0.13	-0.62	-1.43	2.05	0.01

test of all 17 own-price coefficients is significant at the 95% confidence level. Furthermore, in 15 of the 17 food equations, the vector of price coefficients is significantly different than zero at the 95% level. Not surprisingly, the cross-equation test of the joint significance of all 289 price coefficients rejects at the 99% level the hypothesis that prices have no effect on the budget shares of food (see Appendix B).

Derived non-food price elasticities: Following Frisch (1959) and Newberry (1987), we derive non-food price elasticities using the assumption of strongly separable preferences, the price and expenditure elasticities for food, and the expenditure elasticities for each non-food category. The elasticity of demand for food with respect to household expenditure is 0.85, while the price elasticity of food as a whole is -0.82, and the budget share of food is 0.74[1]. Using equation 4-31, we can calculate the value of ϕ as follows:

$$\phi = \frac{\epsilon_{ff} + \epsilon_f w_f}{\epsilon_f(1-w_f\epsilon_f)} = \frac{-.82 + (.85)(.74)}{.85[1-(.74)(.85)]} = -0.60 \qquad (6\text{-}3)$$

By substituting ϕ and the appropriate budget shares and expenditure elasticities into equation 4-30, we can derive the own- and cross-price elasticities of demand for non-food items in the rural area.

The uncompensated price elasticities of demand for non-food items in the rural sector are presented in Table 6-9. These should be treated as highly tentative given the particularly strong assumptions required to obtain them. Nonetheless, the high price elasticity of demand for "luxury" goods such a housing, transportation, and leisure/services is certainly plausible, as is the inelastic demand for tobacco and energy.

The expenditure elasticities shown in Table 6-9 have been re-estimated adding food prices to the model but restricting the price

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1. Strictly speaking, these figures refer only to the 17 modeled food commodities, thus excluding "other food" for which no price information is available. The average budget share allocated to "other food" is 9.8%.

Table 6-9: Derived rural non-food price elasticities

Budget category	share	elasticities expend	price
CLOTH	6.30	1.14	-0.71
HOUSE	3.31	2.78	-1.61
EQUIP	1.54	2.18	-1.30
ENERG	1.19	0.71	-0.44
HEALT	1.68	0.96	-0.59
EDUCA	0.42	1.25	-0.76
TRANS	0.80	2.35	-1.41
TOBAC	0.71	0.79	-0.48
LEISU	0.36	1.97	-1.18
OTHERF	9.87	1.17	-0.74

coefficients to correspond to the cross-price elasticities derived under additivity assumptions[1]. This step causes only slight modification of the expenditure elasticities: comparing Tables 6-6 and 6-9, the largest difference in the expenditure elasticities is 0.01.

The last line in Table 6-9 shows the price and expenditure elasticities of the omitted category, "other food." The expenditure and demographic coefficients are defined in such a way to satisfy adding up, while the price coefficients are defined to satisfy homogeneity for the entire system. These results are presented here only because the non-food coefficients must be determined before the coefficients for the excluded "other food" category can be defined.

6.3 SUR model of rural demand with symmetry imposed

Consistent consumer behavior requires that the matrix of compensated substitution effects be symmetric. In Chapter 4, it was shown that, for the demand function used here, symmetric substitution effects imply that the matrix of price coefficients, α_{ij}, must be symmetric.

1. This is done by regressing $w_n-\alpha_{nf}p_f$ on the same set of five independent variables plus the constant, where w_n is the budget share of non-food category n, α_{nf} is the matrix of food-non-food cross-price coefficients derived using additivity, and p_f is the vector of food prices.

Since the α matrix is 17x17, imposing symmetry requires 136 restrictions on the estimated coefficients[1].

The discussion of the rural model with symmetry will be relatively brief, focusing on the price and expenditure elasticities. The effect of household composition will not be reviewed, and the various joint hypotheses will not be retested. The complete set of coefficients and t statistics from the restricted rural model are presented in Appendix C.

Table 6-10 provides the correlation coefficients obtained for the rural demand model with symmetry imposed. Comparing these results with those of the unrestricted rural model (Table 6-4), imposing symmetry appears to reduce the value of R^2 by 4-6% for most food items. The equations for bananas, beans, and traditional beers suffer the most from the imposition of symmetry. On the other hand, the non-food correlation coefficients remain unchanged in the restricted rural model.

The expenditure elasticities from the SUR model with symmetry, presented in Table 6-11, are similar to those without symmetry (see Table 6-6). The expenditure elasticity for sweet potatoes changes from barely positive in the unrestricted model to barely negative in the restricted version. Only one commodity (peas) changes from luxury to necessity, and no commodity switches in the reverse direction. The expenditure elasticities for food commodities are almost all within 0.20 of the unrestricted value, and many are within 0.05. The coefficients and the expenditure elasticities for the non-food categories do not change at all with the symmetry restriction, presumably because these equations do not contain any restricted parameters.

By contrast, the estimated food price elasticities in the restricted model, presented in Table 6-12, differ considerably from those in the unrestricted model (see Table 6-7). Although factory beer and

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1. There are $17 \cdot 17=289$ elements in the matrix, $289-17=272$ off-diagonal elements, and thus $272/2=136$ elements in each off-diagonal triangle.

Table 6-10: Summary of rural model with symmetry imposed

Budget category	Mean budget share	R_2
SORGH	1.41	0.11
RICE	0.49	0.06
CASSA	5.92	0.07
SWPOT	12.54	0.32
WHPOT	4.02	0.26
BANAN	5.86	0.06
BEANS	21.61	0.17
PEAS	1.39	0.05
TOMAT	0.13	0.12
BEEF	1.39	0.09
MEAT	1.91	0.10
BBEER	10.15	0.10
SBEER	3.91	0.14
FBEER	0.80	0.19
OIL	0.96	0.17
SALT	1.02	0.17
SUGAR	0.31	0.07
CLOTH	6.30	0.06
HOUSE	3.31	0.18
EQUIP	1.54	0.04
ENERG	1.19	0.03
HEALT	1.68	0.01
EDUCA	0.42	0.03
TRANS	0.80	0.07
TOBAC	0.71	0.01
LEISU	0.36	0.01

white potatoes are the most price-elastic food commodities in both versions, rice and oil become highly inelastic in the restricted version, while beans and sugar become considerably more price elastic. Although such a judgement is necessarily subjective, the price elasticities estimated with symmetry restrictions seem, on the whole, less credible than do the unrestricted price elasticities. This is most notable in the cases of oil, rice, and beans.

Under symmetry, the expenditure elasticity of food (0.86) is almost the same as in the unrestricted version (0.85). The price elasticity of food (-0.90) is more elastic than the corresponding figure from the unrestricted model (-0.82). Substituting these values into equation 6-3, the value of ϕ for the rural model under symmetry is

Table 6-11: Effect of expenditure on rural demand under symmetry

Budget category	ln(exp) $ß_1$	t	ln(exp) sqrd $ß_2$	t	expend elast
SORGH	-17.48	-1.91	0.84	1.83	0.30
RICE	3.29	0.51	-0.15	-0.46	1.71
CASSA	20.83	0.66	-1.21	-0.76	0.54
SWPOT	-105.13	-2.88	4.69	2.54	-0.08
WHPOT	67.42	2.35	-3.30	-2.27	1.72
BANAN	9.05	0.31	-0.38	-0.25	1.28
BEANS	85.34	1.81	-4.68	-1.96	0.72
PEAS	8.24	0.62	-0.44	-0.65	0.77
TOMAT	0.53	0.28	-0.03	-0.30	0.86
BEEF	-1.22	-0.13	0.12	0.25	1.77
MEAT	2.24	0.12	-0.04	-0.04	1.75
BBEER	3.41	0.09	0.01	0.01	1.36
SBEER	24.31	1.11	-1.22	-1.10	1.13
FBEER	-16.03	-1.47	0.89	1.62	2.78
OIL	9.37	1.40	-0.45	-1.33	1.62
SALT	3.16	0.88	-0.18	-1.01	0.59
SUGAR	1.68	0.34	-0.07	-0.27	2.22
CLOTH	2.63	0.12	-0.09	-0.08	1.15
HOUSE	-92.54	-2.95	5.04	3.17	2.77
EQUIP	6.74	0.39	-0.25	-0.29	2.17
ENERG	1.69	0.18	-0.10	-0.21	0.72
HEALT	3.30	0.37	-0.17	-0.38	0.96
EDUCA	4.30	0.62	-0.21	-0.61	1.25
TRANS	-5.33	-0.64	0.33	0.78	2.35
TOBAC	-0.41	-0.08	0.01	0.05	0.80
LEISU	3.34	0.47	-0.15	-0.42	1.97

-0.83. Under the assumption of additive preferences, this parameter is used to derive the non-food price elasticities shown in Table 6-13.

A comparison of the rural non-food elasticities in the unrestricted and restricted versions of the model reveals that the restricted non-food price elasticities follow roughly the same rank order as the unrestricted elasticities. In both versions, the most price elastic categories are housing, transportation, and household equipment, while the least price responsive are tobacco and energy.

On the other hand, the restricted figures are consistently more price elastic. This pattern reflects the fact that imposing symmetry increases the price elasticity of food without changing appreciably the expenditure elasticity of food. Under the assumption of additive

Table 6-12: Effect of prices on rural food demand under symmetry

Budget category	own price coeff α_{ii}	t	own price elast
SORGH	0.08	0.09	-0.93
RICE	0.46	0.50	-0.08
CASSA	-2.08	-1.80	-1.32
SWPOT	-1.22	-0.80	-0.96
WHPOT	-6.10	-3.25	-2.55
BANAN	2.63	3.80	-0.57
BEANS	-3.78	-1.14	-1.11
PEAS	-2.00	-2.53	-2.43
TOMAT	-0.04	-0.62	-1.34
BEEF	0.31	0.41	-0.79
MEAT	-1.00	-0.64	-1.54
BBEER	-1.66	-0.82	-1.20
SBEER	-1.87	-1.04	-1.48
FBEER	-6.46	-2.36	-9.12
OIL	0.70	1.37	-0.28
SALT	0.42	1.14	-0.58
SUGAR	-0.41	-2.17	-2.32

Table 6-13: Derived rural non-food price elasticities under symmetry

Budget category	share	elasticities expend	price
CLOTH	6.30	1.15	-0.96
HOUSE	3.31	2.79	-2.19
EQUIP	1.54	2.18	-1.78
ENERG	1.19	0.72	-0.61
HEALT	1.68	0.96	-0.81
EDUCA	0.42	1.25	-1.04
TRANS	0.80	2.36	-1.94
TOBAC	0.71	0.79	-0.66
LEISU	0.36	1.97	-1.63
OTHFO	9.87	1.06	-0.90

preferences, the relationship between price and expenditure elasticities is assumed constant across strongly separable categories.

6.4 Unrestricted SUR model of urban demand

This section reviews the results of the model of urban demand without symmetry. As noted in section 6.1.2, the urban food classification is similar to the rural classification except that the former includes bread, milk, and prepared meals, and it disaggregates cassava into cassava root and cassava flour. In addition, the urban model includes the category "vegetables," where the rural model has only "tomatoes." Thus, the urban model includes 21 food equations and 9 non-food equations.

With six coefficients common to all 30 equations and 21 price terms in each of the 21 food equations, the unrestricted urban model involves the simultaneous estimation of 621 coefficients. As in the case of the rural model, only selected results are presented here. The full set of coefficients and t statistics is given in Appendix C.

6.4.1 Overall goodness-of-fit and significance

In general, the urban model provides a better fit to the data than does the rural model. As shown in Table 6-14, three commodity equations in the urban model (beans, sweet potatoes, and white potatoes) have correlation coefficients (R^2) above 0.35, but only one equation in the rural model (sweet potatoes) reaches this level. Similarly, five of the nine non-food categories have R^2 values above 0.10 in the urban model, whereas only one does in the rural model.

Another indication of the better fit of the urban model is the fact that the independent variables are jointly significant in almost every equation. Table 6-14 shows that for 27 out of 30 commodity equations, we can reject the hypothesis that all the coefficients are zero at the 99% confidence level. The null hypothesis can be rejected at the 95% confidence level for two more goods. Only in the case of clothing are the coefficients jointly insignificant.

The higher level of explanatory power of the urban demand model is probably due to the greater variability in income and household expendi-

Table 6-14: Summary of unrestricted SUR model of urban demand

Budget category	Mean budget share	R^2	F stat for all variab	Prob under Ho
SORGH	0.92	0.14	1.57	0.03
RICE	2.37	0.15	2.06	0.00
BREAD	0.67	0.21	2.78	0.00
CASSA	1.79	0.31	5.06	0.00
SWPOT	3.84	0.49	10.37	0.00
WHPOT	6.24	0.38	6.50	0.00
BANAN	2.93	0.18	2.56	0.00
CASFL	2.40	0.26	3.73	0.00
BEANS	10.37	0.51	11.01	0.00
PEAS	0.41	0.20	2.62	0.00
VEGET	1.57	0.17	2.27	0.00
BEEF	2.90	0.21	2.93	0.00
MEAT	2.11	0.13	1.69	0.02
MILK	2.30	0.19	2.76	0.00
BBEER	4.82	0.35	5.74	0.00
SBEER	1.16	0.23	3.08	0.00
FBEER	4.17	0.23	3.43	0.00
OIL	2.07	0.19	2.65	0.00
SALT	0.54	0.32	4.99	0.00
SUGAR	2.59	0.26	4.26	0.00
MEALS	2.76	0.19	2.77	0.00
CLOTH	5.50	0.02	1.18	0.24
HOUSE	10.04	0.34	27.86	0.00
EQUIP	2.87	0.16	10.80	0.00
ENERG	4.62	0.11	6.50	0.00
HEALT	3.05	0.07	4.36	0.00
EDUCA	1.07	0.06	3.57	0.00
TRANS	4.84	0.18	12.32	0.00
TOBAC	1.51	0.09	5.50	0.00
LEISU	1.88	0.29	23.01	0.00

ture (see section 5.3.2). In addition, the "lumpiness" of non-food spending is less of a problem in the urban areas because household expenditure is generally greater and the percentage allocated to non-food categories is higher. A $ 20 radio represents "only" one half the annual expenditure on leisure/services of an average urban household, compared to 10 times the leisure/services spending of a typical rural household.

6.4.2 Effect of total expenditure

The expenditure elasticities for the unrestricted model of urban food demand are shown in Table 6-15. Comparing the urban and rural expenditure elasticities, it is interesting that the rank order of the products is quite similar, but that the elasticities are generally lower in the urban sector.

Table 6-15: Effect of household expenditure on urban demand

Budget category	ln(exp) β_1	t	ln(exp) sqrd β_2	t	expend elast	F stat for expend	Prob under Ho
SORGH	-1.95	-0.71	0.07	0.58	0.59	2.85	0.06
RICE	17.19	3.96	-0.81	-3.95	1.10	7.83	0.00
BREAD	5.27	3.36	-0.24	-3.22	1.42	8.57	0.00
CASSA	3.27	0.76	-0.21	-1.05	0.34	13.10	0.00
SWPOT	-28.57	-3.75	1.20	3.35	0.12	31.59	0.00
WHPOT	10.28	1.45	-0.56	-1.69	0.75	10.18	0.00
BANAN	-1.47	-0.25	-0.00	-0.01	0.47	10.82	0.00
CASFL	-4.20	-0.86	0.13	0.57	0.40	13.09	0.00
BEANS	-23.30	-1.84	0.77	1.29	0.31	48.48	0.00
PEAS	0.43	0.24	-0.02	-0.28	0.86	0.24	0.79
VEGET	3.98	1.98	-0.19	-2.02	0.98	2.27	0.10
BEEF	18.83	4.15	-0.90	-4.22	0.96	9.57	0.00
MEAT	5.53	1.29	-0.26	-1.26	1.08	0.91	0.40
MILK	10.18	1.82	-0.49	-1.86	0.97	1.89	0.15
BBEER	19.19	1.93	-0.98	-2.11	0.69	6.68	0.00
SBEER	-0.10	-0.03	-0.01	-0.07	0.68	1.47	0.23
FBEER	13.07	1.30	-0.50	-1.06	1.60	9.25	0.00
OIL	10.29	4.05	-0.49	-4.08	1.02	8.43	0.00
SALT	-0.36	-0.49	0.00	0.15	0.53	18.75	0.00
SUGAR	11.59	2.91	-0.55	-2.94	1.00	4.48	0.01
MEALS	-19.41	-1.43	0.90	1.41	0.82	1.07	0.34
CLOTH	9.81	1.35	-0.46	-1.33	1.04	0.94	0.39
HOUSE	-63.88	-3.26	3.49	3.77	1.94	53.91	0.00
EQUIP	1.41	0.24	0.03	0.11	1.72	22.31	0.00
ENERG	22.05	2.98	-0.98	-2.80	1.33	10.19	0.00
HEALT	7.42	1.71	-0.34	-1.65	1.10	1.97	0.14
EDUCA	5.25	1.00	-0.23	-0.93	1.36	1.25	0.29
TRANS	-14.90	-1.25	0.88	1.56	1.72	18.25	0.00
TOBAC	7.59	2.13	-0.38	-2.28	0.68	6.73	0.00
LEISU	-4.25	-1.04	0.26	1.35	1.66	18.67	0.00

For example, among food categories, in both urban and rural areas the highest expenditure elasticities are those of factory beer, sugar, rice, oil, and animal products, while the lowest are those of cassava root, sweet potatoes, beans, bananas, and salt. Bread, a category not included in the rural model, is a "luxury" good, with an expenditure elasticity second only to factory beer among food commodities. This is not surprising given the fact that, on a per calorie basis, bread is three times as expensive as sweet potatoes in the urban sector.

Among the non-food categories, the highest expenditure elasticities in both rural and urban areas are those of housing, household equipment, and transportation. In both cases, tobacco has one of the lowest expenditure elasticities of the non-food categories. One important difference is that energy is a luxury among urban households but a necessity among rural households (although the latter elasticity is not significantly below 1.0).

As mentioned above, the urban expenditure elasticities are generally lower than in the rural elasticities. For example, none of the urban budget categories has an elasticities over 2.0, while there are five such categories in the rural model. One implication is that some of the goods that are "luxuries" in the countryside, such as white potatoes and traditional beers, are "necessities" in the cities.

In the urban model, the expenditure elasticities of food and non-food are 0.72 and 1.52, respectively. By contrast, the corresponding expenditure elasticities in the rural model are 0.85 and 1.59[1]. It may seem paradoxical that both food and non-food categories have lower expenditure elasticities in the urban model, since the weighted average of all expenditure elasticities must be 1.0 in any system, according to the Engel aggregation condition. The explanation is that the non-food elasticities, which are higher on average, are weighted more heavily in the urban model because non-food categories represent a much larger share of the urban budgets.

According to the F test in Table 6-15, the two expenditure terms are jointly significant at the 99% level in 20 of the 30 equations (for

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1. The average food elasticities cited here exclude the category "other food," whose expenditure elasticity is derived as a residual. Thus, the weighted average of the two elasticities presented here is not exactly equal to 1.0.

the other ten, we cannot reject the null hypothesis that budget share is constant across expenditure levels). Given this result, it is not surprising that the 60 expenditure terms in the complete model are jointly significant at the 99% confidence level ($F = 10.47$).

Finally, Table 6-15 indicates that there is significant curvature in the relationship between budget share and log expenditure. The quadratic expenditure coefficient (β_2) is significant in eleven of the 30 equations, as indicated by the t statistic. Furthermore, this coefficient is jointly significant in the system at the 99% confidence level ($F = 2.94$).

6.4.3 Effect of household composition

Of the 90 coefficients representing the effect of household composition on urban food budget shares, about one third (31) are significantly different than zero at the 95% confidence level, as shown in Table 6-16. The two household size variables are jointly significant for the unrestricted urban model as a whole ($F = 5.06$), as is the sex of the head of household ($F = 3.32$).

The coefficients for number of adults and number of children (γ_1 and γ_2) indicate the effect of an additional family member given the same prices and real expenditure per adult-equivalent. These results show that, at the 95% confidence level, a larger family allocates a greater share of its budget to bread, cassava flour, "other meat," milk, oil, sugar, and most of the non-food categories, while devoting a smaller share to cassava root, beans, traditional beers, meals away from home, and tobacco. The first group has expenditure elasticities close to or above 1.0, while every good in the second group has an elasticity below 1.0. Thus, an increase in household size while holding expenditure per adult equivalent constant has an effect on budget allocations similar to an increase in total expenditure. These results correspond to the hypothesis of economies of scale in household size, as discussed in section 6.2.3.

Table 6-16: Effect of household composition on urban demand

Budget category	number adults γ_1	t	number childr γ_2	t	sex of head γ_3	t
SORGH	-0.10	-1.26	-0.03	-0.78	-0.06	-0.23
RICE	-0.13	-1.06	0.12	1.73	-0.06	-0.14
BREAD	0.09	1.95	0.06	2.55	0.07	0.48
CASSA	-0.32	-2.54	0.12	1.82	-0.72	-1.76
SWPOT	-0.37	-1.70	-0.14	-1.18	0.39	0.54
WHPOT	-0.19	-0.95	0.07	0.66	0.36	0.53
BANAN	-0.05	-0.32	0.04	0.39	1.03	1.83
CASFL	0.00	0.00	0.17	2.22	0.50	1.07
BEANS	-1.26	-3.49	-0.45	-2.29	-0.75	-0.62
PEAS	-0.00	-0.03	0.01	0.20	-0.17	-1.02
VEGET	0.13	2.29	0.01	0.32	0.53	2.80
BEEF	-0.12	-0.90	0.10	1.40	-0.45	-1.05
MEAT	0.29	2.35	0.09	1.33	0.03	0.07
MILK	0.33	2.06	0.09	1.08	0.76	1.43
BBEER	-1.19	-4.17	-0.63	-4.12	-4.46	-4.74
SBEER	-0.15	-1.33	-0.13	-2.19	-0.63	-1.71
FBEER	-0.30	-1.05	-0.08	-0.52	-2.08	-2.18
OIL	-0.00	-0.02	0.11	2.74	0.50	2.08
SALT	-0.01	-0.34	-0.02	-1.36	0.12	1.76
SUGAR	-0.01	-0.12	0.14	2.25	1.33	3.51
MEALS	-1.15	-2.93	-0.82	-3.93	-2.89	-2.25
CLOTH	0.22	1.13	0.09	0.83	-0.36	-0.53
HOUSE	1.26	2.42	0.22	0.73	1.67	0.91
EQUIP	0.21	1.32	0.17	1.87	0.37	0.67
ENERG	0.44	2.25	0.22	1.98	0.92	1.33
HEALT	0.38	3.29	0.11	1.63	0.69	1.69
EDUCA	0.12	0.85	0.26	3.20	1.32	2.68
TRANS	1.22	3.86	0.35	1.91	1.39	1.25
TOBAC	-0.16	-1.71	-0.19	-3.46	-1.03	-3.09
LEISU	0.79	7.28	0.04	0.69	0.40	1.04

Turning our attention to the effect of the gender of the head of household, Table 6-16 reveals that, other things equal, female-headed households allocate a smaller portion of their budget to banana beer, factory beer, meals away from home, and tobacco, while spending a larger share on vegetables, cooking oil, sugar, and education. In the case of banana beer and prepared meals, the coefficients (γ_3) are close in magnitude to the corresponding mean budget shares, implying that spending on these items by female-headed household is virtually non-existent.

The smaller shares allocated to banana beer, factory beer, and tobacco clearly reflect social norms. Similarly, eating at restaurants and bars is less acceptable for women in Rwanda. The lower spending on sugar and cooking oil by male-headed household may be simply the result of under-reporting in these households: women generally do the shopping but the interviews were more often carried out with the (male) heads of household.

6.4.4 Effect of prices

As in the rural model, the effect of food prices on the demand for food is estimated directly as part of the SUR model. Non-food price effects are not estimated but derived under the assumptions of strongly separable preferences. The results of each procedure are discussed in turn.

Estimated food price elasticities: The uncompensated own-price elasticities in the urban areas, shown in Table 6-17, are similar to those in the rural areas, although there are a few unexpected differences. As in the rural model, rice and traditional beer are relatively price elastic, while salt, cassava root, and beans are price inelastic. In fact, the estimated own-price elasticities of salt and cassava root are positive, although they are not significantly greater than zero[1]. Somewhat surprising are the low price elasticities of bread and factory beer. Since neither elasticities is significantly less than one, this may be simply the result of insufficient variability in price within the urban areas. Also unexpected were the relatively high price elasticities of sweet potatoes, cassava flour, and sorghum. One possible explanation is that the greater degree of choice among staples in the cities makes demand more sensitive to price.

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1. The t statistic associated with α_{ii} tests the null hypothesis that the budget share does not vary with own-price. For goods with a small budget share, like cassava root and salt, this essentially corresponds to a test of the null hypothesis that the uncompensated own-price elasticity is -1 (see footnote in section 6.2.4).

The t test on the own-price coefficients in the urban model, presented in the second and third columns of Table 6-17, reveal that six of the 21 goods have own-price terms which are significant at the 95% confidence level. The F test of the joint effect of all 21 own-price terms indicates that they are statistically significant at the 99% confidence level (F = 5.23).

The F tests shown in the last two columns of Table 6-17 indicate that the price vector is significantly different than zero at the 95% confidence level in 13 of the 21 equations. Looking at the model as a

Table 6-17: Effect of prices on urban food demand

Budget category	own price coeff α_{ii}	t	own price elast	F stat for all prices	Prob under Ho
SORGH	-0.48	-1.37	-1.52	0.93	0.55
RICE	-3.77	-3.00	-2.59	1.53	0.06
BREAD	0.23	1.47	-0.65	1.47	0.07
CASSA	2.01	4.15	0.13	3.96	0.00
SWPOT	-1.88	-2.11	-1.46	4.36	0.00
WHPOT	-1.61	-0.90	-1.24	4.75	0.00
BANAN	-0.90	-1.89	-1.29	1.31	0.15
CASFL	-1.19	-1.95	-1.48	1.67	0.03
BEANS	2.98	1.26	-0.64	2.43	0.00
PEAS	-0.16	-0.69	-1.38	3.02	0.00
VEGET	-0.21	-0.84	-1.13	1.61	0.04
BEEF	-0.25	-0.51	-1.08	1.91	0.01
MEAT	-0.34	-0.74	-1.16	1.45	0.09
MILK	0.71	1.20	-0.69	2.31	0.00
BBEER	-6.30	-6.03	-2.29	3.08	0.00
SBEER	-0.98	-2.08	-1.84	2.56	0.00
FBEER	0.74	0.41	-0.85	1.37	0.12
OIL	0.21	1.13	-0.90	1.22	0.22
SALT	0.60	4.26	0.12	1.42	0.10
SUGAR	0.19	0.62	-0.93	3.04	0.00
MEALS	-0.99	-1.17	-1.35	1.77	0.02

whole, the price terms are jointly significant at the 99% confidence level.

Derived non-food price elasticities: The non-food price elasticities for the urban sector are derived under the assumption of strongly separable preferences. Substituting into equation 6-3 the average urban food share (0.59), the expenditure elasticity of food (0.72), and the price elasticity of food (-0.91), the value of ϕ is calculated as -1.17. Combining this parameter with the non-food expenditure elasticities, the non-food price elasticities are calculated as shown in Table 6-18.

Table 6-18: Derived effect of prices on urban non-food demand

Budget category	share	elasticities expend	price
CLOTH	5.50	1.04	-1.20
HOUSE	10.04	1.93	-2.02
EQUIP	2.87	1.72	-1.97
ENERG	4.62	1.33	-1.52
HEALT	3.05	1.10	-1.28
EDUCA	1.07	1.36	-1.59
TRANS	4.84	1.72	-1.93
TOBAC	1.51	0.69	-0.80
LEISU	1.88	1.66	-1.92
OTHERF	5.69	0.69	-0.80

As in the rural model, these elasticities must be considered highly tentative. Housing, household equipment, transportation, and leisure/services are price elastic, while tobacco is the only price inelastic non-food category, according to these calculations.

As explained in section 6.2.4, the expenditure elasticities in this table reflect minor changes due to the re-estimation of the non-food categories imposing the price terms derived under additive preferences. Only in the case of tobacco is the adjustment noticeable at the level of precision presented in Table 6-18.

Finally, having completed the estimation of the 26 food and non-food categories, we derive the coefficients for the excluded budget category, "other food." The expenditure and household composition coefficients are defined so as to satisfy adding up, while the price terms are defined to satisfy homogeneity in the complete system. It is difficult to evaluate the plausibility of the estimates for "other food," but it is worth noting that the price and expenditure elasticities (-0.80 and 0.69) are similar to the averages for the explicitly modeled food categories (-0.91 and 0.72).

6.5 SUR model of urban demand with symmetry imposed

In this section, we briefly consider the results of the urban model when symmetry of compensated cross-price substitution effects is imposed. Since the estimated price terms form a 21x21 matrix, symmetry requires imposing 210 restrictions on the urban SUR model.

The correlation coefficients (R^2) for the urban equations are presented in Table 6-19. The non-food equations are unaffected by the restrictions placed on the food price terms. With regard to the food equations, except in a few cases (beans, sweet potatoes, and white potatoes), the reduction in the value of R^2 is generally around 3-5 percentage points. A Wald test of the 210 restrictions rejects the null hypothesis of symmetry at the 99% confidence level. However, we retain the symmetric demand model as one alternative because the willingness-to-pay calculations used in Chapter 7 require symmetry to qualify as well-defined measures of welfare.

The expenditure elasticities in the urban model with symmetry imposed are presented in Table 6-20. Under symmetry, the expenditure elasticities of sweet potatoes, beans, and prepared meals fall, with sweet potatoes becoming slightly inferior. On the whole, however, the expenditure elasticities are not greatly affected by the symmetry restriction.

Table 6-19: Summary of urban model with symmetry imposed

Budget category	Mean budget share	R^2
SORGH	0.92	0.11
RICE	2.37	0.12
BREAD	0.67	0.19
CASSA	1.79	0.27
SWPOT	3.84	0.39
WHPOT	6.24	0.29
BANAN	2.93	0.14
CASFL	2.40	0.22
BEANS	10.37	0.45
PEAS	0.41	0.15
VEGET	1.57	0.16
BEEF	2.90	0.17
MEAT	2.11	0.07
MILK	2.30	0.13
BBEER	4.82	0.28
SBEER	1.16	0.14
FBEER	4.17	0.18
OIL	2.07	0.16
SALT	0.54	0.31
SUGAR	2.59	0.22
MEALS	2.76	0.12
CLOTH	5.50	0.02
HOUSE	10.04	0.34
EQUIP	2.87	0.16
ENERG	4.62	0.11
HEALT	3.05	0.07
EDUCA	1.07	0.06
TRANS	4.84	0.18
TOBAC	1.51	0.09
LEISU	1.88	0.29

The estimated price elasticities, on the other hand, are substantially affected by imposing symmetry, as shown in Table 6-21. The price elasticities of sweet potatoes and salt, which were slightly positive in the unrestricted model, become slightly negative in the model with symmetry. Six other food price elasticities change by at least 0.20: rice and factory beer become more price responsive under symmetry, while sorghum, white potatoes, milk, and sorghum beer become less so.

Symmetry does not affect the urban expenditure elasticity for food as a whole (0.72), but it does increase the price elasticity of food somewhat (from -0.87 to -0.91). Because of the fixed relationship

Table 6-20: Effect of expenditure on urban demand under symmetry

Budget category	ln(exp) β_2	t	ln(exp) sqrd β_2	t	expend elast
SORGH	-1.59	-0.59	0.06	0.44	0.56
RICE	18.87	4.39	-0.88	-4.34	1.18
BREAD	5.24	3.37	-0.24	-3.23	1.41
CASSA	4.49	1.06	-0.26	-1.33	0.40
SWPOT	-35.19	-4.72	1.48	4.22	-0.06
WHPOT	8.50	1.22	-0.49	-1.50	0.70
BANAN	-1.06	-0.19	-0.02	-0.07	0.51
CASFL	-5.32	-1.11	0.18	0.81	0.39
BEANS	-25.85	-2.09	0.86	1.47	0.24
PEAS	0.02	0.01	-0.01	-0.07	0.75
VEGET	4.29	2.16	-0.20	-2.19	0.99
BEEF	22.18	4.99	-1.05	-5.02	1.03
MEAT	5.36	1.27	-0.24	-1.23	1.11
MILK	9.42	1.72	-0.45	-1.75	0.97
BBEER	22.52	2.34	-1.14	-2.51	0.69
SBEER	-0.98	-0.26	0.02	0.13	0.57
FBEER	12.18	1.24	-0.45	-0.98	1.64
OIL	11.15	4.46	-0.53	-4.47	1.05
SALT	-0.45	-0.62	0.01	0.26	0.50
SUGAR	11.41	2.92	-0.54	-2.94	1.01
MEALS	-17.51	-1.34	0.84	1.36	1.04
CLOTH	9.81	1.35	-0.46	-1.33	1.04
HOUSE	-63.88	-3.26	3.49	3.77	1.94
EQUIP	1.41	0.24	0.03	0.11	1.72
ENERG	22.05	2.98	-0.98	-2.80	1.33
HEALT	7.42	1.71	-0.34	-1.65	1.10
EDUCA	5.25	1.00	-0.23	-0.93	1.36
TRANS	-14.90	-1.25	0.88	1.56	1.72
TOBAC	7.59	2.13	-0.38	-2.28	0.68
LEISU	-4.25	-1.04	0.26	1.35	1.66

between price and expenditure elasticities of strongly separable commodity groups, this result make the non-food price elasticities somewhat greater under symmetry than in the unrestricted model. As shown in Table 6-22, the derived non-food price elasticities for the urban model with symmetry are roughly 0.10 greater than those without the symmetry restrictions. The relatively high price elasticity of demand for housing, household equipment, and transportation and the relatively inelastic demand for tobacco remain unchanged, however.

The coefficients of "other food," defined to satisfy adding up and homogeneity, generate elasticities which are roughly the same as those

Table 6-21: Effect of prices on urban food demand with symmetry imposed

Budget category	own price coeff α_{ii}	t	own price elast
SORGH	-0.28	-0.88	-1.30
RICE	-3.04	-2.91	-2.29
BREAD	0.15	1.03	-0.77
CASSA	1.50	3.33	-0.15
SWPOT	-2.60	-3.17	-1.64
WHPOT	-0.16	-0.11	-1.01
BANAN	-0.85	-1.91	-1.27
CASFL	-0.96	-1.72	-1.38
BEANS	1.59	0.79	-0.77
PEAS	-0.13	-0.62	-1.31
VEGET	-0.12	-0.59	-1.08
BEEF	-0.07	-0.18	-1.03
MEAT	-0.43	-1.05	-1.20
MILK	1.25	2.32	-0.46
BBEER	-5.51	-5.72	-2.13
SBEER	-0.39	-0.93	-1.33
FBEER	-0.54	-0.34	-1.16
OIL	0.04	0.26	-0.98
SALT	0.49	3.86	-0.09
SUGAR	0.04	0.14	-0.99
MEALS	-1.25	-1.57	-1.45

obtained in the unrestricted model.

6.6 Effect of zero expenditures on model

This section presents a brief digression to compare the rural food results obtained from the linear model with those of the Tobit model which adjusts for the fact that the dependent variable (budget share) is limited to being non-negative. We do not adopt the Tobit model for subsequent analysis because of the problems discussed in section 3.3.3, primarily the difficulty in imposing adding up and symmetry on the system. The test is limited to comparing OLS estimation of rural food demand estimation and Tobit estimation of rural food demand (single-equation OLS results are used for comparison because the Tobit model is also estimated equation-by-equation).

Table 6-22: Derived non-food price elasticities under symmetry

Budget category	share	elasticities expend	price
CLOTH	5.50	1.04	-1.11
HOUSE	10.04	1.93	-1.88
EQUIP	2.87	1.72	-1.82
ENERG	4.62	1.33	-1.41
HEALT	3.05	1.10	-1.18
EDUCA	1.07	1.36	-1.47
TRANS	4.84	1.72	-1.79
TOBAC	1.51	0.69	-0.74
LEISU	1.88	1.66	-1.77
OTHFO	5.69	0.74	-0.81

The software package LIMDEP is used to implement the Tobit estimation of rural food demand. The marginal effect of each independent variable on the dependent variable is calculated using the expression given in MacDonald and Moffitt (1980). These partial derivatives are then used to evaluate the price and income elasticities at the means. Table 6-23 compares elasticities obtained with the Tobit model to those obtained from the unrestricted linear model.

Several patterns can be identified from this table. First, as expected, for goods consumed by a high proportion of the households, the differences between the two models is negligible. This is the case for the basic staple commodities such as sweet potatoes, cassava, bananas, and beans, as well as banana beer and salt. Overall, eight of the 17 expenditure elasticities differ by less than 0.10, while nine of the 17 price elasticities differ by less than 0.20.

The divergence between the two models is greatest for the goods consumed by less than a quarter of the sample: tomatoes, rice, and sugar. Only one good (tomatoes) is a luxury in one model and a necessity in the other (none change in the other direction). And just one commodity (sugar) is price inelastic in one model and price elastic in the other (none switch from elastic to inelastic).

Table 6-23: Comparison of elasticities estimated with Tobit and OLS

Product	Mean budget share	% hhs consum-ing	expenditure elasticities Tobit	OLS	price elasticities Tobit	OLS
SORGH	1.41	58.9	0.70	0.48	-0.90	-0.77
RICE	0.49	23.7	2.11	1.83	-1.86	-3.15
CASSA	5.92	79.6	0.58	0.45	-1.09	-1.05
SWPOT	12.54	96.7	0.04	-0.00	-0.96	-0.96
WHPOT	4.02	64.4	1.78	1.82	-1.86	-2.41
BANAN	5.86	80.7	1.09	1.02	-0.80	-0.81
BEANS	21.86	100.0	0.62	0.62	-0.89	-0.89
PEAS	1.39	44.8	1.37	1.07	-1.03	-1.84
TOMAT	0.13	21.9	1.63	0.68	-1.17	-1.77
BEEF	1.39	63.0	1.82	1.66	-0.61	-0.18
OTHMT	1.91	44.4	2.06	1.79	-1.52	-1.37
BBEER	10.15	90.4	1.42	1.36	-1.59	-1.65
SBEER	3.91	72.2	1.19	1.23	-1.68	-1.97
FBEER	0.80	26.7	2.74	2.87	-1.11	-8.49
OIL	0.96	45.9	1.82	1.58	-0.96	-0.94
SALT	1.02	87.0	0.56	0.55	-0.62	-0.55
SUGAR	0.31	21.5	2.22	2.28	-0.86	-1.25

Second, the divergence between the two models is greater for the price elasticities than for the expenditure elasticities. For example, among expenditure elasticities, the gap between the two estimates is greater than 0.35 for only one good (tomatoes). By contrast, among price elasticities, the divergence is larger than this for seven commodities (factory beer, rice, peas, tomatoes, white potatoes, beef, and sugar).

Third, the price elasticities tend to be closer to -1.0 in the Tobit model. In the case of goods with price inelastic demand, this is may be the result of the bias in the Tobit model identified by Pitt (1983). He notes that, by forcing the same parameters to predict both the probability of positive budget shares and the expected budget share among consumers, the Tobit estimates are biased when the signs of these effects are different. This occurs with price insensitive goods since an increase in price lowers the probability of consumption but raises the expected budget share among those who consume it. In this case, the price parameter, α_{ii}, is biased toward zero and the price elasticity is biased toward -1. This bias may explain the fact that the Tobit price elasticities for the three most price-insensitive goods (sorghum, salt, and beef) are considerably closer to -1.0 than the corresponding OLS estimates.

In summary, the differences between the elasticity estimates of the Tobit model and the OLS model are relatively small, particularly for staple commodities and other goods consumed by a majority of the households. In the case of price insensitive goods, the differences between the two models may be due to biases in the Tobit model. For the purposes of this analysis, the arguable statistical advantages of the Tobit model do not seem to outweigh the problem that restrictions from economic theory (adding up and symmetry) cannot be imposed. As discussed in Chapter 3, symmetry is necessary for the "willingness-to-pay" measures to be well-defined.

6.7 Measurement error and quality effects

In this section, we briefly explore the possibility that the estimated price elasticities are affected by quality effects and/or measurement error. Following Deaton (1987 and 1988), it is assumed that there is no true price variation within the sample cluster. This assumption means that quality and measurement error effects can be tested in two ways which are explained in turn. In order to simplify the analysis, the results are based on single-equation OLS regression.

6.7.1 Effect of household expenditure on prices paid

Any significant (positive) effect of household expenditure on the average "price" (unit value) paid for a good within the cluster must be the result of quality effects since true prices are presumed constant in each cluster. Thus, the elasticity of unit value with respect to household expenditure within the cluster may be interpreted as the "elasticity of quality with respect to household expenditure."

This relationship is tested by regressing "unit values" on total expenditure and household composition, using only within-cluster variation in each variable (this is equivalent to adding a dummy variable for each cluster in the sample). The first column of Table 6-24 shows the estimated quality elasticities for the rural sector, while the second and third columns give the F statistic for the joint impact of the two expenditure terms and the corresponding probability under the null hypothesis.

The rural quality elasticities are relatively low: 13 of the 17 are 0.05 or less and six are even negative. The highest values are for tomatoes (0.14), bananas (0.09), and banana beer (0.08). Furthermore, in none of the equations can we reject the null hypothesis that there are no expenditure effects, even at the 90% confidence level. Thus, there is little or no evidence of quality effects in rural food demand.

Table 6-25 presents the results for the urban food demand model. Here, the estimated quality elasticities are even lower: all but one is below 0.05 and nine of the 21 are negative. And again, in none of the equations are the expenditure terms statistically significant, even at the 90% confidence level[1]. Thus, urban food demand also reveals little or no sign of quality effects.

6.7.2 Effect of within-cluster unit value on budget share

Assuming that prices do not vary within the cluster, a significant effect of "price" (unit value) on demand within the cluster is probably due to measurement error. Measurement error can generate this pattern since, for a given monetary value of a transaction, a

1. The largest quality elasticity is for prepared meals, 0.23. This product also comes closest to being statistically significant at the 90% confidence level.

Table 6-24: Quality and measurement error effects in rural food demand

	Estimation of unit values[1]			Estimation of budget share[2]	
	Impact of expenditure			Impact of unit values	
Prod	elast	F	prob	F	prob
SORGH	-0.03	0.55	0.84	1.30	0.27
RICE	0.03	8.72	0.11	0.90	0.65
CASSA	0.04	0.61	0.80	1.24	0.32
SWPOT	0.03	0.64	0.79	0.42	1.00
WHPOT	0.05	1.71	0.44	0.73	0.85
BANAN	0.09	0.60	0.81	0.52	0.98
BEANS	-0.06	1.65	0.45	0.67	0.90
PEAS	-0.01	0.24	0.98	0.95	0.59
TOMAT	0.14	1.87	0.41	0.88	0.68
BEEF	0.01	0.05	1.00	0.96	0.58
MEAT	0.02	0.38	0.92	0.56	0.97
BBEER	0.08	2.61	0.32	1.70	0.10
SBEER	0.05	1.67	0.45	0.50	0.99
FBEER	-0.01	0.58	0.82	1.02	0.51
OIL	0.07	2.35	0.35	0.89	0.66
SALT	-0.02	1.13	0.58	1.24	0.32
SUGAR	-0.00	0.21	0.99	2.37	0.02

1. Price (unit value) is regressed on log expenditure, log expenditure squared, number of adults, number of children, a dummy for female-headed household and dummy variables for each sample cluster.

2. Budget share is regressed on log expenditure, log expenditure squared, number of adults, number of children, a dummy for female-headed households, prices (unit values), and dummy variables for each sample cluster.

positive error in quantity generates a negative error in "price[1]."

The test is implemented by estimating the standard demand equation, but using the deviations from the cluster mean as observations (this is equivalent to including dummy variables for each sample cluster). If the price vector is statistically significant within clusters, then measurement error is a likely cause.

1. This relationship could also result from quality effects if richer households spend the same portion of their budget on a good as do poorer households but purchase a smaller quantity of higher quality (higher priced) goods. However, this seems a less likely cause.

Table 6-25: Quality and measurement error effects in urban food demand

	Estimation of unit value[1]			Estimation of budget share[2]	
	Impact of expenditure			Impact of unit value	
Prod	elast	F	prob	F	prob
SORGH	-0.04	0.88	0.68	0.60	0.96
RICE	-0.03	2.50	0.33	0.96	0.59
BREAD	0.02	0.56	0.83	1.55	0.12
CASSA	0.02	3.50	0.25	1.78	0.06
SWPOT	0.02	0.51	0.86	1.22	0.31
WHPOT	-0.01	0.38	0.93	1.58	0.11
BANAN	-0.02	0.10	1.00	0.73	0.87
CASFL	0.01	0.35	0.94	1.29	0.25
BEANS	0.02	0.43	0.90	0.68	0.91
PEAS	-0.01	1.02	0.62	1.33	0.22
VEGET	0.05	1.88	0.41	0.66	0.92
BEEF	0.00	0.02	1.00	0.80	0.79
MEAT	0.05	1.02	0.62	1.85	0.05
MILK	0.02	1.14	0.58	1.57	0.11
BBEER	-0.04	0.79	0.72	2.11	0.02
SBEER	0.03	1.58	0.47	1.37	0.20
FBEER	-0.01	0.40	0.91	0.83	0.75
OIL	-0.02	0.13	1.00	0.90	0.66
SALT	-0.04	3.07	0.28	1.58	0.11
SUGAR	0.05	0.46	0.88	1.36	0.21
MEALS	0.23	7.77	0.12	1.14	0.38

1. Price (unit value) is regressed on log expenditure, log expenditure squared, number of adults, number of children, a dummy for female-headed household and dummy variables for each sample cluster.

2. Budget share is regressed on log expenditure, log expenditure squared, number of adults, number of children, a dummy for female-headed households, prices (unit values), and dummy variables for each sample cluster.

The last two columns Table 6-24 give the F statistic and the corresponding probability under the null hypothesis that there are no "within cluster" price effects on budget share in the rural sector. The null hypothesis cannot be rejected at the 95% confidence level for 16 of the 17 equations; only sugar shows some "within cluster" effects which indicate measurement error effects.

The last two columns of Table 6-25 provide the corresponding results from the urban demand model. In this case, the null hypothesis cannot be rejected at the 95% level in 19 out of 21 equations; "other meat" and banana beer are the only goods which show signs of measurement error effects.

In summary, although quality effects and measurement error may exist in the ENBC data, these tests indicate that they are not statistically significant and that the quality elasticities are generally below 0.05. The measurement error is probably reduced by several factors. First, the ENBC involved 56 days of transaction data, thus including in many cases multiple observations for the same good and the same household. The measurement error would be reduced by calculating the average unit value over several purchases. Second, because home production is so important in the rural sector, many of the unit values for food were in fact average prices at the region-round level, again diluting measurement error.

The small size of the quality effects is probably the result of the generally low level of income in Rwanda and the high degree of disaggregation in this demand study. For much of the population, additional income is allocated to increasing the quantity of food consumption rather than improving the quality. Nonetheless, the estimated elasticities are similar in magnitude to previous estimates. Using 1979 data from the Côte d'Ivoire, Deaton (1988) estimated quality elasticities which ranged from 0.023 to 0.065. Similarly, Deaton (1990) estimated quality elasticities from 1981 Indonesian data and obtained values from -0.04 to 0.22. Thus, it is possible that with a larger sample, some of the Rwandan quality elasticities may have been statistically significant.

CHAPTER SEVEN

WELFARE AND NUTRITIONAL IMPACT OF DEVALUATION

7.1 Introduction

This chapter uses information about household demand and the sources of household income to evaluate the welfare and nutritional effects of price changes associated with currency devaluation. In carrying out the simulation, various assumptions can be made about the supply response of agriculture and about the prices and wages associated with devaluation. In order to reduce the number of alternative scenarios, a set of base assumptions is adopted, and the sensitivity analysis is limited to studying the effects of changing each assumption one at a time. In addition, various measures of welfare impact are compared.

In the base scenario, household demand is simulated using the demand parameters estimated under the restrictions associated with consumer theory: adding up, symmetry, and homogeneity. The effect of price changes on income (the "profit effect") is modeled using survey data on the composition of income, but no agricultural supply response is assumed. The price changes for both consumers and producers are hypothesized based on the tradeability of each good. Real wages are assumed to follow the average trend of other countries undergoing currency devaluation, as studied by Edwards (1989). And welfare impact is measured using equivalent variation (EV) and compensating variation (CV), calculated using the Vartia method with 20 iterations. The results of this base scenario are presented in section 7.2.

Alternative scenarios will also be considered to determine the sensitivity of the results to changes in assumptions about demand, supply, prices, and wages. In section 7.3, the base scenario is compared to the simulated impact of the historical prices observed in Rwanda over the seven months following devaluation. Section 7.4 tests the sensitivity of the results to alternative assumptions about real wage trends. Section 7.5 considers the implications of a more sophisticate model which incorporates agricultural supply response and a simpler model which ignores the profit effect completely. The last variant, presented in section 7.6, analyzes the results when the unrestricted parameters are used to model consumer demand. Finally, in section 7.7 we compare the various methods of calculating welfare impact, including consumer surplus, first- and second-order approximations of EV and CV, and two levels of precision in implementing the Vartia method.

7.2 Effects of hypothetical currency devaluation: base scenario

7.2.1 Assumption used in base scenario

On November 20, 1990, the Rwandan franc was devalued 40% relative to the International Monetary Fund Special Drawing Right. In other words, the local cost of foreign currency increased by two thirds (the inverse of 0.6 is 1.667). As discussed in section 4.2.5, we adopt the results of econometric analysis of devaluation episodes in 29 countries by Edwards (1989) and assume a rate of effectiveness of 0.6 in the first year after devaluation. Thus, a 67% increase in the local cost of foreign currency is translated into a increase in the ratio of tradeable to non-tradeable prices by 40%.

In Rwanda, the tradeable food commodities are limited to rice, wheat products, cooking oil, sugar, and most processed foods. Factory beer and beans are intermediate cases. The beer uses imported malt, but these imports represent a small portion of the total cost to consumers (Haggblade, 1987). Beans are imported to Rwanda, but these imports represent perhaps 10-15% of national bean consumption. In addition, beans are imported informally so that devaluation affects bean prices only indirectly through its effect on the parallel exchange rate. For the purpose of this analysis, factory beer is considered 50% tradeable and beans are considered 25% tradeable. These assumptions are summarized in Table 7-1.

Table 7-1: Assumed tradeable component of each budget category

Budget category	Tradeable component Rural	Urban
SORGH	0.00	0.00
RICE	1.00	1.00
BREAD	-	1.00
CASSA	0.00	0.00
SWPOT	0.00	0.00
WHPOT	0.00	0.00
BANAN	0.00	0.00
CASFL	-	0.00
BEANS	0.25	0.25
PEAS	0.00	0.00
TOMAT	0.00	-
VEGET	0.00	0.00
BEEF	0.00	0.00
MEAT	0.00	0.00
MILK	-	0.00
BBEER	0.00	0.00
SBEER	0.00	0.00
FBEER	0.50	0.50
OIL	1.00	1.00
SALT	0.00	0.00
SUGAR	1.00	1.00
MEALS	-	0.00
CLOTH	0.96	0.94
HOUSE	0.14	0.16
EQUIP	0.64	0.76
ENERG	0.82	0.27
HEALT	0.50	0.73
EDUCA	0.34	0.16
TRANS	0.51	0.84
TOBAC	0.00	0.00
LEISU	0.51	0.30
OTHFO	0.10	0.21

For the non-food categories, a highly disaggregated list of non-food goods and services was classified into tradeable and non-tradeable. Then the proportion of expenditure on each category which goes to tradeable goods was calculated. The price of each non-food category was assumed to rise in proportion with the share of tradeable good expenditure in that category. This procedure was carried out separately in the rural and urban areas to allow for the fact that the tradeable component of each non-food category varies somewhat between them.

As shown in Table 7-1, among the non-food categories, the tradeable component is highest for clothing and lowest for tobacco. Not surprisingly, the tradeable component is greater among urban consumers than rural for household equipment, health/hygiene, and transportation. Presumably, the higher incomes of urban consumers make them more likely to purchase imported goods which are generally of a higher quality and more expensive. In contrast, the tradeable component is higher among rural consumers for educational expenditures. This is due to the large share of rural education spending which is allocated to school uniforms, which are classified as tradeable. Because private schools are more common in the cities, urban households spend a greater portion of educational expenses on school fees which are considered non-tradeable services. Similarly, rural energy/water spending has a higher tradeable component because of the importance of kerosene[1]; most urban spending on energy/water is allocated to charcoal and electrical services, both of which are classified as non-tradeable.

In order to express the price changes in real terms, we normalize prices so that the budget share weighted average is 1.0. The result is that the price of pure non-tradeable goods and services falls about 7%, while that of pure tradeables rises by 30%. It is assumed that the percentage changes in price for a given commodity are the same throughout the country[2].

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1. Firewood is the primary source of energy in the rural areas, but it is generally gathered by families for their own consumption. Information on firewood use is not available for this analysis.

2. Since transportation depends on tradeable goods (fuel and vehicles), we would expect marketing margins to increase somewhat following devaluation. A more sophisticated modelling approach would use data on the regional flows of goods and transportation costs to incorporate this effect.

On the income side, agricultural producer prices are assumed to change in proportion to the consumer prices of the same commodities. Similarly, beer brewer income is assumed to reflect banana beer prices. Coffee prices are assumed to follow tradeable good patterns. Although coffee prices have not risen since devaluation due to international price trends, this assumption reflects the fact that, in the absence of devaluation, local coffee prices would certainly have had to decline.

Regarding real wages, Edwards (1989: 335-336) analysis of devaluation episodes reveals that, on average, real agricultural wages fall 3.5%, while real non-agricultural wages decline 8.5% over the year following devaluation. These figures are adopted for artisanal, commercial, and wage income. These assumptions cover only 20% of net income in rural areas, but they account for 92% of urban net income (see Table 5-2). Thus, the impact of devaluation on urban income is fairly crudely modeled, so that the distributional results within the urban sector reflect primarily different expenditure patterns among households.

As noted above, household demand in the base scenario is simulated using the demand parameters estimated under the restrictions of consumer theory: symmetry and homogeneity. These results were presented in sections 6.4 and 6.6. On the supply side, the base scenario assumes no agricultural supply response. This does not mean that there is no "profit effect," but rather that the profit effect is limited to the change in price multiplied by the original quantity of output. This can be considered an estimate of the short-term impact of price changes, before supply has time to adjust, or as a first-order estimate of the long-term impact of the price change (see section 3.4.1).

7.2.2 Aggregate demand and caloric intake

The assumptions described in the previous section are used to simulate the change in income and prices affecting each household in the sample, allowing us to predict the change in demand for each household. In this section, the aggregate results for the rural and urban sectors are considered.

Table 7-2 shows the change in mean budget shares resulting from the hypothesized price changes. These figures differ from those that would be obtained using the individual price elasticities presented in Chapter 6 for several reasons. First, these figures incorporate the effect of all prices, not just own-price, on demand for a given commodity. Second, this table incorporates the "profit effect" in which prices influence income which in turn affects demand. Third, the elasticities in Chapter 6 are valid for a household "at the mean" but do not necessarily represent the response of aggregate demand to price changes. Finally, the estimated elasticities are applicable only for marginal changes in prices, whereas non-marginal changes are simulated here.

It should be recalled that an increase (decrease) in budget share does not always correspond to an increase (decrease) in quantity demanded. For example, in the case of cooking oil, the budget share increases roughly 10% in response to a 30% increase in price; this implies a reduction in quantity demanded.

The last two columns of Table 7-2 provide a rough indicator of the welfare impact of each price change on the expenditure side (the effect of price changes on agricultural income is not included in this measure). CV_1 is the first-order approximation of compensating variation expressed as percentage of household expenditure: the percentage price change times the old budget share. EV_1, the first-order approximation of equivalent variation is similarly calculated except that the new budget share is used. These numbers show that, among the consumer price increases, the one with the most serious impact on rural welfare by far is the 30% increase in the price of clothing. This is particularly true when we consider that the welfare impact of changes in food prices is offset by simultaneous effects on agricultural income.

Table 7-2: Effect of hypothetical devaluation on rural demand

Prod	price change (pct)	budget share (percent) old	new	CV1 (pct)	EV1 (pct)
SORGH	-7.0	1.4	1.6	0.1	0.1
RICE	30.0	0.5	0.8	-0.1	-0.2
CASSA	-7.0	5.9	6.0	0.4	0.4
SWPOT	-7.0	12.5	12.4	0.9	0.9
WHPOT	-7.0	4.0	4.6	0.3	0.3
BANAN	-7.0	5.9	6.1	0.4	0.4
BEANS	2.0	21.6	22.0	-0.4	-0.4
PEAS	-7.0	1.4	1.8	0.1	0.1
TOMAT	-7.0	0.1	0.2	0.0	0.0
BEEF	-7.0	1.4	1.9	0.1	0.1
MEAT	-7.0	1.9	2.0	0.1	0.1
BBEER	-7.0	10.1	9.5	0.7	0.7
SBEER	-7.0	3.9	3.9	0.3	0.3
FBEER	11.0	0.8	0.8	-0.1	-0.1
OIL	30.0	1.0	1.1	-0.3	-0.3
SALT	-7.0	1.0	0.9	0.1	0.1
SUGAR	30.0	0.3	0.2	-0.1	-0.1
OTHFO	-3.0	9.9	7.8	0.3	0.2
CLOTH	29.0	6.3	6.4	-1.8	-1.8
HOUSE	-2.0	3.3	3.3	0.1	0.1
EQUIP	17.0	1.5	1.4	-0.3	-0.2
ENERG	23.0	1.2	1.3	-0.3	-0.3
HEALT	12.0	1.7	1.7	-0.2	-0.2
EDUCA	5.0	0.4	0.4	-0.0	-0.0
TRANS	12.0	0.8	0.8	-0.1	-0.1
TOBAC	-7.0	0.7	0.7	0.0	0.0
LEISU	12.0	0.4	0.4	-0.0	-0.0
TOTAL	-0.1	100.0	100.0	0.1	-0.0

Source: Simulation based on ENBC data.

Table 7-3 focuses on food consumption and caloric intake. Price increases result in reduced demand for beans, factory beer, cooking oil, and sugar. However, this is more than offset by increased consumption of tubers and bananas, with the result that the volume of food consumption and caloric intake rise slightly.

The aggregate impact of devaluation is simulated for the urban sector in the same manner as for the rural sector. Table 7-4 shows the mean budget shares among urban households before and after the relative price changes associated with devaluation. Higher prices reduce the average share allocated to rice, factory beer, cooking oil, sugar,

Table 7-3: Effect of hypothetical devaluation on rural food consumption

Prod	price change (pct)	quantity consumed (kilograms/ae/yr) old	new	% change	caloric intake (kcal/ae/day) old	new	% change
SORGH	-7.0	7.7	8.8	14.2	69.2	79.0	14.2
RICE	30.0	0.8	1.0	17.3	7.6	8.9	17.3
CASSA	-7.0	72.1	76.5	6.2	333.6	354.3	6.2
SWPOT	-7.0	208.4	211.8	1.6	439.6	446.8	1.6
WHPOT	-7.0	43.7	51.1	16.9	79.1	92.5	16.9
BANAN	-7.0	20.8	22.7	9.0	40.4	44.1	9.0
BEANS	2.0	92.2	89.6	-2.8	818.4	795.6	-2.8
PEAS	-7.0	5.4	7.2	32.8	38.4	51.0	32.8
TOMAT	-7.0	0.6	0.9	66.6	0.3	0.5	66.6
BEEF	-7.0	1.8	2.5	38.4	10.9	15.1	38.4
MEAT	-7.0	2.2	2.3	4.8	7.7	8.1	4.8
BBEER	-7.0	51.9	50.2	-3.4	122.4	118.3	-3.4
SBEER	-7.0	37.7	39.4	4.6	175.4	183.5	4.6
FBEER	11.0	1.2	1.0	-18.4	1.6	1.3	-18.4
OIL	30.0	0.8	0.7	-16.1	22.6	18.9	-16.1
SALT	-7.0	2.5	2.3	-11.6	0.0	0.0	-11.6
SUGAR	30.0	0.6	0.3	-40.6	5.9	3.5	-40.6
OTHFO	-3.0	35.0	27.4	-21.7	114.0	89.3	-21.7
TOTAL	-0.1	585.3	595.6	1.8	2287.1	2310.6	1.0

Source: Simulation based on ENBC data.

household equipment, and transportation. The last two columns of Table 7-4 indicate that the price increases in clothing and transportation have the greatest impact on the average urban household. Among the food categories, the most damaging price increases are those of sugar, cooking oil, and rice. By comparison, price increases in bread, beans, and factory beer are less important, at least to the average household.

It is worth noting that urban prices rise by 4.4% using a base weighted average. Although prices were normalized for the country as a whole, the higher budget shares of tradeable goods among urban consumers mean that the weighted average price change is positive (reflecting the same pattern, the weighted average rural price change is slightly negative).

Table 7-4: Effect of hypothetical devaluation on urban demand

Prod	price change (pct)	budget share (percent) old	new	CV1 (pct)	EV1 (pct)
SORGH	-7.0	0.92	1.01	0.06	0.07
RICE	30.0	2.37	1.71	-0.71	-0.51
BREAD	30.0	0.67	0.73	-0.20	-0.22
CASSA	-7.0	1.79	1.47	0.13	0.10
SWPOT	-7.0	3.84	4.82	0.27	0.34
WHPOT	-7.0	6.24	6.43	0.44	0.45
BANAN	-7.0	2.93	2.84	0.20	0.20
CASFL	-7.0	2.40	2.73	0.17	0.19
BEANS	2.0	10.37	11.35	-0.21	-0.23
PEAS	-7.0	0.41	0.75	0.03	0.05
VEGET	-7.0	1.57	1.45	0.11	0.10
BEEF	-7.0	2.90	2.83	0.20	0.20
MEAT	-7.0	2.11	2.25	0.15	0.16
MILK	-7.0	2.30	2.12	0.16	0.15
BBEER	-7.0	4.82	5.65	0.34	0.40
SBEER	-7.0	1.16	1.35	0.08	0.09
FBEER	11.0	4.17	3.95	-0.46	-0.43
OIL	30.0	2.07	1.98	-0.62	-0.59
SALT	-7.0	0.54	0.53	0.04	0.04
SUGAR	30.0	2.59	2.49	-0.78	-0.75
MEALS	-7.0	2.76	3.16	0.19	0.22
OTHFO	1.0	5.69	4.53	-0.06	-0.05
CLOTH	28.0	5.50	5.43	-1.54	-1.52
HOUSE	-1.0	10.04	9.89	0.10	0.10
EQUIP	21.0	2.87	2.48	-0.60	-0.52
ENERG	3.0	4.62	4.60	-0.14	-0.14
HEALT	20.0	3.05	3.00	-0.61	-0.60
EDUCA	-1.0	1.07	1.09	0.01	0.01
TRANS	24.0	4.84	4.00	-1.16	-0.96
TOBAC	-7.0	1.51	1.56	0.11	0.11
LEISU	4.0	1.88	1.80	-0.08	-0.07
TOTAL	4.4	100.00	100.00	-4.38	-3.62

Source: Simulation based on ENBC data.

Table 7-5 concentrates on food demand and caloric intake in the urban areas. There appears to be substitution away from rice and bread and toward sweet potatoes, white potatoes, and cassava flour, as well as substitution away from factory beer and toward sorghum beer. The total volume of food consumption rises somewhat (2.8%), but the caloric intake falls slightly (1.1%). The fall in caloric intake is due primarily to the reduced consumption of cooking oil and rice.

Table 7-5: Effect of hypothetical devaluation on urban food consumption

Prod	price change (pct)	quantity consumed (kilograms/ae/yr) old	new	% change	caloric intake (kcal/ae/day) old	new	% change
SORGH	-7.0	8.71	9.59	10.11	78.50	86.44	10.11
RICE	30.0	11.38	5.95	-47.71	103.82	54.29	-47.71
BREAD	30.0	2.67	2.13	-20.06	29.25	23.38	-20.06
CASSA	-7.0	21.74	16.48	-24.21	100.66	76.29	-24.21
SWPOT	-7.0	70.56	97.46	38.14	148.86	205.63	38.14
WHPOT	-7.0	150.64	158.45	5.18	272.43	286.53	5.18
BANAN	-7.0	58.91	57.52	-2.35	114.60	111.90	-2.35
CASFL	-7.0	20.21	23.88	18.17	190.45	225.06	18.17
BEANS	2.0	65.05	69.00	6.07	577.49	612.56	6.07
PEAS	-7.0	2.95	5.46	85.09	20.78	38.45	85.09
VEGET	-7.0	18.73	17.39	-7.18	12.83	11.91	-7.18
BEEF	-7.0	10.88	10.77	-0.96	65.56	64.93	-0.96
MEAT	-7.0	5.50	5.88	6.98	19.44	20.80	6.98
MILK	-7.0	7.33	6.68	-8.84	15.66	14.28	-8.84
BBEER	-7.0	206.65	214.06	3.59	486.95	504.42	3.59
SBEER	-7.0	20.87	25.29	21.19	97.20	117.80	21.19
FBEER	11.0	21.39	16.93	-20.87	29.31	23.19	-20.87
OIL	30.0	8.57	5.96	-30.47	234.81	163.26	-30.47
SALT	-7.0	3.25	3.20	-1.50	0.00	0.00	-1.50
SUGAR	30.0	13.54	9.37	-30.83	140.99	97.53	-30.83
MEALS	-7.0	5.97	6.19	3.71	26.35	27.33	3.71
OTHFO	1.0	33.06	22.76	-31.14	102.36	70.48	-31.14
TOTAL	4.4	768.54	790.40	2.84	2868.29	2836.46	-1.11

Source: Simulation based on ENBC data.

7.2.3 Distributional effects of hypothetical devaluation

Until this point, we have only considered the effects of the hypothetical devaluation on *aggregate* demand, food consumption, and caloric intake for the urban and rural sectors. In this section, the impact on different types of households will be considered. In this analysis, households are disaggregated by region, total expenditure (income), principal occupation, and sex of head of household. The welfare impact is calculated using the Vartia method to approximate the equivalent variation (EV) and the compensating variation (CV). As mentioned above, the Vartia method is applied with 20 iterations[1].

The welfare impact of price and income changes can be separated into the effect of changes in income and the effect of changes in consumer prices, as shown in section 3.4.4. The first component is the effect of the price changes on the household as producer, measured by producer surplus[2]. The second component is the impact on the household as consumer, measured as the CV or EV associated with the change in consumer prices[3]. Combining the producer and consumer impact, we get the total welfare impact of the price and income changes.

Table 7-6 shows the producer impact, the two measures of consumer impact, and the total impact of the hypothetical prices on different groups of households. For example, the value -3.5 under EV means that the price and income changes associated with devaluation are, on average, equivalent to a 3.5% decrease in the level of real expenditure (income) per adult equivalent. This figure is the sum of a negative producer impact (-4.0) and a smaller positive consumer impact (0.5). Similarly, the CV value of -3.6 means that, on average, compensation equal to 3.6% of their original level of expenditure would be necessary to make Rwandan households as well of as before devaluation.

This result should be interpreted with some caution. The fact that the average impact is negative has little bearing on the desirability of devaluation as a policy option. First, as mentioned in Chapter

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1. Price changes are divided into 20 increments and after each increment, household income is adjusted to compensate for the price change. Willingness to pay is approximated by the sum of these adjustments (Vartia, 1983).

2. In the base scenario, no supply response is assumed so the percentage change in producer surplus is simply the weighted average of output price increases, where the weights are the proportion of output from each source (see equation 3-31).

3. This is measured as the area under the compensated demand function, h(p,u), over the range of price movement (see equation 3-42). CV uses the "before" demand function, while EV uses the "after" function.

Table 7-6: Effect of hypothetical devaluation on households

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Sector						
Rural	-3.8	0.7	0.6	-3.1	-3.2	1.3
Urban	-7.8	-2.7	-3.5	-10.4	-11.3	0.8
Mean	-4.0	0.5	0.4	-3.5	-3.6	1.3
Expenditure quintile						
1st	-4.0	1.5	1.4	-2.5	-2.6	0.4
2d	-4.0	1.0	0.9	-2.9	-3.0	0.7
3d	-2.6	-0.0	-0.1	-2.6	-2.8	1.9
4th	-4.3	0.7	0.6	-3.6	-3.8	0.7
5th	-5.1	-0.6	-0.9	-5.7	-6.0	2.6
Mean	-4.0	0.5	0.4	-3.5	-3.6	1.3
Principal occupation						
Farmer	-3.4	1.0	0.9	-2.5	-2.6	1.1
Artisan	-6.5	-0.2	-0.5	-6.7	-7.0	1.5
Merchant	-3.2	-1.6	-1.9	-4.8	-5.1	2.3
Employee	-6.9	-1.7	-2.2	-8.6	-9.1	2.7
Various	-4.8	-0.1	-0.3	-4.9	-5.1	1.0
Mean	-4.0	0.5	0.4	-3.5	-3.6	1.3
Sex of head of household						
Male	-3.9	0.5	0.4	-3.4	-3.5	1.5
Female	-4.5	0.5	0.4	-4.0	-4.1	0.5
Mean	-4.0	0.5	0.4	-3.5	-3.6	1.3

Source: Simulation based on ENBC data.

2, the pre-devaluation situation is generally unsustainable so that maintaining the original condition is not an option. Second, this model simulates only the short-term relative price effect, ignoring any impact on aggregate output and all long-term effects. Third, since price changes are expressed in relative terms, the negative impact is primarily a function of the *assumption* that real wages fall. In fact, given the size of the assumed drop in real wages, it is somewhat surprising that the average welfare impact is so modest.

Turning our attention to the distributional effects, the first part of Table 7-6 makes it clear that, under the assumptions of the base scenario, the proportional reduction in real income due to currency devaluation is over three times as great for urban households as for rural households. For urban households, the prices associated with devaluation imply a 10% decline in standard of living on average. For their rural counterparts, the decline is only about 3%[1]. Rural households face moderately lower incomes partially offset by small reductions in consumer prices. Urban households, by contrast, experience sharply reduced income, exacerbated by somewhat higher consumer prices[2].

It is worth noting that these results overestimate the proportional impact on rural households to the extent that non-food home production (excluded from our calculation of expenditure) is important. As noted in section 5.3.1, the value of collected firewood is probably the most significant component of rural non-food home production. Since non-food home production is likely to be much more important in the rural areas than in the cities, this omission also implies that, if anything, the results in Table 7-6 understate the difference between rural and urban impact.

Interestingly, the caloric impact is, on average, slightly positive, in spite of the reduction in real income. This may be the result of the fact that the food prices fall relative to non-food prices (see Tables 7-2 and 7-4). This, in turn, is a result of the greater tradeable component of non-food items compared to food (see Table 5-23). In addition, the tradeable food items whose prices increase (rice, bread, factory beer, and cooking oil) tend to be relatively expensive sources of calories compared to the non-tradeable staples (cassava, sweet potatoes, bananas, and so on).

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1. Without some assumptions about the marginal utility of money for different households, we cannot say which group is "hurt" more by the price changes. For example, we cannot be sure that a 3% reduction in the real income of a rural household would be less "painful" than a 10% reduction in the income of an urban household. Nonetheless, these figures provide useful information and contribute to a more informed application of the value judgements necessary to policy making.

2. The simulation assumes that the percentage price changes for a given commodity are equal or similar across households (compare Tables 7.2 and 7.4). However, the *average* price faced by a household is also a function of the composition of expenditure, which varies across households. Thus, saying that consumer prices rise more for urban households than rural means that they consume proportionately more of the (tradeable) goods whose prices increased.

The second part of Table 7-6 disaggregates the results by quintiles of real expenditure per adult equivalent. This section indicates that the price changes associated with devaluation affect higher-income households more seriously than lower-income households. The percentage reduction in real income is more than twice as great for the richest 20% of households as for the poorest 20% of them. Although the patterns are not clear-cut, it seems that the richest fifth of Rwandan households purchase more tradeables and sell more non-tradeables as a proportion of income (expenditure) than other households. Given the weak relationship between the tradeable share of the budget and total expenditure (see Tables 5-25 and 5-26), this pattern seems to be attributable to the greater market participation of high-income households. In other words, low income households are insulated from price changes by their reliance on home production.

With regard to principal occupation, farmers are the least affected by currency devaluation. Under the assumptions of the base scenario, households whose primary source of income is agriculture experience a 3% reduction in their standard of living, on average. These households account for 74% of all Rwandan households (see Table 5-3). At the other extreme, wage earners are the most severely affected by devaluation. For the 6% of Rwandan households whose primary source of income is wage employment, the price changes associated with devaluation are equivalent to an 8.6% decline in real income. This is due to a large reduction in income and the fact that they purchase more tradeable goods, whose prices rise.

It is worth noting that although non-agricultural income is assumed to fall 8.5%, the actual reduction in income among artisans, merchants, and employees ranges from 3.2% to 6.9%. The effect of wage reductions on household income is softened by the fact that most households have other sources of income.

Given the common practice of using a small number of socio-professional categories to analyze the distributional aspects of policy, it is worth asking how much of the variation in welfare impact is captured by this type of classification. Analysis of variance was used to determine the proportion of the variance in EV which can be "explained" by the principal occupation of the households. The results indicate that 50% of the variance occurs among occupations and 50% exists within each occupation. One implication of this result is that models which analyze policy impact using average characteristics of, say, half a dozen socio-professional categories may be ignoring 50% of the variation in welfare impact. This suggests that the micro-simulation approach adopted in this study merits wider application when sufficient data are available.

Table 7-6 also confirms, as a result of the price changes associated with devaluation, that female-headed households experience a slightly greater percentage reduction in real income than male-headed households. This is the result of different sources of income rather than different spending patterns. Nonetheless, it is worth noting that the difference is not very great: devaluation is equivalent to a 4% decrease in real income for female-headed households and it is equivalent to a 3.4% decline in real income for male-headed households.

At this point, we separate the rural and urban samples to analyze each one more closely. Table 7-7 shows the welfare impact on different categories of rural households. The first part of the table disaggregates the households according to rural expenditure quintiles (the fifth quintile represents the 20% of *rural* households with the highest expenditure per adult equivalent). The negative effect of devaluation is greatest among the high-income households and lowest among the poorest. Both spending and income patterns appear to contribute to this result.

Table 7-7: Effect of hypothetical devaluation on rural households

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Rural expenditure quintile						
1st	-3.9	1.5	1.4	-2.4	-2.5	0.4
2d	-4.0	1.2	1.1	-2.8	-2.8	0.7
3d	-2.7	-0.1	-0.3	-2.8	-2.9	2.0
4th	-4.0	0.7	0.6	-3.3	-3.4	0.9
5th	-4.5	0.1	-0.0	-4.4	-4.5	2.5
Mean	-3.8	0.7	0.6	-3.1	-3.2	1.3
Region						
N West	-4.5	1.0	0.8	-3.5	-3.7	2.0
S West	-3.6	-0.0	-0.1	-3.6	-3.8	1.8
N Centr	-3.9	0.8	0.7	-3.1	-3.2	0.4
S Centr	-4.1	0.4	0.3	-3.7	-3.8	1.5
East	-3.2	1.1	1.0	-2.2	-2.2	1.1
Mean	-3.8	0.7	0.6	-3.1	-3.2	1.3
Principal occupation						
Farmer	-3.4	1.0	0.9	-2.4	-2.5	1.1
Artisan	-6.2	0.1	-0.1	-6.1	-6.3	1.6
Merchant	-2.4	-1.2	-1.4	-3.6	-3.8	2.4
Employee	-6.3	-0.7	-1.0	-7.0	-7.3	3.1
Various	-4.6	0.0	-0.1	-4.6	-4.7	1.1
Mean	-3.8	0.7	0.6	-3.1	-3.2	1.3
Sex of head of households						
Male	-3.7	0.7	0.6	-3.0	-3.1	1.5
Female	-4.4	0.7	0.5	-3.7	-3.8	0.7
Mean	-3.8	0.7	0.6	-3.1	-3.2	1.3

Source: Simulation based on ENBC data.

The second section of Table 7-7 disaggregates rural households by region. These figures reveal that there is little geographic variation in the impact of devaluation, except that the East is less hurt than other rural regions. The Eastern zone is relatively low-density, drier area of the country. The farms in the East tend to be larger, averaging 2.0 hectares compared to 1.3 ha. for the country as a whole[1]. The East

1. These figures are from the Pilot Agricultural Census of 1982. Although average farm size has undoubtedly fallen since then, the East is still less densely populated than the rest of Rwanda.

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is even more specialized in agriculture than the rest of rural Rwanda, and it is the most important surplus producing area of the country (Ministry of Planning, 1988).

The impression that farmers are relatively shielded from the impact of devaluation is confirmed in the third section of Table 7-7 which separates rural households by principal occupation. Farmers are the least affected, the welfare impact being equivalent to a 2.4% reduction in real expenditure. In contrast, the impact on salaried employees and artisans in the rural sector is over twice as great. Most of the difference between them is due to the sources of income rather than spending patterns.

The last part of Table 7-7 breaks down the welfare impact by sex of head of household. The impact of devaluation is greater for female-headed households, although again the difference is rather small.

Turning to the impact of prices associated with devaluation on urban households, Table 7-8 reveals many of the same patterns found in the rural sector. The relative effect of devaluation appears to be the most serious for high-income households, salaried employees, merchants, and residents of Kigali. The effect is less severe for the poor, farmers (about 14% of the "urban" households), and residents of cities other than Kigali. In contrast to the rural results, there is little difference between male- and female-headed households in the urban sector; if anything, male-headed households are more severely affected by the prices associated with devaluation.

Table 7-8: Effect of hypothetical devaluation on urban households

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Urban expenditure quintile						
1st	-6.9	-0.6	-1.1	-7.6	-8.1	-2.2
2d	-7.6	-1.5	-2.1	-9.1	-9.7	-3.1
3d	-8.0	-3.2	-4.1	-11.2	-12.1	-0.6
4th	-8.1	-4.4	-5.5	-12.5	-13.6	-0.3
5th	-8.3	-3.6	-4.6	-11.9	-12.9	10.0
Mean	-7.8	-2.7	-3.5	-10.4	-11.3	0.8
City						
Kigali	-8.0	-2.9	-3.7	-10.9	-11.7	1.6
Other	-7.1	-2.2	-2.9	-9.3	-10.0	-1.3
Mean	-7.8	-2.7	-3.5	-10.4	-11.3	0.8
Principal occupation						
Farmer	-6.0	-0.0	-0.4	-6.0	-6.4	-2.9
Artisan	-8.2	-2.1	-2.8	-10.3	-11.0	1.1
Merchant	-8.2	-3.9	-5.0	-12.1	-13.2	1.7
Employee	-8.2	-4.0	-5.1	-12.2	-13.3	1.7
Various	-7.0	-1.9	-2.6	-8.9	-9.6	0.5
Mean	-7.8	-2.7	-3.5	-10.4	-11.3	0.8
Sex of head of household						
Male	-7.9	-2.7	-3.5	-10.6	-11.4	1.4
Female	-6.9	-2.7	-3.6	-9.7	-10.5	-2.5
Mean	-7.8	-2.7	-3.5	-10.4	-11.3	0.8

Source: Simulation based on ENBC data.

7.3 Effects of historical price changes

This section analyzes the historical price changes associated with the November 1990 devaluation and simulates the effect of these changes on different types of households in Rwanda. This allows us to compare the hypothetical prices changes which "should have" accompanied devaluation with the price changes that actually occurred. In addition, it provides some information on changes in the standard of living among Rwandan households over the period 1989-1991 during which devaluation took place.

On the other hand, historical prices reflect not just the devaluation but also a variety of factors from seasonal cycles and economic policy to trends in international prices. This is a particular problem in the case of the Rwandan devaluation because it occurred just one month after an unsuccessful invasion of the country by rebels in Uganda. Security measures impeded the flow of goods and labor within the country, as well as restricting international trade through Uganda[1].

7.3.1 <u>General price trends over 1989-1991</u>

Using prices collected by the Ministry of Planning and the budget shares from the ENBC, a monthly consumer price index (CPI) was constructed for the period from October 1989 to June 1991. As shown in Figure 7-1, the CPI rose significantly in May and June 1989, declined gradually over the following year. This pattern probably reflects the crop failures in the south and southwest of Rwanda which led to scattered outbreaks of famine. In October 1990, the CPI increased sharply, rising 17% above the September level. Since the devaluation did not occur until 20 November, much of this increase would seem to be attributable to the invasion[2]. Based on the limited data available, the October increase appears to have been a discrete increase in price level rather than an increase in the rate of inflation.

The impact of devaluation can be observed by constructing separate indexes for tradeable and non-tradeable goods, as shown in Figure 7-2. This graph makes it clear that the 1989 increase was principally the result of higher non-tradeable prices. Since this category is dominated by the starchy staples, this seems to confirm the idea that the 1989 increase was linked to the localized crop failure. Regarding the

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1. In normal times, the most direct route to the coast is through Uganda to Mombassa, Kenya. As a result of attacks on trucks in Uganda, much of Rwandan overland trade is rerouted through Tanzania.

2. Although prices often increase in anticipation of devaluation, it should be noted that devaluation had been expected for over a year and yet the price hikes did not occur until November.

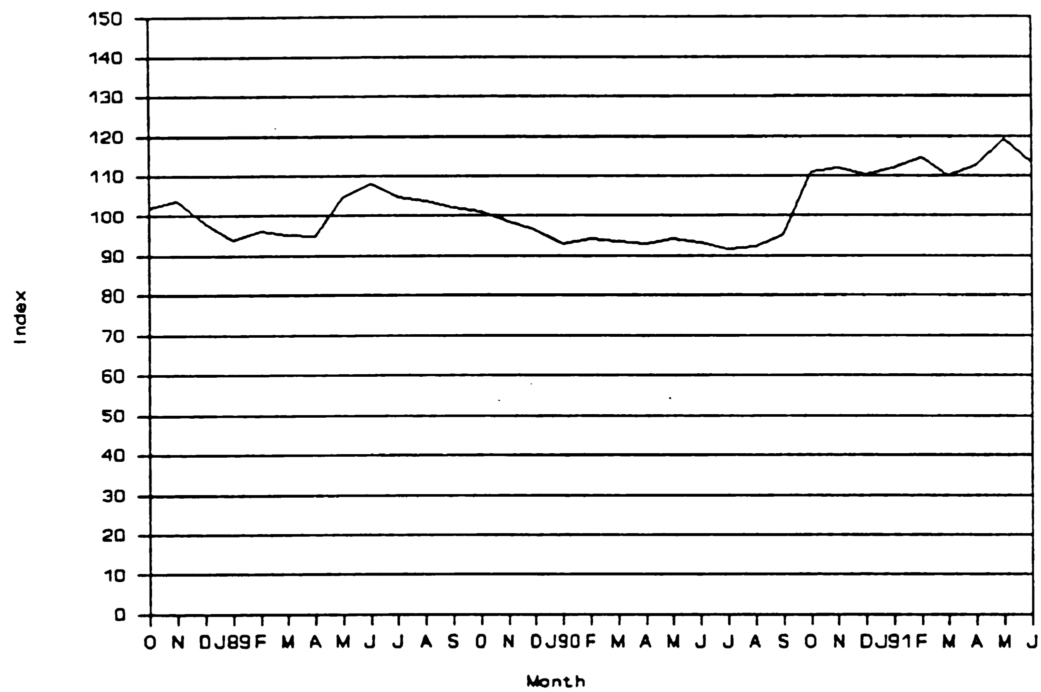

Figure 7-1: Consumer price index for Rwanda (1989=100)

October 1990 price increase, Figure 7-2 reveals that tradeable and non-tradeable prices increased in similar measure (14% and 17% respectively). However, the two indexes diverge substantially starting in November 1990. Non-tradeable prices fluctuate around the 110 level, while tradeable prices continue rising, reaching almost 130 by June 1991. From October 1990 to June 1991, the real exchange rate (RER), defined as the ratio of tradeable to non-tradeable prices, rose 31%.

Given the 66.7% increase in the official cost of foreign exchange, this increase in the RER implies an effectiveness ratio of 47%, short of the 60% average calculated by Edwards (1989) and adopted for the hypothetical devaluation in section 7.2. However, Edwards' figure represented the average for the calendar year following devaluation, so more recent price data would be necessary to make an appropriate comparison.

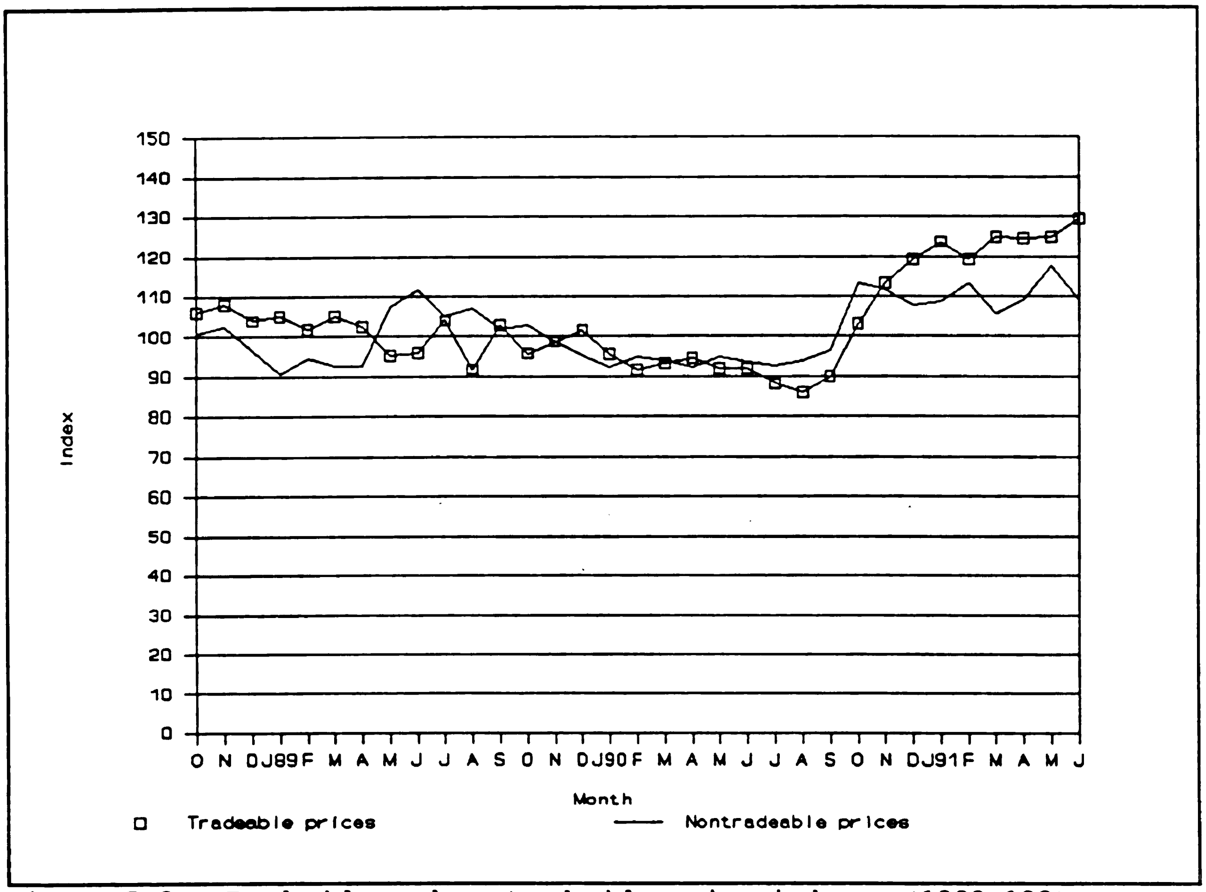

Figure 7-2: Tradeable and nontradeable price indexes (1989=100)

As noted above, historical prices are influenced by a variety of factors. The real exchange rate may have been affected by the war. For example, if internal security measures raised the prices of non-tradeable more than those of imports, the effect of devaluation on the RER would be dampened. On the other hand, if guerrilla activity in Uganda raised the price of tradeables disproportionately, the shift in RER may be strengthened by the war. Finally, it should be recalled that the import liberalization policies initiated at the end of 1990 probably dampened the effect of devaluation on the real exchange rate.

7.3.2 Prices used in the simulation

In order to evaluate the impact of historical price changes on Rwandan households, the first step is to choose a "before" and "after" period. Because of the significant fluctuations in monthly prices, particularly those of agricultural commodities, it was decided to use a three-month average for both periods. To avoid the potential interference of seasonal patterns, it seemed preferable to compare the same quarter in two different years. Thus, the second quarter of 1990 was chosen to represent the situation before devaluation, while the second quarter of 1991 represents the prices after devaluation. These two periods are centered six months before and six months after November 1990 when the Rwandan franc was devalued.

The food indexes are based on unpublished product-level prices for Kigali collected by the Office of Prices within the Ministry of Planning. These prices, along with the average prices from the urban portion of the ENBC, are presented in Table 7-9.

For the non-food categories, price indexes published by the Ministry of Planning (1991) were used. These indexes were calculated by Ministry personnel based on the prices of representative products and services within each category. These indexes are shown in Table 7-10.

As in the hypothetical case, the producer prices of agricultural commodities are assumed to change in the same proportion as the Kigali consumer price for the same good. As before, agricultural wages are assumed to decline by 3.5% in real terms, while non-agricultural wages fall by 8.5% in real terms. Coffee and tea prices are assumed to remain constant in nominal terms. This reduction in real coffee prices is a delayed reaction to the fall in international coffee prices in the late 1980s.

Tables 7-9 and 7-10 bear little resemblance to the price changes expected on the basis of the tradeability of each budget category (see Table 7-2). Even taking into account the fact that the hypothetical p

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Table 7-9: Food prices in Kigali before and after devaluation

Food category	Nominal prices (FRw/kg) ENBC/U 1985	May-July 1989	May-July 1990	% change '89-'90
Sorghum	22.9	33.7	45.3	34.7
Rice	90.2	109.3	122.0	11.6
Bread	65.4	50.0	54.3	8.7
Cassava	19.6	16.0	23.7	47.9
Cassava flour	34.1	43.7	50.3	15.3
Sweet potato	15.5	15.3	16.0	4.3
White potato	15.0	14.7	17.3	18.2
Banana	13.2	16.7	27.0	62.0
Beans (dry)	48.4	36.0	42.7	18.5
Peas (dry)	51.2	65.3	59.0	-9.7
Groundnuts	143.9	125.3	148.0	18.1
Cabbage	17.2	12.0	13.7	13.9
Eggplant	32.0	26.0	29.7	14.1
Onion	60.7	80.7	128.7	59.5
Tomato	42.7	26.0	34.3	32.1
Beef	141.5	191.3	192.7	0.7
Goat meat	141.7	250.7	248.0	-1.1
Fish (indagala)	162.9	189.3	255.0	34.7
Banana wine	29.7	45.7	50.7	10.9
Sorghum beer	15.0	18.3	22.3	21.8
Factory beer	90.0	95.0	86.7	-8.8
Carbonated soda	24.7	28.3	37.0	30.6
Palm oil	156.0	159.3	180.0	13.0
Salt	55.7	48.3	65.0	34.5
Sugar	87.8	113.7	142.3	25.2
Prepared meal	55.3	127.3	116.0	-8.9

Source: Unpublished data collected by the Ministry of Planning.

prices are normalized while the historical prices are not, it is clear that prices cannot be reliably predicted at this level of disaggregation. Tradeable goods such as rice, beans, and factory beer registered modest increases, while some non-tradeable commodities such as bananas and cassava experienced sharp increases.

There a number of possible explanations. First, these are Kigali prices so that the price increases for bananas and cassava may reflect in part the increased cost of transporting them to the capital (on the other hand, if this were a factor, we would expect the price of sweet potatoes to increase as well). Second, some prices were set by administrative decision rather than by market forces. An initial increase in the government-set price of factory beer was rescinded when tax revenue

Table 7-10: Non-food prices in Kigali before and after devaluation

Budget category	Price index (1989=100) 2d quart 1990	2d quart 1991	Price change (pct)
Clothing	101.8	130.1	33.1
Household equipment	96.4	137.1	41.3
Energy	96.8	168.1	76.2
Water	101.5	101.5	2.4
Health	93.9	110.3	8.5
Hygiene	93.7	140.3	43.7
Education	109.4	133.3	31.1
Transport	94.1	117.8	23.7
Tobacco	122.7	148.6	21.1
Leisure/services	97.7	106.9	9.3

Source: Ministère du Plan, 1991.

fell as a result. Another example is water and electricity rates, which were raised significantly to more closely reflect costs. This policy is part of the structural adjustment program but not a result of devaluation *per se*. Third, it may be that there is simply too much natural variability in commodity prices to pick up the impact of devaluation at this level of disaggregation and in this short a period of time. It is worth recalling that when aggregated into tradeable and non-tradeable groups, the price trends follow the expected patterns.

In spite of the divergence between anticipated price changes and the historical price trends, the model is run using historical prices. This simulation does not isolate the impact of devaluation, but it does give an idea of the probable effect on households of the all price changes that occurred over 1990-1991, regardless of their cause.

7.3.3 Aggregate demand and caloric intake

The simulated effect of the historical price changes on rural budgets is shown in Table 7-11. The budget shares of cassava and bananas rise but by less than the increase in price, implying reduced quantity demanded. The share allocated to factory beer rises significantly, though starting from a very low base. The non-food budget shares are relatively unaffected by the price changes. According to the last two columns in Table 7-11, the most serious impact on rural households *as consumers* were caused by the large price increase for bananas and the more moderate increase in bean prices. However, it should be noted that the welfare impact of these price changes is offset by their influence on rural households as producers. Among non-food categories, the increase in clothing price has the greatest effect on rural households.

Table 7-11: Effect of historical price changes on rural budgets

Prod	price change (pct)	budget share (percent) old	new	CV1 (pct)	EV1 (pct)
SORGH	34.7	1.4	1.6	-0.5	-0.5
RICE	11.6	0.5	0.3	-0.1	-0.0
CASSA	47.9	5.9	6.0	-2.8	-2.9
SWPOT	4.3	12.5	12.4	-0.5	-0.5
WHPOT	18.2	4.0	3.7	-0.7	-0.7
BANAN	62.0	5.9	6.6	-3.6	-4.1
BEANS	18.5	21.6	23.0	-4.0	-4.3
PEAS	-9.7	1.4	1.4	0.1	0.1
TOMAT	32.1	0.1	0.1	-0.0	-0.0
BEEF	0.7	1.4	0.8	-0.0	-0.0
MEAT	-0.2	1.9	2.7	0.0	0.0
BBEER	10.9	10.1	9.0	-1.1	-1.0
SBEER	21.8	3.9	3.4	-0.9	-0.7
FBEER	-8.8	0.8	2.0	0.1	0.2
OIL	30.6	1.0	0.6	-0.3	-0.2
SALT	34.5	1.0	0.6	-0.4	-0.2
SUGAR	25.2	0.3	0.5	-0.1	-0.1
OTHFO	23.0	9.9	9.5	-2.3	-2.2
CLOTH	33.1	6.3	6.2	-2.1	-2.1
HOUSE	23.0	3.3	3.1	-0.8	-0.7
EQUIP	41.3	1.5	1.4	-0.6	-0.6
ENERG	76.2	1.2	1.4	-0.9	-1.0
HEALT	8.5	1.7	1.6	-0.1	-0.1
EDUCA	31.1	0.4	0.4	-0.1	-0.1
TRANS	23.7	0.8	0.8	-0.2	-0.2
TOBAC	21.1	0.7	0.7	-0.1	-0.1
LEISU	9.3	0.4	0.4	-0.0	-0.0
TOTAL	22.1	100.0	100.0	-22.1	-22.2

Source: Simulation based on ENBC data.

Table 7-12 presents the aggregate changes in the quantity of food consumed and caloric intake by rural households. There is substitution away from cassava, white potatoes, and bananas, whose prices rose significantly, and toward beans and sweet potatoes, whose price increases were more modest. The price increase of cassava has the greatest negative impact on caloric intake, but this is offset by increased reliance on beans. The net effect is that the volume of food consumption and caloric intake fall by less than 2%. The small size of the fall in caloric intake is due to the fact that participation in the market is limited. In addition, the increases in food prices are offset by increased revenue for surplus food producers.

Table 7-12: Effect of historical prices on rural food consumption

Prod	price change (pct)	quantity consumed (kilograms/ae/yr) old	new	% change	caloric intake (kcal/ae/day) old	new	% change
SORGH	34.7	7.7	7.3	-4.3	69.2	66.2	-4.3
RICE	11.6	0.8	0.5	-38.5	7.6	4.7	-38.5
CASSA	47.9	72.1	58.6	-18.7	333.6	271.1	-18.7
SWPOT	4.3	208.4	224.6	7.8	439.6	473.9	7.8
WHPOT	18.2	43.7	39.0	-10.7	79.1	70.6	-10.7
BANAN	62.0	20.8	17.8	-14.5	40.4	34.6	-14.5
BEANS	18.5	92.2	97.8	6.1	818.4	868.6	6.1
PEAS	-9.7	5.4	6.9	25.9	38.4	48.3	25.9
TOMAT	32.1	0.6	0.4	-21.0	0.3	0.2	-21.0
BEEF	0.7	1.8	1.2	-36.3	10.9	6.9	-36.3
MEAT	-0.2	2.2	3.4	55.4	7.7	12.0	55.4
BBEER	10.9	51.9	49.2	-5.3	122.4	115.9	-5.3
SBEER	21.8	37.7	30.7	-18.4	175.4	143.1	-18.4
FBEER	-8.8	1.2	2.9	143.2	1.6	4.0	143.2
OIL	30.6	0.8	0.5	-44.2	22.6	12.6	-44.2
SALT	34.5	2.5	1.4	-46.1	0.0	0.0	-46.1
SUGAR	25.2	0.6	0.7	27.9	5.9	7.5	27.9
OTHFO	23.0	35.0	31.4	-10.1	114.0	102.5	-10.1
TOTAL	22.1	585.3	574.3	-1.9	2287.1	2242.7	-1.9

Source: Simulation based on ENBC data.

The simulated impact of historical price changes on urban budgets is shown in Table 7-13. On average, prices increased about 20% in the urban areas. The shifts in budget allocations seem to be driven more by reductions in real income than by the individual price changes. Larger shares of the budget are spent on necessities such as beans, sweet potatoes, cassava root, and cassava flour, while smaller shares are allocated to luxuries such as factory beer, rice, bread, sugar, and most non-food categories. The price increases which put the largest dent in urban living standards are those of energy/water, housing, beans, and clothing.

Table 7-13: Effect of historical price changes on urban budgets

Prod	price change (pct)	budget share (percent) old	new	CV1 (pct)	EV1 (pct)
SORGH	34.7	0.9	0.9	-0.3	-0.3
RICE	11.6	2.4	1.9	-0.3	-0.2
BREAD	8.7	0.7	0.5	-0.1	-0.0
CASSA	47.9	1.8	2.3	-0.9	-1.1
SWPOT	4.3	3.8	4.1	-0.2	-0.2
WHPOT	18.2	6.2	8.2	-1.1	-1.5
BANAN	62.0	2.9	2.5	-1.8	-1.6
CASFL	0.0	2.4	2.8	0.0	0.0
BEANS	18.5	10.4	11.8	-1.9	-2.2
PEAS	-9.7	0.4	0.5	0.0	0.1
VEGET	0.0	1.6	1.4	0.0	0.0
BEEF	0.7	2.9	3.1	-0.0	-0.0
MEAT	-0.2	2.1	1.9	0.0	0.0
MILK	0.0	2.3	1.9	0.0	0.0
BBEER	10.9	4.8	5.4	-0.5	-0.6
SBEER	21.8	1.2	1.2	-0.3	-0.3
FBEER	-8.8	4.2	4.0	0.4	0.3
OIL	30.6	2.1	2.0	-0.6	-0.6
SALT	34.5	0.5	0.6	-0.2	-0.2
SUGAR	25.2	2.6	2.4	-0.7	-0.6
MEALS	-8.9	2.8	2.9	0.2	0.3
OTHFO	23.0	5.7	6.0	-1.3	-1.4
CLOTH	33.1	5.5	5.3	-1.8	-1.8
HOUSE	23.0	10.0	8.6	-2.3	-2.0
EQUIP	41.3	2.9	2.3	-1.2	-1.0
ENERG	76.2	4.6	3.7	-3.5	-2.8
HEALT	8.5	3.1	3.0	-0.3	-0.3
EDUCA	31.1	1.1	1.0	-0.3	-0.3
TRANS	23.7	4.8	4.2	-1.1	-1.0
TOBAC	21.1	1.5	1.6	-0.3	-0.3
LEISU	9.3	1.9	1.8	-0.2	-0.2
TOTAL	20.5	100.0	100.0	-20.5	-19.7

Table 7-14 concentrates on the effect of the historical price changes on urban food consumption. In caloric terms, the largest reductions in consumption are those of bananas, cooking oil, and sugar, but this is offset by increase caloric intake from white potatoes, cassava flour, and beans. The net effect is that urban caloric intake declines by less than 3%.

Table 7-14: Effect of historical prices on urban food consumption

Prod	price change (pct)	quantity consumed (kilograms/ae/yr) old	new	% change	caloric intake (kcal/ae/day) old	new	% change
SORGH	34.7	8.7	6.1	-30.4	78.5	54.6	-30.4
RICE	11.6	11.4	8.4	-25.9	103.8	76.9	-25.9
BREAD	8.7	2.7	1.9	-29.6	29.2	20.6	-29.6
CASSA	47.9	21.7	23.4	7.5	100.7	108.2	7.5
SWPOT	4.3	70.6	73.2	3.7	148.9	154.4	3.7
WHPOT	18.2	150.6	184.7	22.6	272.4	334.0	22.6
BANAN	62.0	58.9	31.1	-47.2	114.6	60.5	-47.2
CASFL	0.0	20.2	25.0	23.8	190.5	235.7	23.8
BEANS	18.5	65.1	69.6	7.1	577.5	618.3	7.1
PEAS	-9.7	3.0	4.3	45.1	20.8	30.1	45.1
VEGET	0.0	18.7	17.5	-6.7	12.8	12.0	-6.7
BEEF	0.7	10.9	12.1	11.1	65.6	72.8	11.1
MEAT	-0.2	5.5	5.0	-10.0	19.4	17.5	-10.0
MILK	0.0	7.3	6.0	-17.5	15.7	12.9	-17.5
BBEER	10.9	206.6	192.9	-6.7	486.9	454.5	-6.7
SBEER	21.8	20.9	19.4	-7.2	97.2	90.2	-7.2
FBEER	-8.8	21.4	22.5	5.4	29.3	30.9	5.4
OIL	30.6	8.6	6.8	-20.4	234.8	186.8	-20.4
SALT	34.5	3.2	3.0	-6.2	0.0	0.0	-6.2
SUGAR	25.2	13.5	10.2	-24.9	141.0	105.9	-24.9
MEALS	-8.9	6.0	6.5	9.3	26.4	28.8	9.3
OTHFO	23.0	33.1	28.5	-13.8	102.4	88.2	-13.8
TOTAL	20.5	768.5	758.1	-1.4	2868.3	2794.0	-2.6

Source: Simulation based on ENBC data.

7.3.4 Distributional effects of historical price changes

This section considers the effect of the historical price changes on different groups of households. As explained above, the welfare and caloric impact are calculated for each household in the sample and then averaged over the household category. Table 7-15 presents the producer impact, the two measures of consumer impact, and the net impact, as well as the percentage change in caloric intake for each group.

The net effect of the price changes between the second quarter of 1990 and a year later is equivalent, for the average household, to a reduction in real income of 4.7%. Compensation of 5.8% of household

Table 7-15: Effect of historical price changes on households

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Sector						
Rural	16.2	-20.3	-21.4	-4.1	-5.1	-2.5
Urban	1.4	-16.0	-19.1	-14.6	-17.8	0.8
Mean	15.5	-20.1	-21.3	-4.7	-5.8	-2.3
Expenditure quintile						
1st	16.7	-20.2	-21.2	-3.6	-4.5	-3.3
2d	16.7	-20.0	-20.8	-3.3	-4.1	-2.6
3d	15.8	-20.7	-22.0	-5.0	-6.3	-2.8
4th	16.0	-20.5	-21.6	-4.5	-5.6	-3.0
5th	12.1	-19.1	-20.6	-6.9	-8.5	-0.2
Mean	15.5	-20.1	-21.3	-4.7	-5.8	-2.3
Principal occupation						
Farmer	17.2	-20.7	-21.5	-3.4	-4.3	-2.2
Artisan	10.6	-19.2	-21.2	-8.6	-10.6	-3.3
Merchant	12.1	-17.5	-18.8	-5.4	-6.7	-3.1
Employee	4.4	-16.4	-19.1	-12.0	-14.7	-2.2
Various	15.0	-20.4	-21.7	-5.3	-6.6	-2.1
Mean	15.5	-20.1	-21.3	-4.7	-5.8	-2.3
Sex of head of household						
Male	15.2	-20.0	-21.1	-4.8	-6.0	-2.3
Female	16.6	-20.7	-21.8	-4.1	-5.1	-2.4
Mean	15.5	-20.1	-21.3	-4.7	-5.8	-2.3

Source: Simulation based on ENBC data.

expenditure would be necessary to restore the original living standard. However, this figure varies considerably from one type of household to another. The relative impact on urban households is over three times as great as the impact on rural households (the absolute equivalent variation or compensating variation would be much greater). Most of this difference is due to the fact that urban income, based heavily on wages and services, rises only slightly (1.4%). By contrast, a large portion of rural incomes is tied to commodity prices and rise significantly (16%).

The second part of Table 7-15 divides households according to the level of expenditure per adult equivalent. These results indicate that low-income households are much less affected by the price changes over

1990-91 than high-income households. For the poorest 20% of the households, the price changes were equivalent to a 3.6% reduction in real income, while for the richest 20%, they were equivalent to a 6.9% reduction. This difference is due primarily to the relative importance of different sources of income rather than to the composition of expenditure.

The third part of the table disaggregates the households by principal occupation. Again, employees are the hardest hit, and farmers are relatively insulated from the price changes. This is consistent with the quintile results since salaried workers earn high incomes on average, while farmers tend to be the poorest segment of the population.

Finally, male-headed households appear to have been more affected by the price trends than female-headed households, although the differences are quite modest.

In the interest of space, the rural and urban results will not be presented here. However, it is worth briefly reviewing some of the results. In the rural areas, the households least affected by the historical price changes were poor households, farmers, and those in the Eastern zone. Employees were particularly hard hit. In the urban areas, poor households are again less affected than others (though the relationship is weaker than in the rural sector). Farmers and urban residents outside Kigali were also relatively protected from the price changes. Differences in impact according to the sex of head of household were weak or non-existent.

Thus, in spite of the fact that the historical price trends were quite different than the expected "hypothetical" price changes, the results of the simulation in terms of distributional impact were quite similar. One possible explanation is that the similarity is due to the wage assumptions, which were the same in the two simulations. An alternative explanation is that semi-subsistence households (and by extension, poor households) are somewhat insulated from price changes by virtue of their limited participation in the market.

7.4 Wage rate assumptions

As described in section 5.2, only 6% of Rwandan households depend on wages for a majority of their income, but over half of both urban and rural households have some wage income. This section tests the hypothesis that the results obtained in sections 7.2 and 7.3 were primarily the result of the assumption that real wages decline. In particular, the greater impact of devaluation on high income households may have resulted from the assumption that real wages fall, since wages are an important source of income for these households. The base scenario of is rerun except that now it is assumed that wages and salaries are held constant in real terms.

Table 7-16 shows the welfare and caloric impact of the hypothetical devaluation with nominal wages allowed to rise at the same level as commodity prices. Not surprisingly, both urban and rural households are better off in this simulation than in the base scenario. The effect of the hypothetical devaluation is equivalent to a 1.7% increase in real income for the average Rwandan household. Once again, urban households are more negatively affected than rural households: the impact for rural households is equivalent to a 2% increase in real income, while for urban households it is equivalent to a 4% decrease in real income.

The table reveals that urban incomes fall while urban consumer prices rise, whereas in the rural sector average income increases while average prices fall. Another way to express this is that urban income is more heavily dependent on non-tradeables (particularly services) than rural income, and urban spending is more heavily weighted to tradeable goods (particularly non-food spending) than rural spending.

The second part of Table 7-16 divides households according to their expenditure quintile. As in previous scenarios, the poorest

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Table 7-16: Effect of hypothetical devaluation on households assuming real wage remains constant

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Sector						
Rural	1.3	0.7	0.6	2.0	1.9	4.6
Urban	-1.1	-3.1	-3.5	-4.1	-4.6	3.1
Mean	1.2	0.5	0.4	1.7	1.6	4.5
Expenditure quintile						
1st	1.0	1.4	1.4	2.5	2.4	4.4
2d	1.1	1.0	0.9	2.1	2.1	4.4
3d	2.2	-0.1	-0.1	2.1	2.0	4.9
4th	0.8	0.7	0.6	1.5	1.4	4.1
5th	0.9	-0.7	-0.9	0.1	-0.0	4.9
Mean	1.2	0.5	0.4	1.7	1.6	4.5
Principal occupation						
Farmer	1.4	1.0	0.9	2.4	2.3	4.4
Artisan	0.3	-0.4	-0.5	-0.1	-0.2	5.0
Merchant	2.1	-1.8	-1.9	0.3	0.2	5.1
Employee	-0.0	-2.0	-2.2	-2.0	-2.3	5.3
Various	0.5	-0.2	-0.3	0.3	0.2	4.1
Mean	1.2	0.5	0.4	1.7	1.6	4.5
Sex of head of household						
Male	1.4	0.5	0.4	1.8	1.7	4.7
Female	0.5	0.5	0.4	1.0	0.9	3.9
Mean	1.2	0.5	0.4	1.7	1.6	4.5

Source: Simulation based on ENBC data.

households are the least harmed by the hypothetical price changes. In this case, the price changes are equivalent to a 2.5% increase in real income. As household expenditure rises, the benefits of the hypothetical devaluation decline, until they are essentially zero for the richest 20% of households.

The third part of Table 7-16 separates households according to the principal occupation. As in the base scenario, employees are the most seriously affected by the price and income changes, while farmers are the least negatively affected. In this case, farmers actually gain from the hypothetical devaluation. The other occupations remain in an intermediate position, neither gaining nor losing.

According to the last section of Table 7-16, male-headed households benefit more under this scenario than female-headed households. The table also indicates that the difference is due to income patterns rather than to spending patterns. This result is probably related to the fact that wage income is less common for female-headed households than for male-headed households.

Most of these patterns are repeated in the rural and urban subsamples (see Appendix X). In the rural sector, the poor benefit the most and the rich the least from this devaluation scenario. In the cities, the pattern is less clear, but the poorest 40% are certainly less negatively affected than the rest of the urban population.

In summary, most of the patterns observed in the base scenario and the historical price scenario have been repeated in this simulation with real wages held constant. Thus, these results appear not to be due simply to the real wage assumptions. Rather, they seem to be a reflection of the different spending and income patterns among Rwandan households.

7.5 Supply response assumptions

In the base scenario, the producer impact (the effect of prices on income) is simply the change in price multiplied by the level of output. This can be described as a first-order estimate of producer surplus or the short-term effect of prices on income. In this section, we consider the sensitivity of the results to changes in the way the effects on producers are specified.

The first question is whether it is important to include the producer impact at all. Brief inspection of Tables 7-6 and 7-15 make it clear that ignoring the producer impact would seriously distort the results. This is particularly true when nominal price changes are modeled since the implicit assumption behind omitting the producer impact in this case is that nominal income remains constant. For exam

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example, if we ignored the producer impact in the historical price simulation of Table 7-15, we would conclude that the welfare effect of the price changes was equivalent to a 20% fall in real income rather than the actual figure of less than 5%.

Omitting the producer impact is probably less distorting when deflated prices are used, since in this case the implicit assumption is that *real* income is constant. On the other hand, to the extent that real wages tend to fall as a result of devaluation, this procedure would underestimate the negative effect. For example, the base scenario simulates a hypothetical devaluation using normalized prices. Table 7-6 demonstrates that the consumer effect gives an overly optimistic view of the net effect of the price changes.

The next question concerns the possible improvement in the simulation by incorporating supply response. In the medium- to long-term, producers adapt to price changes, substituting away from goods whose prices have declined and toward those with higher returns. Clearly, a model which incorporates supply response will generate a more positive (or less negative) welfare impact than one which holds output constant. But it is an empirical issue whether the magnitude of this change is important.

Ansoanuur (1991) estimated the supply elasticities for a number of agricultural commodities. The elasticities ranged from 0.02 for bananas to 1.92 for the long-run response of coffee, as shown in Table 7-17. Since these elasticities were estimated using deflated prices, the supply response was calculated using the relative price changes of agricultural commodities. In carrying out these calculations for each household, we assume that the supply elasticity of each household is the same, and that each household changes the output of existing crops but d

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Table 7-17: Estimated agricultural supply elasticities

Crop	Estimated supply elasticity
Sorghum	0.167
Rice	0.069
Cassava	0.121
Sweet potatoes	0.081
White potatoes	0.394
Bananas	0.018
Beans	0.094
Coffee (short term)	0.385
Coffee (long term)	1.925
Tea (short term)	0.046
Tea (long term)	0.250

Source: Ansoanuur (1991).

does not change the crop mix[1].

Since supply response information is only available for agricultural commodities, the analysis in this section will focus on the rural sector. Table 7-18 shows the distributional impact of the hypothetical devaluation on rural households with agricultural supply response as estimated by Ansoanuur (1990). Comparing this table with Table 7-7 from the base scenario (without supply response), it appears that the introduction of these supply elasticities makes virtually no difference in the results. The average producer impact is -3.7% of household expenditure, only a very slight improvement from -3.8% in the base scenario. The other sets of corresponding figures are equal close or indistinguishable at this level of precision.

Certainly part of the explanation for the fact that incorporating these supply elasticities has virtually no effect on the results is that the elasticities are quite small, particularly for beans, sweet potatoes, and bananas. Thus, another simulation was run setting all the agricultural supply elasticities to 1.0. In view of agricultural supply

1. This assumption is a necessary result of using time-series data to model supply response. Modeling crop mix would require cross-sectional data, perhaps in conjunction with a tobit model.

response studies from other less developed countries, this probably represents an probably upper bound for the actual supply elasticities.

Table 7-18: Effect of hypothetical devaluation on rural households, assuming medium agricultural supply elasticities

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Rural expenditure quintile						
1st	-3.9	1.5	1.4	-2.4	-2.4	0.6
2d	-3.9	1.2	1.1	-2.7	-2.8	0.8
3d	-2.6	-0.2	-0.3	-2.7	-2.8	2.3
4th	-3.9	0.7	0.6	-3.2	-3.3	1.0
5th	-4.4	0.1	-0.0	-4.3	-4.5	2.3
Mean	-3.7	0.7	0.6	-3.1	-3.2	1.4
Region						
N West	-4.4	1.0	0.8	-3.5	-3.6	1.8
S West	-3.5	-0.0	-0.1	-3.6	-3.7	2.0
N Centr	-3.8	0.8	0.7	-3.0	-3.1	0.6
S Centr	-4.0	0.4	0.3	-3.6	-3.7	1.8
East	-3.1	1.1	1.0	-2.1	-2.1	1.3
Mean	-3.7	0.7	0.6	-3.1	-3.2	1.4
Principal occupation						
Farmer	-3.3	1.0	0.9	-2.4	-2.4	1.3
Artisan	-6.1	0.1	-0.1	-6.1	-6.3	1.6
Merchant	-2.2	-1.2	-1.4	-3.5	-3.6	2.8
Employee	-6.3	-0.7	-1.0	-7.0	-7.3	3.1
Various	-4.6	0.0	-0.1	-4.5	-4.7	1.2
Mean	-3.7	0.7	0.6	-3.1	-3.2	1.4
Sex of head of household						
Male	-3.6	0.7	0.6	-2.9	-3.0	1.6
Female	-4.4	0.7	0.5	-3.7	-3.8	0.6
Mean	-3.7	0.7	0.6	-3.1	-3.2	1.4

Source: Simulation based on ENBC data.

Table 7-19 shows the simulated impact of a hypothetical devaluation with agricultural supply elasticities set at 1.0. Again comparing the results to the base scenario presented in Table 7-7, the incorporation of an elastic supply response reduces the average producer impact from -3.8% of household expenditure to -3.5%. The net impact, as measured with equivalent variation, declines from -3.1% without supply response to -2.8% with supply response. Of course, the position of farmers relative to other occupations improves since it is only agricultural production that is allowed to respond to price changes in this simulation. But all of the basic patterns with respect to expenditure quintile, region, occupation, and sex of head of household remain essentially unchanged.

Table 7-19: Effect of hypothetical devaluation on rural households, assuming high agricultural supply elasticities

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Rural expenditure quintile						
1st	-3.7	1.5	1.4	-2.2	-2.3	0.2
2d	-3.7	1.2	1.1	-2.5	-2.6	0.3
3d	-2.3	-0.1	-0.3	-2.4	-2.5	2.5
4th	-3.8	0.7	0.6	-3.0	-3.1	0.6
5th	-4.2	0.2	-0.0	-4.1	-4.3	1.8
Mean	-3.5	0.7	0.6	-2.8	-3.0	1.1
Region						
N West	-4.2	1.0	0.8	-3.2	-3.4	1.9
S West	-3.2	-0.0	-0.1	-3.3	-3.4	1.9
N Centr	-3.7	0.8	0.7	-2.8	-2.9	0.1
S Centr	-3.9	0.5	0.3	-3.4	-3.6	1.2
East	-2.9	1.1	1.0	-1.8	-1.9	0.9
Mean	-3.5	0.7	0.6	-2.8	-3.0	1.1
Principal occupation						
Farmer	-3.1	1.0	0.9	-2.1	-2.2	1.0
Artisan	-6.1	0.1	-0.1	-5.9	-6.2	1.2
Merchant	-1.9	-1.2	-1.4	-3.2	-3.3	2.7
Employee	-6.2	-0.7	-1.0	-6.9	-7.2	2.7
Various	-4.4	0.1	-0.1	-4.4	-4.5	0.5
Mean	-3.5	0.7	0.6	-2.8	-3.0	1.1
Sex of head of household						
Male	-3.4	0.7	0.6	-2.7	-2.8	1.4
Female	-4.2	0.7	0.5	-3.5	-3.7	-0.1
Mean	-3.5	0.7	0.6	-2.8	-3.0	1.1

Source: Simulation based on ENBC data.

In summary, the effect of incorporating agricultural supply response into the simulation is modest to negligible. Even with agricultural production is assumed to be quite responsive to price, the distributional patterns of the hypothetical devaluation are not affected. Although incorporating some kind of producer impact is critical in such a model, it appears that a first-order approximation of producer surplus is sufficient for most purposes.

7.6 Demand response assumptions

In the base scenario, demand was modeled using the parameters estimated under the restrictions of consumer theory. It is worth asking whether the results change appreciably when the unrestricted demand parameters are used instead. These demand parameters, and their corresponding price and income elasticities, are described in sections 6.3 and 6.5.

Table 7-20 indicates that the consumer effect and hence the net impact is somewhat greater, in absolute value, when the unrestricted demand model is adopted. This presumably reflects the fact that imposing symmetry made demand somewhat more price responsive, allowing greater adaptation on the part of consumers to changes in price. Nonetheless, all the basic results obtained when using the restricted model hold as well when the unrestricted model is adopted.

The relative insensitivity of the results to changes in demand response is illustrated by the considering the extreme case when there is no demand response. If compensated demand is perfectly inelastic, then the area under the curve (willingness to pay) is simply the original quantity times the price change. This is equal to the first-order approximation of compensating variation for an arbitrary demand system. Thus, we can use CV_1 under the base scenario to indicate the exact compensating variation in the extreme case in which consumer demand is completely inflexible.

As shown in Table 7-21, CV_1 is greater (in absolute magnitude) than the other welfare measures. At the same time, CV_1 is closely correlated with the other measures, in the sense that it gives the same results regarding the relative impact on rural and urban households, 7

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rich and poor households, and so on. In other words, the results concerning the relative impact of devaluation on different households are fairly insensitive to the responsiveness of demand to price changes.

Table 7-20: Effect of hypothetical devaluation on households using the unrestricted demand model

	Producer impact (PS)	Consumer impact (EV-PS)	Consumer impact (CV-PS)	Net impact (EV)	Net impact (CV)	Pct change in caloric intake
Sector						
Rural	-3.8	0.8	0.7	-3.0	-3.1	-1.7
Urban	-7.8	-2.6	-3.5	-10.4	-11.3	2.2
Mean	-4.0	0.7	0.5	-3.4	-3.6	-1.5
Rural expenditure quintile						
1st	-4.0	1.6	1.5	-2.4	-2.5	-3.1
2d	-4.0	1.2	1.0	-2.8	-2.9	-1.8
3d	-2.6	0.1	-0.0	-2.5	-2.7	-1.1
4th	-4.3	0.8	0.7	-3.5	-3.7	-2.6
5th	-5.1	-0.5	-0.9	-5.6	-6.0	1.0
Mean	-4.0	0.7	0.5	-3.4	-3.6	-1.5
Principal occupation						
Farmer	-3.4	1.1	1.0	-2.3	-2.5	-2.1
Artisan	-6.5	-0.1	-0.4	-6.6	-6.9	-0.5
Merchant	-3.2	-1.4	-1.8	-4.7	-5.0	1.4
Employee	-6.9	-1.6	-2.2	-8.5	-9.0	2.1
Various	-4.8	0.0	-0.2	-4.8	-5.0	-2.2
Mean	-4.0	0.7	0.5	-3.4	-3.6	-1.5
Sex of head of household						
Male	-3.9	0.7	0.5	-3.2	-3.4	-1.3
Female	-4.5	0.7	0.5	-3.8	-4.0	-2.4
Mean	-4.0	0.7	0.5	-3.4	-3.6	-1.5

Source: Simulation based on ENBC data.

7.7 Comparison of alternative welfare measures

Until this point, the only welfare measures used were the Vartia estimates of equivalent variation (EV) and compensating variation (CV). In implementing the Vartia method, 20 iterations were used to approximate EV and CV. In this section, these measures are compared to both more and less accurate approximations. More accurate approximations can

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be obtained by increasing the number of iterations used in the Vartia method. Less accurate measures can be calculated using first- and second-order Taylor series approximations of the expenditure function. In addition, consumer surplus is a frequently used measure of welfare impact, in spite of the theoretical problems described in section 3.4.2.

Returning to the base scenario, nine measures of welfare impact are calculated for each group of households and presented in Table 7-21. To conserve space, the producer and consumer impact are not listed separately; the figures in the table represent the net impact of the hypothetical devaluation.

Three conclusions can be drawn from this table. First, there are consistent differences in the magnitude of the welfare measures. The first-order approximation of compensating variation (CV_1) consistently overestimates by about 10% the magnitude of CV as measured by the 50-iteration Vartia estimate (CV_{50}). This is because it uses the "before" quantities as weights in averaging price changes, thus ignoring adaptation of consumers to price changes. In contrast, EV_1, which uses the "after" quantities as weights, underestimates the most accurate approximation of EV by about 10%. Consumer surplus falls between EV_1 and CV_1, as expected.

Second, the 20-iteration Vartia estimates and the second-order Taylor approximations tend to be more accurate (compared to the 50-iteration Vartia estimate) than the first-order Taylor approximation and consumer surplus.

And third, the order of different groups of households is virtually the same, no matter which welfare measure is used. In other words, all seven measures show the same relative patterns of welfare impact by location (urban or rural), expenditure quintile, principal occupation, or sex of head of household.

The high degree of correlation of different welfare measures across households is dramatically confirmed in Table 7-22. In every

Table 7-21: Welfare impact of hypothetical devaluation according to different welfare measures

	EV_1	EV_2	EV_{20}	EV_{50}	CS	CV_{50}	CV_{20}	CV_2	CV_1
Sector									
Rural	-2.8	-3.2	-3.1	-3.1	-3.3	-3.2	-3.2	-3.2	-3.7
Urban	-9.8	-10.4	-10.4	-10.5	-11.0	-11.2	-11.3	-11.1	-12.2
Mean	-3.2	-3.6	-3.5	-3.5	-3.6	-3.6	-3.6	-3.6	-4.1
Expenditure quintile									
1st	-2.3	-2.6	-2.5	-2.6	-2.6	-2.6	-2.6	-2.6	-3.0
2d	-2.7	-3.0	-2.9	-3.0	-3.1	-3.0	-3.0	-3.0	-3.5
3d	-2.3	-2.7	-2.6	-2.7	-2.8	-2.8	-2.8	-2.7	-3.3
4th	-3.4	-3.7	-3.6	-3.7	-3.8	-3.7	-3.8	-3.7	-4.2
5th	-5.3	-5.7	-5.7	-5.7	-6.0	-6.0	-6.0	-6.0	-6.6
Mean	-3.2	-3.6	-3.5	-3.5	-3.6	-3.6	-3.6	-3.6	-4.1
Principal occupation									
Farmer	-2.2	-2.5	-2.5	-2.5	-2.6	-2.5	-2.6	-2.5	-3.0
Artisan	-6.3	-6.8	-6.7	-6.7	-7.0	-7.0	-7.0	-6.9	-7.6
Merchant	-4.3	-4.8	-4.8	-4.8	-5.0	-5.1	-5.1	-5.1	-5.7
Employee	-8.1	-8.6	-8.6	-8.6	-8.9	-9.1	-9.1	-9.0	-9.8
Various	-4.6	-5.0	-4.9	-5.0	-5.1	-5.1	-5.1	-5.1	-5.7
Mean	-3.2	-3.6	-3.5	-3.5	-3.6	-3.6	-3.6	-3.6	-4.1
Sex of head of household									
Male	-3.1	-3.4	-3.4	-3.4	-3.5	-3.5	-3.5	-3.5	-4.0
Female	-3.7	-4.0	-4.0	-4.0	-4.1	-4.1	-4.1	-4.1	-4.6
Mean	-3.2	-3.6	-3.5	-3.5	-3.6	-3.6	-3.6	-3.6	-4.1

NOTE: EV1 = first-order approximation of equivalent variation
EV2 = second-order approximation of equivalent variation
EV20 = Vartia estimate of equivalent variation (20 iterations)
EV50 = Vartia estimate of equivalent variation (50 iterations)
CS = consumer surplus
CV50 = Vartia estimate of compensating variation (50 iterations)
CV20 = Vartia estimate of compensating variation (20 iterations)
CV2 = second-order approximation of compensating variation
CV1 = first-order approximation of compensating variation
All figures are expressed as a percentage of expenditure.

Source: Simulation based on ENBC data.

pair-wise comparison, the correlation coefficient (R^2) is over 0.99. This result does not mean that every measure is accurate but rather the ranking of households by impact is very similar across measures.

Table 7-23 compares each of the seven rougher approximations of relative welfare impact to the corresponding value of the 50-iteration Vartia estimate. The first line shows the mean difference, or bias, of each measure relative to the reference measure (EV_{50} or CV_{50}). For

Table 7-22: Correlation across households of different welfare measures

	EV_1	EV_2	EV_{20}	EV_{50}	CS	CV_{50}	CV_{20}	CV_2	CV_1
EV1	100.00	99.96	99.92	99.91	99.86	99.71	99.71	99.73	99.54
EV2	99.96	100.00	99.97	99.97	99.95	99.81	99.81	99.82	99.73
EV20	99.92	99.97	100.00	100.00	99.96	99.86	99.86	99.85	99.79
EV50	99.91	99.97	100.00	100.00	99.96	99.86	99.86	99.85	99.79
CS	99.86	99.95	99.96	99.96	100.00	99.95	99.95	99.95	99.91
CV50	99.71	99.81	99.86	99.86	99.95	100.00	100.00	99.99	99.95
CV20	99.71	99.81	99.86	99.86	99.95	100.00	100.00	99.99	99.95
CV2	99.73	99.82	99.85	99.85	99.95	99.99	99.99	100.00	99.93
CV1	99.54	99.73	99.79	99.79	99.91	99.95	99.95	99.93	100.00

Source: Calculated from simulations based on ENBC data.

example, EV_1 is, on average, half a percentage point (0.51) smaller, in absolute value, than EV_{50}. As shown in the second line, this corresponds to a 7.4% error. Similarly, CV_1 overestimates the Vartia estimate by almost 10%. The percentage error in using consumer surplus to measure either equivalent variation or compensating variation is smaller (4.6% and 1.6%, respectively). The second-order estimates of CV and EV and the 20-iteration Vartia estimates are even more accurate. These four measures have mean biases of less than 1%.

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Table 7-23: Comparison of alternative welfare measures

	Comparison with EV_{50}				Comparison with CV_{50}			
	EV_1	EV_2	EV_{20}	CS	CS	CV_{20}	CV_2	CV_1
Difference in mean value	0.51	-0.01	0.02	-0.32	0.12	-0.02	0.06-	0.71
Pct difference in mean value	-7.38	0.10	-0.27	4.63	-1.63	0.29	-0.79	9.66
Mean absolute deviation	0.52	0.08	0.02	0.32	0.19	0.02	0.08	0.71
Mean difference in rank	4.42	2.01	0.13	2.05	1.72	0.15	1.49	3.66

Source: Calculated from simulations based on ENBC data.

A measure may be very inaccurate, yet be unbiased, if the positive and negative errors offset each other. Thus, it is useful to look at the mean *absolute* value of the error, as shown in the third line of Table 7-23. For example, even though EV_2 has a smaller bias than EV_{20}, its mean absolute deviation is greater. In other words, EV_{20} consistently provides a slight underestimate, while EV_2 is less accurate but has both positive and negative errors.

The last line in Table 7-23 shows the mean difference between the order of the household when ranked by different measures. For example, if households are ranked first by EV_2 and then by EV_{50}, a household will change only two places, on average, out of the 567 possible rankings. The first-order approximations of welfare impact would be much less accurate, ranking households roughly four places away from their "true" place, on average. In contrast, the 20-iteration Vartia estimates give virtually the same ranking, household by household, as the 50-iteration Vartia estimates.

In summary, for the purpose of ranking household by welfare impact, there is little difference among the alternative welfare measures. However, if the magnitude of the welfare impact is of

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interest, then a second-order approximation or a Vartia approximation would be necessary to reduce the bias to less than 5%.

7.8 Conclusions

This chapter presents simulations of the relative price changes associated with devaluation and describes their impact on household welfare. Given the structure of the Rwandan economy, it appears that the adverse effect of these changes on urban households is three times as great as the effect on rural households. Furthermore, even within each sector, the higher income households are more adversely affected than the poor. This pattern is due to the sources of income and the composition of expenditure. Farmers are relatively insulated from these impacts because of the importance of subsistence production, while wage-earners are the most affected. Furthermore, the poor spend a larger share of their income on staple foods, which tend to be non-tradeables. There is little difference in impact between male- and female-headed households.

In the rural areas, price increases of clothing and kerosene probably had the most serious impact on household welfare. In the urban sector, price increases in clothing, transportation, rice and sugar were expected to have the greatest impact. Instead, the higher rates for water and electricity, housing, and beans were the most significant for the average urban household.

These results are relatively robust to changes in the assumptions of the model. The conclusions are not significantly affected when historical prices are used rather than hypothetical price, when real wages are assumed to remain constant rather than decline, when alternate demand parameters are used, and when agricultural supply response is assumed to be positive instead of zero.

In comparing various welfare measures, the simplest approximations of welfare impact performed relatively well in ranking households by the leve

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level of impact resulting from price changes. However, these measures are generally biased, with the magnitude of bias being between 8 and 10% for the modeled price changes.

CHAPTER EIGHT

SUMMARY AND CONCLUSIONS

This chapter reviews the principal results of the study and discusses the implications for policy and for research methods. In addition, a number of limitations of the study are listed and used to make suggestions for extending and improving the approach in future research.

8.1 Summary of results

8.1.1 Income and expenditure patterns

The results of the National Household Budget and Consumption Survey (ENBC) in Rwanda confirm the general view that Rwanda is a predominantly rural, predominantly agricultural, semi-subsistence economy. Farming is the principal occupation of almost three quarters of Rwandan households. Even in the urban sector, which accounts for 6% of the population, one household in seven relies on agriculture for most of its net income. Subsistence (or non-marketed) production accounts for three quarters of the value of food consumption in the rural areas, which in turn is over 80% of total expenditure. Even in the cities, home production represents a non-negligible source of food (21% of the value of food consumption, 17% of total expenditure).

At the same time, the survey reveals that there is considerable diversity of income sources in both rural and urban sectors. In the rural sector, 10% of the households obtain most of their income from self-employment in manufacturing and services, the largest sub-sector being the production of traditional beers. Another 15% are primarily occupied as traders, as employees, or in a variety of activities, no one of which accounts for over 50% of total income. In addition, rural households often have three or more income generating activities. Virtually all households brew traditional beer, 40% of them have other manufacturing or service activities, a quarter are involved in trading, and half of them earn some form of wage or salary income.

Urban households, like their rural counterparts, have diverse sources of income and one-job households are rare. In contrast to the view that the cities are composed primarily of wage-earners, the survey indicates that only 35% of the urban households obtain most of their income from wages and salaries. Over half of the urban household earn most of their income from self-employment.

The ENBC results also confirm that urban residents are generally better off than their rural counterparts. Although prices are higher in the cities, particularly the prices of unprocessed local foods, urban households have higher levels of expenditure per capita than do rural households even after taking into account the difference in prices. In the urban sector, the average level of expenditure is 2.4 times that of the rural sector. Furthermore, 87% of the urban household have per capita expenditure levels above the rural median.

One surprising result of the ENBC is the absence of a positive relationship between total farm size on the one hand and expenditure and caloric intake on the other. Three reasons for this patterns can be identified. First, small farms tend to be operated by small families due to life cycle patterns. Second, small farms have much higher economic returns per hectare than large farms. Presumably, this results from more intensive cultivation and the fact that, over time, farms have fragmented to smaller sizes in areas where agro-climatic conditions are the best. Third, small farms rely to a larger degree on non-farm sources of income. At the same time, the ENBC data indicate that there is a positive relationship between farm size per adult equivalent and measures of well-being. Not surprisingly, this relationship is stronger among households in which agriculture is the dominant activity.

The survey confirms the conventional view that only a small portion of agricultural production is marketed. For all the staple food crops, less than one third of total production reaches the market. In the case of sweet potatoes, bananas, and beans, the proportion is less than 10%. This implies that coffee and other export crops represent a larger percentage of agricultural sales than of agricultural production. In fact, coffee is by far the most important source of cash income among individual crops. Less well recognized, however, is the fact that food crops sales *as a whole* are twice as important as cash crop sales. Furthermore, most of the food crop sales are destined, not for the urban sector, but for other rural consumers. In other words, in spite of low levels of rural expenditure and the small share of expenditure which is in the form of cash purchases, rural households still account for the bulk of the *market* demand for food crops in Rwanda.

The effect of the price changes associated with devaluation on households is a function of several factors. First, the larger the proportion of total expenditure which is in the form of cash purchases, the more sensitive a household is to any fluctuations in market prices, including devaluation. The ENBC data indicate that market transactions account for 83% of the average urban budget but only 35% of the average rural budget. Furthermore, for the country as a whole and within each sector, market transactions are a larger share of total expenditure (and income) among high-income households than low-income households. The implication is that a price change will affect urban households over twice as much as rural households even in the absence of any difference in the composition of cash expenditure. Similarly, the richest 20% of households would be affected more than twice as much as the poorest 20%.

Second, to the extent that devaluation affects food prices, the impact on urban household is unambiguous, but the impact on rural households is less clear. The effect depends, in part, on the direction of change in relative prices and whether a household is a net seller or net buyer of the commodity in question. Analysis of the distribution of rural households by their net sales position in several key food crops

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reveals that, for most crops, about one quarter of the households are net buyers, one quarter net sellers, and half neither buy nor sell. Beans, and to a lesser degree sorghum, present a different pattern in which most rural households are net buyers. Furthermore, supporting the finding of Loveridge (1988), total purchases appear to exceed total sales for beans and sorghum, implying informal imports of these two crops from neighboring countries.

The correlation of net sales across commodities is weak and, for a number of commodity pairs, negative. In other words, net buyers of one staple food are not necessarily net buyers of others. At the same time, 45% of rural households are overall net buyers (expressed in caloric terms) of the six major food crops. With regard to the question whether net buyers tend to be poor, the answer is that it depends on the crop. This pattern is most evident in the case of beans, and appears weaker for cassava and sweet potatoes. In the case of white potatoes, net buyers may be better off than net sellers, on average.

The third factor influencing the effect of devaluation on households is the percentage of expenditure and of income which can be considered tradeable. Since a successful devaluation raises the price of tradeables relative to non-tradeables, a household gains to the extent that it produces tradeables and consumes non-tradeables. In the rural sector of Rwanda, almost half of all tradeable spending is on clothing, mostly imported cloth and used clothing. In the urban sector, transportation, clothing, and rice are the most important types of tradeable spending. The tradeable component of cash expenditure is, somewhat surprisingly, the same in rural and urban areas. It varies positively with income in the urban sector but apparently not in the rural sector. On the income side, tradeable production is somewhat erratic, possibly due to measurement and definitional problems. However, among the urban poor, their somewhat lower spending on tradeables is more than offset by very low levels of tradeable output.

However, the above measures of welfare impact are incomplete and do not take into account the adaptation of households as consumers and as producers to changing prices. When the demand for a good is highly elastic, the welfare impact of a price increase is less, reflecting the fact that there are substitutes in consumption or that the good is not essential. Similarly, if the supply is price elastic, then a price decrease has a less severe welfare impact, reflecting the fact that there are substitutes in production. The construction of more sophisticated welfare measures depends on estimating a demand model and, for measuring long-term welfare impact, estimating supply response.

8.1.2 Model of consumer demand

Separate rural and urban demand models were constructed using seemingly unrelated regression. The functional form used was the Almost Ideal Demand System (AIDS) augmented with a squared income term. Prices were included for all food items in the system, but no non-food prices were available. Three household composition variables were included: number of adults, number of children, and sex of head of household. The rural model included 17 food categories, while the urban model contained 21. Each model had nine non-food categories. Food own-price and cross-price elasticities were estimated directly, while non-food price elasticities were derived using Frisch's method which assumes strong separability of preferences.

The estimated elasticities of food demand with respect to total expenditure are closely correlated with the cost per calorie of the food product. The least expensive sources of calories (sorghum, cassava, sweet potatoes, bananas, and beans) have the lowest expenditure elasticities in both rural and urban sectors. Sweet potatoes have the lowest expenditure elasticity, but are not an inferior good at the mean expenditure level in either sector. More expensive sources of calories such as white potatoes, rice, and banana beer have higher expenditure elasticities. The highest expenditure elasticities are those of factory

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beer, animal products, and sugar, all quite costly sources of calories. Expenditure elasticities are generally lower in the urban sector than in the rural sector. For example, white potatoes and banana beer are "luxuries" in the countryside, but they are classified as "necessities" in the cities. Most of the tradeable food items such as rice, bread, sugar, and factory beer are "luxuries," implying that they are consumed disproportionately by higher-income households.

With regard to non-food categories, housing, household equipment, and transportation are "luxuries" in both urban and rural sectors, while tobacco has the lowest expenditure elasticity. In the case of clothing, education, and health/hygiene, the budget shares are relatively constant across expenditure levels within each sector.

The household composition variables reveal that, other things being equal, larger households consume more "luxuries" and fewer "necessities." This pattern is consistent with the hypothesis of economies of scale in household size, often found in household budget studies. Female-headed households spend significantly less on banana beer in both sectors. In the cities, they also spend less on factory beer, tobacco, and meals away from home, while allocating larger budget shares to vegetables and education.

The estimated food price elasticities are roughly proportional to the expenditure elasticities for the same items. In the rural sector, the demand for factory beer, rice, and white potatoes is quite responsive to prices, while that of the staple food commodities is less so. The pattern is less clear in the urban sector, with factory beer being less price-responsive and several staples having price elastic demand, perhaps due to greater substitution possibilities in the cities. By assumption, the derived non-food price elasticities are generally proportional to the corresponding expenditure elasticities.

Imposing symmetry of compensated cross-price effects naturally influences the price elasticities more than expenditure elasticities.

Nonetheless, the basic conclusions, as discussed above, apply equally to the unrestricted and restricted versions of the model.

Quality and measurement error effects were investigated using the within-cluster variation in the variables, as proposed by Deaton (1987 and 1988). Quality effects were tested by analyzing the within-cluster effect of household expenditure on the average price paid for different food items. For no commodity was the quality effect statistically significant, and in a third of the equations, the sign was wrong (negative). Measurement error was tested by examining the within-cluster effect of prices on budget shares. Of the 37 rural and urban food equations, only three showed any sign of significant measurement error effects.

8.1.3 Impact of price changes associated with devaluation

In the base scenario, the price of each budget category is assumed to rise in proportion with the tradeable content of the category. Wages are assumed to fall by 4-8%, in accordance with the historical patterns of other devaluation episodes, as analyzed by Edwards (1989). Demand response is simulated using the parameters from the restricted model (with symmetry imposed). Although supply response is not included in the base scenario, the effect of price changes on income and the consequent effect of income on demand (the profit effect) is simulated. The welfare impact, in the form of equivalent variation and compensating variation, is measured using Vartia's method with 50 iterations. In order to make full use of the sample data, the demand response, profit effect, and the welfare and nutritional impact are simulated for each household in the sample and then aggregated to the appropriate group.

The most striking result of the simulation under the base scenario is that the negative welfare impact (expressed as a percentage of total expenditure) is over three times greater for urban households than for rural households. The price changes associated with devaluation are equivalent to a 3% reduction in the real income of rural households and a 10% drop in real income for urban households. In addition, it is twice as great for the richest 20% of households as it is for the poorest 20%. Households whose primary occupation is farming are least affected, while wage earners are the most severely affected. Female-headed households are slightly more affected than male-headed households. Caloric intake rises slightly, presumably because the (nontradeable) staple foods have become less expensive relative to many (tradeable) non-food items.

Within the rural sector, households which are poor, agricultural, male-headed and/or in the Eastern region are more insulated from the devaluation than others. In the urban sector, households which are poor, agricultural, female-headed, and/or in cities other than Kigali are least affected. This confirms the conventional wisdom that the urban poor are harder hit than the rural poor, but it is at odds with the common perception that low-income urban households are affected more than higher-income households in the city.

Historical prices were examined for the two years before and the seven months after the Rwandan franc was devalued on November 20, 1990. An index of consumer prices based on 35 goods showed that prices rose sharply during October 1990. This rise is probably the result of the outbreak of guerilla warfare during that month. Developing separate indexes for tradeable and non-tradeable goods shows that both rose in parallel fashion in October, but in November tradeable good prices continued rising while non-tradeable prices fell. The real exchange rate, defined as the ratio of tradeable to nontradeable prices, rose 31% from one month before to seven months after the devaluation.

The average prices during the second quarter of 1990 were used to simulate the "before" situation, while those of the second quarter of 1991 were used to represent the "after" situation. Although the individual price changes bore little resemblance to the hypothesized price changes, the welfare impact was similar in the two cases. Historical prices affected rural, poor, and agricultural households the least, while the effect on urban, high-income, and wage-earning households was the greatest.

These results are relatively robust to changes in the assumptions of the model. The relative impact on different types of households is no different in any meaningful way when 1) real wages are assumed to remain constant rather than decline, 2) agricultural supply response is introduced, and 3) alterative demand parameters are adopted.

A comparison of alternative measures of welfare impact revealed that the simplest first-order approximations performed relatively well in ranking household by impact. On the other hand, these measures are generally biased by 8-10%. For example, the first-order approximation of compensating variation overstates the welfare impact of price changes.

8.2 Implications for policy

Several policy implications can be drawn from the results of this study. Some apply to Rwanda alone, while others may be applicable to other less developed countries with similar economies.

8.2.1 Magnitude of the impact of devaluation

In Rwanda, and by extension in similar semi-subsistence agricultural economies, the expenditure-switching effect of devaluation has a relatively moderate impact on rural households and the poor in general. In all the scenarios considered, the effect on the poor was equivalent to a reduction in real income of 4% or less. The impact on caloric intake is even less, perhaps slightly positive. In one sense, this may represent an overstatement of the impact, since the model does account for substitution *within* each budget category. For example, the effect of higher prices for petroleum products may induce substitution within energy expenditures, but these cannot be captured in a model which does not disaggregate energy spending.

On the other hand, these results apply only to the relative price (or "expenditure switching") effects of devaluation. The simulation does not incorporate any change in aggregate output ("expenditure-reducing"). In particular, the short-term contractionary effect, identified in some devaluation episodes, could result in unemployment. Nor does it take into account other aspects of the structural adjustment program such as reductions in government expenditure, restrained growth of public sector employment, trade liberalization, and so on.

The results of the simulations are consistent with political explanations of resistance to currency devaluation. It is sometimes argued that policy makers are reluctant to devalue the currency because of a direct stake they have in access to "cheap" foreign exchange. Only weak support was found for the idea that higher-income households consume more tradeables, whose relative price rises with devaluation. However, the simulation indicates that rural farmers, who represent 73% of Rwandan households, experience price changes equivalent to a small (2.4%) reduction in real income, but urban wage-earners, who account for less than 2% of all households, face price changes which are equivalent to a 12% reduction in real income.

8.2.2 Alleviation of the impact of devaluation

With respect to the rural sector, there are no simple ways to alleviate the impact of devaluation on rural households. The same factor that protects them from the devaluation, limited participation in the market economy, also insulates them from the benefits of price policies. Manipulation of food prices, even if it were practical, would leave many rural households unaffected and have mixed effects on the remainder.

One exception is bean prices, reduction of which would benefit over 70% of the rural households. Furthermore, because net purchases

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represent a larger share of the expenditure of the poor than other households, lower bean prices would benefit the poor disproportionately. These results confirm the wisdom of the government's decision to discontinue efforts to support bean prices. They also suggest that restrictions on bean imports would, by raising prices, be particularly harmful to the poor. Furthermore, it suggests that efforts to remove impediments to "informal" regional trade would yield significant benefits for poor rural households. To the extent that the informal trade is subject to additional costs because it is not officially recognized, legalization of this trade could well reduce marketing costs.

In addition, hypothetical and the historical simulation indicated that increased prices for clothing account for a large portion of the negative impact on rural households. Actual subsidies may not be feasible, given budget constraints, but reduction or elimination of import duties on clothing could be considered. In order to target the benefits toward the poor, the tax reduction could be restricted to used clothing, which is purchased disproportionately by the poor.

Although the effect of agricultural price policy is constrained by the limited market participation of most rural households, the impact of cost-reducing agricultural technology is much deeper and more widely distributed. For example, an increase in the price of sweet potatoes benefits roughly a quarter of the rural households, with a small number of households capturing much of the gains. By contrast, a reduction in the cost of producing sweet potatoes benefits over 85% of the rural households. Furthermore, for a given change in cost/price, the benefits of cost-reducing technology are much greater because they apply to the volume of production rather than the small portion which is marketed.

The scope for assisting the urban poor is greater, since cash purchases are an important part of expenditure (68% for the poorest 20% of the urban households). In the early stages of the structural adjustment program, the government of Rwanda gave special access to foreign exchange for the importation of sugar, cooking oil, and wheat flour. Since these are the food items with the highest expenditure elasticities in the urban areas, the benefits of such a policy accrue disproportionately to higher-income urban residents[1]. Subsidies on an inferior good would be self-targeting in the sense that the absolute benefits of subsidies would be greater for the poor than other households. But the ENBC data indicate that there are no inferior goods at the mean level of expenditure in the urban sector. Nonetheless, a subsidy on sweet potatoes would be more targeted than any other food subsidy: the absolute benefit would be relatively constant across households, but it would represent a larger share of the budget of poor households.

8.3 Implications for research methods

8.3.1 Advantages of micro-simulation

In order to make full use of the sample data, the demand response, profit effect, and the welfare and nutritional impact are simulated for each household in the sample and then aggregated to the appropriate group. This "micro-simulation" approach is in contrast to the usual practice of simulating the impact of price change on a small number of "representative" or "archetypal" households. Micro-simulation allows the analyst to examine the impact on any sub-group of the population, rather than being limited to the selected "representative" households. For example, it allows the results to be disaggregated by expenditure quintile, by region, by sex of head of household, or any other classification.

In addition, this approach provides some information about the variation within each group. For example, it was shown that the five

1. The expenditure elasticities of these items range from 0.97 to 1.42. Thus, the benefits as a percentage of expenditure are constant or increasing as a function of household expenditure.

occupational groups explain about one half of the variation in welfare impact across households. Combined with household expenditure, sex of head of household, and urban/rural residence, 65% of the variation is explained. This type of information is not available when the simulation is run for a small number of "representative" households.

A third advantage of micro-simulation is that it allows the use of a demand specification without the property of exact aggregation. The Almost Ideal Demand System, which does allow exact aggregation, was shown to be insufficiently flexible in representing the relationship between budget share and total expenditure. Yet adding a quadratic expenditure term is not an option unless micro-simulation is used because the resulting functional form does not have exact aggregation.

Naturally, the cost of micro-simulation is that it is computationally more burdensome. The additional programming time is not that significant since it only involves iterating the same procedure for each household in the sample. And the additional computational time becomes less important with each advance in micro-computer technology.

8.3.2 Factors affecting the impact of devaluation

Various approaches have been used to analyze the distributional impact of devaluation. Cross-country econometric studies tend to focus on wage rates, since time-series data are available for a number of countries (e.g. Edwards, 1989). For countries like Rwanda, wage rates are a highly deceptive measure of the welfare of the poor. As noted above, only 6% of the households in Rwanda obtain most of their income from wages. Furthermore, these households are disproportionately located in the urban sector. Even within the urban sector, employees have income levels significantly above the mean.

The other approach is to examine the average composition of spending and income (e.g. Sahn, 1990 and Glewwe and de Tray, 1988 and 1989). This is the core of the method used in this study, but several caveats must be mentioned. First, as mentioned above, the use of

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averages hides a large amount of variation within the population. Second, it is not always clear whether cash budgets or total expenditure are being analyzed. This study indicates that the importance of home production in the budget may be at least as important as the tradeable component of the budget in determining the effect of price changes, including those associated with devaluation.

8.3.3 Alternative welfare measures

The conclusions with regard to alternative welfare measures is mixed. The simplest welfare measure is the first-order approximation of compensating variation. This measure uses only the "before" budget and income shares, thus avoiding completely the need to estimate demand. This measure is highly correlated with the most sophisticated welfare measures and performs quite well in ranking households by welfare impact. If the only objective of a study is to determine which groups are most benefited or least hurt, then this is a very cost-effective approach.

The reason for this is that demand response is a second-order effect, while the budget shares are first order effects. In geometric terms, the budget shares are the rectangle portion of the trapezoid, while the demand response determines the size of the triangle at the end of the trapezoid. In the same fashion, the income shares are first-order effects while the supply response is a second-order effect. In other words, a respectable approximation of the "profit effect" can be obtained without estimating supply response. This is fortunate, because budget and income shares are much more widely available than demand and supply response parameters.

On the other hand, the first-order approximation of compensating variation overestimates the "true" welfare impact. In the base simulation of this study, the magnitude of the overestimate was 8-10%. If price and income elasticities are to be estimated, then it is worth using the Vartia method to estimate willingness-to-pay. As Deaton argues, willingness to pay requires no information beyond what is needed to calculate consumer surplus, yet it is conceptually superior to consumer surplus. Furthermore, the intuitive meaning of willingness to pay is arguably easier to explain to the non-specialist reader than is the meaning of consumer surplus.

Equivalent variation (EV) appears to be better suited to applied policy analysis than compensating variation, in spite of the popularity of the latter. The principal advantage is the ability of EV to rank alternative policy outcomes.

8.4 Limitations of the study and suggestions for future research

Perhaps the greatest weakness of this study is the use of exogenous price changes to simulate devaluation. This study made use of price trends observed in other countries after currency devaluation. Nonetheless, a number of somewhat arbitrary judgements had to be made in classifying tradeable and nontradeable goods, most notably in the case of beans and factory beer. The most serious implication of this approach is that there is no mechanism to equilibrate supply and demand.

One alternative would be to set the new price of tradeable goods exogenously, since by definition their price is set by the international market, and allow non-tradeable prices to be set endogenously such that supply and demand are equated[1]. Although it is not at all clear that such a method would be more successful in predicting price changes, it would have the advantage of being internally consistent.

A related problem is that prices were assumed to change by the same percentage throughout the country. However, devaluation usually involves sharp increases in transportation costs. To the extent that transportation costs rise more than the price of a given commodity, the

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1. This approach was attempted in the present study, but the lack of exact aggregation in the demand specification meant that it was difficult to reliably predict the direction of price change necessary to reduce the gap between supply and demand. As a result, the system tended to "explode" after seven or eight iterations.

percentage increase in price will be lower where it is produced than elsewhere. The magnitude of this difference depends on 1) the share of transportation costs in the final consumer price and 2) how much higher transportation costs rose relative to the commodity. Following this logic, the geographic variation in the percentage price increase should be greatest for nontradeable goods with a low value/bulk ratio, such as cassava and sweet potatoes. The incorporation of this effect, such as with a spatial equilibrium model, would be more important in a large country with a poor road network.

A third limitation of the study is the use of strong separability assumptions to derive non-food price elasticities. Although this method produced highly plausible elasticities, it would have been preferable to estimate non-food price elasticities directly. This, however, would require a much larger data base which would permit the construction of price indexes for each non-food category. Nonetheless, the analysis in section 7.6 demonstrates that the basic results of this study are not very sensitive to changes in the demand parameters.

One more weakness of the study is that only seven months of prices after devaluation were available for the analysis. If the devaluation is ultimately unsuccessful in addressing the external imbalance, then the devaluation may well have been insufficient. In this case, the relatively weak welfare impact (at least for rural households) may be attributed to the overly modest exchange rate adjustment.

This study confined its attention to the expenditure-switching effects of devaluation. The research approach used could be extended to incorporate the impact of change in employment or the impact of other aspects of the structural adjustment program. The only constraint on the application of this method to other policy changes is that the policies must be able to be translated into price and income changes. Thus, the doubling of oil prices or alternative taxes on factory beer could be modeled more easily than the impact of reductions in public health spending.

Finally, as was mentioned earlier, the distributional impact of devaluation is highly dependent on the structure of the economy. Nonetheless, many aspects of the structure of the Rwandan economy are similar to those in other semi-subsistence agricultural economies. This study has demonstrated the feasibility of calculating "exact" measures of welfare impact in the context of micro-simulation. However, the generalizability of these results to other countries cannot be determined until similar studies are carried out elsewhere.

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APPENDICES

APPENDIX A

DEVALUATION AND BEAN PRICES

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DEVALUATION AND BEAN PRICES

We expect devaluation to raise the price of beans less than the increase in the local price of devaluation for two reasons. First, if the international supply of beans is perfectly elastic, then the price of beans will increase in the same proportion as the parallel exchange rate, since beans are imported unofficially. Most studies (e.g. Edwards, 1989) show that the parallel market premium declines following devaluation. This implies that the cost of foreign exchange on the parallel market rises less than the cost of foreign exchange in the official market.

Second, the increase in the price of beans will be *less* than the increase in the parallel exchange rate if the regional supply of beans are not perfectly elastic. It is probably more realistic to assume that Rwandan demand is "large" relative to the regionally traded volumes of beans so that the supply of imported beans is not perfectly elastic. In this case, the price increase will be dampened in proportion to the price elasticity of market demand for beans in Rwanda. The market demand for beans is likely to be highly price-responsive because the market is "thin" in the sense that only a small portion (16% according to the ENBC) of the total demand for beans is in the form of market purchases. If the elasticity of demand for beans is somewhat around 0.8 (see Chapter 6), then the elasticity of market demand will be almost 5.0 (0.8/0.16 = 4.8). Thus, a 5% reduction in the volume of imported beans would be necessary to raise the domestic price by 1%.

In summary, the increase in the price of Rwandan beans is likely to be less than the increase in the price of foreign currency in the official market. This is because 1) devaluation tends to raise the parallel market rate less than the official rate and 2) if the regional supplies of beans are not perfectly elastic, then bean prices will rise proportionately less than the parallel exchange rate, particularly given the thinness of the bean market in Rwanda.

At the same time, it should be recognized that any increase in the price of beans reduces the real income of perhaps 70% of rural households. Furthermore, such a price increase is likely to have a regressive impact even within the rural sector, reducing the real income of low-income households more than that of other households (see Table 5-21).

APPENDIX B

ADULT EQUIVALENCE SCALES

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ADULT EQUIVALENCE SCALES

Adult equivalence scales are used to measure the "size" of a household in terms of consumption requirements. The simplest approach to calculating adult equivalence scales is to define them in terms of the caloric requirements of household members. Although calorie-based equivalence scales do not take into account non-food consumption needs, this is a less serious bias in a country like Rwanda in which food represents a large share of the value of total expenditure. The equivalence scales used in this study are presented below.

Table B-1: Adult equivalence scale

Age category	Male	Female
Less than 1 year	0.41	0.41
1 - 3 years	0.56	0.56
4 - 6 years	0.76	0.76
7 - 9 years	0.91	0.91
10 - 12 years	0.97	1.08
13 - 15 years	0.97	1.13
16 - 19 years	1.02	1.05
20 - 39 years	1.00	1.00
40 - 49 years	0.95	0.95
50 - 59 years	0.90	0.90
60 - 69 years	0.90	0.80
70 and older	0.70	0.70

Source: Calculated from caloric requirements for "moderate activity" established by the World Health Organization and the Food and Agriculture Organization (see Ministère du Plan, 1998: Annex B).

APPENDIX C

COEFFICIENTS AND T STATISTICS FOR REGRESSION MODELS

Table C-1: Coefficients of the unrestricted SUR model of rural demand

Dependent variable (share)	constant ß0	lnexp ß1	lnexp2 ß2	adults γ1	children γ2	fem hh γ3
SORGH	115.82	-16.19	0.79	-0.04	0.00	-0.37
t	2.35	-1.75	1.69	-0.31	0.04	-1.12
RICE	-37.86	5.79	-0.28	-0.05	0.08	0.40
t	-1.09	0.89	-0.84	-0.63	1.44	1.75
CASSA	-125.78	22.14	-1.30	-0.18	-0.07	0.56
t	-0.74	0.69	-0.80	-0.46	-0.23	0.49
SWPOT	604.61	-98.44	4.41	-0.84	-0.25	0.88
T	3.05	-2.64	2.33	-1.78	-0.74	0.66
WHPOT	-291.40	68.33	-3.33	0.20	0.30	0.12
t	-1.87	2.33	-2.24	0.55	1.13	0.11
BANAN	51.98	-15.77	0.82	0.09	0.16	0.93
t	0.32	-0.52	0.54	0.24	0.59	0.87
BEANS	-308.30	70.83	-4.03	-1.66	-0.85	1.47
t	-1.21	1.47	-1.65	-2.73	-1.95	0.86
PEAS	-30.56	11.62	-0.59	-0.17	-0.12	-0.24
t	-0.42	0.86	-0.86	-1.00	-0.99	-0.50
TOMAT	-2.75	0.20	-0.01	-0.02	0.01	0.09
t	-0.28	0.11	-0.13	-0.67	0.56	1.39
BEEF	-10.59	-1.14	0.11	0.09	0.04	0.28
t	-0.21	-0.12	0.22	0.78	0.47	0.83
MEAT	-52.93	7.48	-0.30	-0.10	0.35	-1.11
t	-0.52	0.39	-0.32	-0.43	2.04	-1.64
BBEER	-101.47	4.32	-0.04	0.15	-0.37	-4.62
t	-0.47	0.11	-0.02	0.29	-1.00	-3.20
SBEER	-103.13	26.46	-1.30	0.42	-0.11	-0.61
t	-0.87	1.18	-1.15	1.47	-0.57	-0.77
FBEER	50.98	-15.23	0.86	0.07	0.03	-0.58
t	0.88	-1.39	1.54	0.54	0.33	-1.48
OIL	-54.17	10.71	-0.52	0.15	0.05	-0.25
t	-1.51	1.58	-1.52	1.71	0.83	-1.04
SALT	-13.79	3.55	-0.20	-0.10	-0.05	-0.05
t	-0.73	0.99	-1.13	-2.20	-1.54	-0.36
SUGAR	-10.36	3.55	-0.16	0.05	0.08	0.17
t	-0.39	0.71	-0.64	0.75	1.72	0.94
CLOTH	-12.78	2.63	-0.09	0.93	-0.37	-0.02
t	-0.12	0.12	-0.08	3.46	-1.93	-0.03
HOUSE	421.36	-92.54	5.04	0.74	0.82	1.55
t	2.73	-2.95	3.17	1.90	2.93	1.41
EQUIP	-40.57	6.74	-0.25	0.08	0.12	-0.38
t	-0.48	0.39	-0.29	0.39	0.80	-0.62
ENERG	-4.67	1.69	-0.10	-0.07	-0.23	-0.11
t	-0.10	0.18	-0.21	-0.61	-2.62	-0.32
HEALT	-14.39	3.30	-0.17	0.15	-0.06	0.03
t	-0.33	0.37	-0.38	1.37	-0.74	0.11
EDUCA	-21.66	4.30	-0.21	0.14	0.10	-0.03
t	-0.63	0.62	-0.61	1.60	1.62	-0.10
TRANS	21.38	-5.33	0.33	-0.03	0.09	0.21
t	0.52	-0.64	0.78	-0.31	1.14	0.73
TOBAC	3.58	-0.41	0.01	0.03	-0.08	-0.19
t	0.13	-0.08	0.05	0.43	-1.73	-1.01
LEISU	-17.54	3.34	-0.15	-0.03	0.02	-0.25
t	-0.50	0.47	-0.42	-0.28	0.31	-0.99

Dependent variable (share)	SOR αi1	RICE αi2	CAS αi3	SWPT αi4	WHPT αi5	BAN αi6	BEAN αi7	PEAS αi8
SORGH	0.23	-0.58	-0.48	-0.88	-1.10	-0.63	0.77	0.13
t	0.24	-0.41	-1.22	-2.10	-1.40	-2.33	1.13	0.19
RICE	0.76	-0.76	0.11	-0.19	0.83	0.05	0.88	0.37
t	1.10	-0.76	0.40	-0.66	1.50	0.28	1.84	0.77
CASSA	1.83	-1.18	-0.56	-0.84	2.90	0.72	-1.69	0.94
t	0.54	-0.24	-0.42	-0.58	1.07	0.78	-0.72	0.40
SWPOT	2.48	1.93	-1.62	-1.20	4.14	1.01	-0.00	0.89
t	0.64	0.35	-1.05	-0.73	1.33	0.96	-0.00	0.33
WHPOT	-1.63	-2.03	1.61	-0.89	-5.75	-2.54	-1.85	2.59
t	-0.53	-0.46	1.29	-0.67	-2.30	-3.00	-0.86	1.19
BANAN	-3.11	0.76	-2.03	1.32	0.57	0.92	0.84	-3.73
t	-0.99	0.17	-1.61	0.98	0.22	1.07	0.38	-1.69
BEANS	-8.18	3.74	6.96	-0.18	-2.33	3.35	2.13	-11.54
t	-1.65	0.52	3.50	-0.08	-0.58	2.46	0.62	-3.31
PEAS	-0.48	-2.66	0.44	-0.59	-0.92	-0.38	0.52	-0.69
t	-0.34	-1.30	0.78	-0.96	-0.80	-0.97	0.52	-0.69
TOMAT	0.18	-0.08	0.03	-0.03	0.24	-0.07	0.10	0.00
t	0.92	-0.27	0.39	-0.38	1.50	-1.32	0.76	0.01
BEEF	0.05	0.26	0.32	1.12	0.85	-0.02	0.45	1.29
t	0.05	0.18	0.79	2.62	1.06	-0.06	0.65	1.83
MEAT	6.66	-4.70	-0.77	0.48	-2.06	0.27	0.17	-1.02
t	3.32	-1.63	-0.96	0.56	-1.27	0.50	0.12	-0.72
BBEER	-3.19	11.73	-3.08	2.51	2.58	2.12	0.01	3.98
t	-0.76	1.95	-1.83	1.40	0.76	1.85	0.00	1.35
SBEER	1.30	2.03	-1.60	-0.51	0.87	-1.21	-2.85	2.50
t	0.55	0.59	-1.68	-0.50	0.45	-1.86	-1.72	1.50
FBEER	-0.64	4.13	-0.02	-0.16	0.53	0.15	0.28	1.18
t	-0.56	2.51	-0.05	-0.33	0.57	0.49	0.35	1.47
OIL	0.77	-2.52	0.07	0.32	0.84	-0.09	0.12	0.62
t	1.08	-2.47	0.23	1.07	1.47	-0.48	0.24	1.24
SALT	-0.54	-1.36	0.16	0.11	0.14	0.14	-0.21	0.01
t	-1.46	-2.56	1.05	0.68	0.48	1.42	-0.80	0.04
SUGAR	0.74	-2.69	-0.40	0.11	-0.15	-0.03	0.20	-0.38
t	1.42	-3.59	-1.90	0.50	-0.37	-0.24	0.56	-1.05

Dependent variable (share)	TOM $\alpha i9$	BEEF $\alpha i10$	MEAT $\alpha i11$	BBR $\alpha i12$	SBR $\alpha i13$	FBR $\alpha i14$	OIL $\alpha i15$	SALT $\alpha i16$	SUGR $\alpha i17$
SORGH	0.28	-2.03	0.55	0.08	-0.14	-1.73	-2.01	-0.46	0.30
t	0.74	-2.52	0.64	0.15	-0.17	-0.68	-2.50	-0.44	0.75
RICE	0.28	-0.51	-0.03	-0.49	0.11	0.90	0.30	0.17	-0.24
t	1.03	-0.90	-0.05	-1.32	0.19	0.50	0.53	0.24	-0.86
CASSA	-1.84	2.78	2.78	2.00	1.07	-0.70	-1.97	2.11	2.30
t	-1.40	1.00	0.93	1.11	0.37	-0.08	-0.71	0.58	1.67
SWPOT	3.27	-4.83	-4.03	6.53	-4.86	-2.61	1.49	-10.02	-2.76
t	2.19	-1.53	-1.17	3.16	-1.47	-0.26	0.47	-2.44	-1.76
WHPOT	-1.43	-3.10	0.43	5.35	-1.14	-11.38	3.47	5.92	-0.82
t	-1.19	-1.22	0.16	3.22	-0.43	-1.42	1.37	1.79	-0.65
BANAN	-0.61	0.97	-1.65	-11.10	3.02	17.37	2.10	-6.48	1.76
t	-0.50	0.38	-0.59	-6.59	1.12	2.14	0.81	-1.93	1.37
BEANS	-0.62	0.37	5.54	2.86	-1.79	-1.88	-0.52	4.43	2.72
t	-0.32	0.09	1.25	1.08	-0.42	-0.15	-0.13	0.84	1.34
PEAS	-0.61	-1.52	-0.23	2.13	-0.84	0.71	0.74	-0.97	-0.98
t	-1.11	-1.30	-0.18	2.79	-0.69	0.19	0.63	-0.64	-1.68
TOMAT	-0.09	-0.11	0.32	-0.27	0.21	0.22	0.16	-0.40	0.11
t	-1.19	-0.67	1.81	-2.58	1.27	0.43	0.99	-1.92	1.35
BEEF	0.47	1.12	0.80	-1.11	-0.15	-1.72	0.72	-1.53	0.88
t	1.21	1.36	0.90	-2.08	-0.17	-0.67	0.88	-1.43	2.16
MEAT	0.36	0.93	-0.46	-3.18	0.76	4.35	-0.44	1.60	-0.07
t	0.46	0.56	-0.26	-2.96	0.44	0.84	-0.27	0.75	-0.08
BBEER	-1.12	6.05	-6.63	-5.84	6.97	3.33	0.00	1.43	-1.32
t	-0.69	1.76	-1.78	-2.60	1.94	0.31	0.00	0.32	-0.77
SBEER	0.19	-5.96	-2.47	4.41	-3.96	-2.56	1.10	1.76	0.54
t	0.21	-3.05	-1.17	3.46	-1.94	-0.42	0.56	0.69	0.56
FBEER	0.44	2.87	-0.94	-0.26	1.62	-6.19	1.38	1.74	-0.92
t	0.99	3.04	-0.92	-0.43	1.65	-2.09	1.47	1.42	-1.97
OIL	0.07	1.62	0.34	-0.21	-0.88	-0.42	0.15	-0.43	-0.05
t	0.26	2.78	0.54	-0.56	-1.45	-0.23	0.26	-0.57	-0.17
SALT	-0.27	0.01	0.37	0.10	0.07	1.15	-0.16	0.38	-0.13
t	-1.91	0.04	1.13	0.50	0.22	1.20	-0.54	0.95	-0.87
SUGAR	0.26	-0.50	0.85	-0.53	-0.49	0.20	0.54	0.02	-0.13
t	1.30	-1.16	1.83	-1.91	-1.10	0.15	1.27	0.03	-0.62

Table C-2: Coefficients of the SUR model of rural demand under symmetry restrictions

Dependent variable (share)	constant $\beta 0$	lnexp $\beta 1$	lnexp2 $\beta 2$	adults $\gamma 1$	children $\gamma 2$	fem hh $\gamma 3$
SORGH	101.92	-17.48	0.84	-0.03	-0.03	-0.31
t	2.21	-1.91	1.83	-0.29	-0.41	-0.97
RICE	-30.60	3.29	-0.15	-0.03	0.06	0.43
t	-0.92	0.51	-0.46	-0.41	1.03	1.88
CASSA	-79.99	20.83	-1.21	-0.09	0.06	0.15
t	-0.52	0.66	-0.76	-0.24	0.20	0.14
SWPOT	586.48	-105.13	4.69	-0.86	-0.44	1.53
t	3.25	-2.88	2.54	-1.89	-1.33	1.19
WHPOT	-332.08	67.42	-3.30	0.22	0.18	0.13
t	-2.34	2.35	-2.27	0.62	0.68	0.13
BANAN	-58.35	9.05	-0.38	-0.38	0.34	0.10
t	-0.40	0.31	-0.25	-1.03	1.28	0.10
BEANS	-366.15	85.34	-4.68	-1.51	-0.55	1.62
t	-1.57	1.81	-1.96	-2.55	-1.30	0.97
PEAS	-34.63	8.24	-0.44	-0.16	-0.21	-0.26
t	-0.52	0.62	-0.65	-0.94	-1.71	-0.55
TOMAT	-5.40	0.53	-0.03	-0.02	0.01	0.07
t	-0.57	0.28	-0.30	-1.04	0.56	1.07
BEEF	-17.76	-1.22	0.12	0.09	0.05	0.27
t	-0.38	-0.13	0.25	0.75	0.54	0.82
MEAT	-1.02	2.24	-0.04	-0.05	0.32	-1.13
t	-0.01	0.12	-0.04	-0.20	1.88	-1.72
BBEER	-8.32	3.41	0.01	0.25	-0.32	-4.89
t	-0.04	0.09	0.01	0.51	-0.89	-3.47
SBEER	-110.06	24.31	-1.22	0.31	-0.21	-0.55
t	-1.01	1.11	-1.10	1.13	-1.08	-0.71
FBEER	67.20	-16.03	0.89	0.09	0.04	-0.48
t	1.18	-1.47	1.62	0.63	0.40	-1.25
OIL	-59.23	9.37	-0.45	0.17	0.04	-0.25
t	-1.75	1.40	-1.33	2.02	0.74	-1.06
SALT	-14.66	3.16	-0.18	-0.09	-0.05	-0.05
t	-0.79	0.88	-1.01	-1.99	-1.59	-0.41
SUGAR	-5.06	1.68	-0.07	0.05	0.06	0.15
t	-0.20	0.34	-0.27	0.84	1.33	0.89
CLOTH	-12.78	2.63	-0.09	0.93	-0.37	-0.02
t	-0.12	0.12	-0.08	3.46	-1.93	-0.03
HOUSE	421.36	-92.54	5.04	0.74	0.82	1.55
t	2.73	-2.95	3.17	1.90	2.93	1.41
EQUIP	-40.57	6.74	-0.25	0.08	0.12	-0.38
t	-0.48	0.39	-0.29	0.39	0.80	-0.62
ENERG	-4.67	1.69	-0.10	-0.07	-0.23	-0.11
t	-0.10	0.18	-0.21	-0.61	-2.62	-0.32
HEALT	-14.39	3.30	-0.17	0.15	-0.06	0.03
t	-0.33	0.37	-0.38	1.37	-0.74	0.11
EDUCA	-21.66	4.30	-0.21	0.14	0.10	-0.03
t	-0.63	0.62	-0.61	1.60	1.62	-0.10
TRANS	21.38	-5.33	0.33	-0.03	0.09	0.21
t	0.52	-0.64	0.78	-0.31	1.14	0.73
TOBAC	3.58	-0.41	0.01	0.03	-0.08	-0.19
t	0.13	-0.08	0.05	0.43	-1.73	-1.01
LEISU	-17.54	3.34	-0.15	-0.03	0.02	-0.25
t	-0.50	0.47	-0.42	-0.28	0.31	-0.99

Dependent variable (share)	SOR αi1	RICE αi2	CAS αi3	SWPT αi4	WHPT αi5	BAN αi6	BEAN αi7	PEAS αi8
SORGH	0.08	0.25	-0.43	-0.70	-1.20	-0.65	0.29	-0.12
t	0.09	0.43	-1.17	-1.73	-1.78	-2.56	0.45	-0.23
RICE	0.25	0.46	0.12	-0.16	0.67	0.09	1.12	0.08
t	0.43	0.50	0.45	-0.54	1.31	0.47	2.38	0.20
CASSA	-0.43	0.12	-2.08	-1.68	2.95	1.04	1.53	0.23
t	-1.17	0.45	-1.80	-1.68	3.05	1.65	1.10	0.46
SWPOT	-0.70	-0.16	-1.68	-1.22	0.12	0.84	-0.98	-0.24
t	-1.73	-0.54	-1.68	-0.80	0.11	1.18	-0.62	-0.44
WHPOT	-1.20	0.67	2.95	0.12	-6.10	-2.39	-1.96	-0.40
t	-1.78	1.31	3.05	0.11	-3.25	-3.46	-1.15	-0.49
BANAN	-0.65	0.09	1.04	0.84	-2.39	2.63	4.20	-1.00
t	-2.56	0.47	1.65	1.18	-3.46	3.80	4.14	-2.83
BEANS	0.29	1.12	1.53	-0.98	-1.96	4.20	-3.78	-1.49
t	0.45	2.38	1.10	-0.62	-1.15	4.14	-1.14	-1.64
PEAS	-0.12	0.08	0.23	-0.24	-0.40	-1.00	-1.49	-2.00
t	-0.23	0.20	0.46	-0.44	-0.49	-2.83	-1.64	-2.53
TOMAT	0.13	0.15	0.08	-0.03	0.14	-0.05	0.23	-0.02
t	0.81	0.85	1.11	-0.42	0.99	-0.89	1.76	-0.16
BEEF	-0.91	-0.21	0.16	1.00	0.20	0.18	0.47	1.04
t	-1.59	-0.42	0.42	2.44	0.29	0.69	0.71	2.01
MEAT	1.15	-0.45	-0.24	0.26	-1.26	0.10	1.52	-0.72
t	1.64	-0.81	-0.32	0.33	-1.03	0.20	1.18	-0.91
BBEER	-0.37	-0.57	-2.60	3.33	5.42	-1.53	-1.36	1.36
t	-0.75	-1.59	-2.39	2.63	4.16	-1.88	-0.72	1.99
SBEER	0.32	0.52	-0.42	-0.17	-1.62	-0.50	-2.00	-0.13
t	0.44	0.94	-0.51	-0.19	-1.29	-0.87	-1.37	-0.16
FBEER	-1.04	2.91	0.12	-0.27	0.79	0.24	0.58	1.08
t	-1.07	2.59	0.28	-0.56	0.90	0.80	0.74	1.50
OIL	-0.22	-0.36	-0.09	0.31	1.18	-0.08	0.33	1.10
t	-0.47	-0.80	-0.35	1.07	2.43	-0.46	0.71	2.88
SALT	-0.43	-0.65	0.07	0.10	0.29	0.08	-0.31	0.12
t	-1.31	-1.61	0.48	0.65	1.03	0.78	-1.20	0.49
SUGAR	0.50	-0.52	-0.27	0.06	-0.31	0.04	0.74	-0.41
t	1.77	-2.10	-1.36	0.26	-0.91	0.33	2.12	-1.55

Dependent variable (share)	TOM $\alpha i9$	BEEF $\alpha i10$	MEAT $\alpha i11$	BBR $\alpha i12$	SBR $\alpha i13$	FBR $\alpha i14$	OIL $\alpha i15$	SALT $\alpha i16$	SUGR $\alpha i17$
SORGH	0.13	-0.91	1.15	-0.37	0.32	-1.04	-0.22	-0.43	0.50
t	0.81	-1.59	1.64	-0.75	0.44	-1.07	-0.47	-1.31	1.77
RICE	0.15	-0.21	-0.45	-0.57	0.52	2.91	-0.36	-0.65	-0.52
t	0.85	-0.42	-0.81	-1.59	0.94	2.59	-0.80	-1.61	-2.10
CASSA	0.08	0.16	-0.24	-2.60	-0.42	0.12	-0.09	0.07	-0.27
t	1.11	0.42	-0.32	-2.39	-0.51	0.28	-0.35	0.48	-1.36
SWPOT	-0.03	1.00	0.26	3.33	-0.17	-0.27	0.31	0.10	0.06
t	-0.42	2.44	0.33	2.63	-0.19	-0.56	1.07	0.65	0.26
WHPOT	0.14	0.20	-1.26	5.42	-1.62	0.79	1.18	0.29	-0.31
t	0.99	0.29	-1.03	4.16	-1.29	0.90	2.43	1.03	-0.91
BANAN	-0.05	0.18	0.10	-1.53	-0.50	0.24	-0.08	0.08	0.04
t	-0.89	0.69	0.20	-1.88	-0.87	0.80	-0.46	0.78	0.33
BEANS	0.23	0.47	1.52	-1.36	-2.00	0.58	0.33	-0.31	0.74
t	1.76	0.71	1.18	-0.72	-1.37	0.74	0.71	-1.20	2.12
PEAS	-0.02	1.04	-0.72	1.36	-0.13	1.08	1.10	0.12	-0.41
t	-0.16	2.01	-0.91	1.99	-0.16	1.50	2.88	0.49	-1.55
TOMAT	-0.04	0.01	0.25	-0.15	0.15	0.04	0.09	-0.26	0.06
t	-0.62	0.10	1.67	-1.47	0.99	0.13	0.68	-2.34	0.88
BEEF	0.01	0.31	0.80	-0.53	-1.31	1.64	1.05	-0.11	0.34
t	0.10	0.41	1.16	-1.05	-1.79	1.97	2.48	-0.38	1.26
MEAT	0.25	0.80	-1.00	-3.78	-0.51	-0.44	-0.55	0.12	0.47
t	1.67	1.16	-0.64	-3.88	-0.43	-0.46	-1.11	0.40	1.33
BBEER	-0.15	-0.53	-3.78	-1.66	4.32	-0.14	-0.42	0.14	-0.54
t	-1.47	-1.05	-3.88	-0.82	3.89	-0.24	-1.19	0.74	-2.05
SBEER	0.15	-1.31	-0.51	4.32	-1.87	1.57	-0.86	-0.02	-0.11
t	0.99	-1.79	-0.43	3.89	-1.04	1.69	-1.63	-0.06	-0.28
FBEER	0.04	1.64	-0.44	-0.14	1.57	-6.46	0.97	1.45	-0.52
t	0.13	1.97	-0.46	-0.24	1.69	-2.36	1.26	2.06	-1.28
OIL	0.09	1.05	-0.55	-0.42	-0.86	0.97	0.70	-0.25	-0.20
t	0.68	2.48	-1.11	-1.19	-1.63	1.26	1.37	-0.94	-0.96
SALT	-0.26	-0.11	0.12	0.14	-0.02	1.45	-0.25	0.42	-0.19
t	-2.34	-0.38	0.40	0.74	-0.06	2.06	-0.94	1.14	-1.36
SUGAR	0.06	0.34	0.47	-0.54	-0.11	-0.52	-0.20	-0.19	-0.41
t	0.88	1.26	1.33	-2.05	-0.28	-1.28	-0.96	-1.36	-2.17

Table C-3: Coefficients of the unrestricted SUR model of urban demand

Dependent variable (share)	constant ß0	lnexp ß1	lnexp2 ß2	adults γ1	children γ2	fem hh γ3
SORGH	14.39	-1.95	0.07	-0.10	-0.03	-0.06
t	0.92	-0.71	0.58	-1.26	-0.78	-0.23
RICE	-89.51	17.19	-0.81	-0.13	0.12	-0.06
t	-3.63	3.96	-3.95	-1.06	1.73	-0.14
BREAD	-37.32	5.27	-0.24	0.09	0.06	0.07
t	-4.21	3.36	-3.22	1.95	2.55	0.48
CASSA	-15.78	3.27	-0.21	-0.32	0.12	-0.72
t	-0.65	0.76	-1.05	-2.54	1.82	-1.76
SWPOT	157.83	-28.57	1.20	-0.37	-0.14	0.39
t	3.65	-3.75	3.35	-1.70	-1.18	0.54
WHPOT	4.44	10.28	-0.56	-0.19	0.07	0.36
t	0.11	1.45	-1.69	-0.95	0.66	0.53
BANAN	6.21	-1.47	-0.00	-0.05	0.04	1.03
t	0.19	-0.25	-0.01	-0.32	0.39	1.83
CASFL	18.15	-4.20	0.13	0.00	0.17	0.50
t	0.65	-0.86	0.57	0.00	2.22	1.07
BEANS	214.25	-23.30	0.77	-1.26	-0.45	-0.75
t	3.00	-1.84	1.29	-3.49	-2.29	-0.62
PEAS	7.78	0.43	-0.02	-0.00	0.01	-0.17
t	0.76	0.24	-0.28	-0.03	0.20	-1.02
VEGET	-24.50	3.98	-0.19	0.13	0.01	0.53
t	-2.16	1.98	-2.02	2.29	0.32	2.80
BEEF	-102.49	18.83	-0.90	-0.12	0.10	-0.45
t	-3.97	4.15	-4.22	-0.90	1.40	-1.05
MEAT	-18.28	5.53	-0.26	0.29	0.09	0.03
t	-0.75	1.29	-1.26	2.35	1.33	0.07
MILK	-88.82	10.18	-0.49	0.33	0.09	0.76
t	-2.81	1.82	-1.86	2.06	1.08	1.43
BBEER	-98.58	19.19	-0.98	-1.19	-0.63	-4.46
t	-1.76	1.93	-2.11	-4.17	-4.12	-4.74
SBEER	8.92	-0.10	-0.01	-0.15	-0.13	-0.63
t	0.41	-0.03	-0.07	-1.33	-2.19	-1.71
FBEER	-73.32	13.07	-0.50	-0.30	-0.08	-2.08
t	-1.28	1.30	-1.06	-1.05	-0.52	-2.18
OIL	-49.59	10.29	-0.49	-0.00	0.11	0.50
t	-3.45	4.05	-4.08	-0.02	2.74	2.08
SALT	2.86	-0.36	0.00	-0.01	-0.02	0.12
t	0.69	-0.49	0.15	-0.34	-1.36	1.76
SUGAR	-52.71	11.59	-0.55	-0.01	0.14	1.33
t	-2.33	2.91	-2.94	-0.12	2.25	3.51
MEALS	141.19	-19.41	0.90	-1.15	-0.82	-2.89
t	1.83	-1.43	1.41	-2.93	-3.93	-2.25

Dependent variable (share)	constant ß0	lnexp ß1	lnexp2 ß2	adults γ1	children γ2	fem hh γ3
CLOTH	-47.60	9.81	-0.46	0.22	0.09	-0.36
t	-1.24	1.35	-1.33	1.13	0.83	-0.53
HOUSE	290.47	-63.88	3.49	1.26	0.22	1.67
t	2.81	-3.26	3.77	2.42	0.73	0.91
EQUIP	-16.53	1.41	0.03	0.21	0.17	0.37
t	-0.53	0.24	0.11	1.32	1.87	0.67
ENERG	-120.65	22.05	-0.98	0.44	0.22	0.92
t	-3.09	2.98	-2.80	2.25	1.98	1.33
HEALT	-38.72	7.42	-0.34	0.38	0.11	0.69
t	-1.69	1.71	-1.65	3.29	1.63	1.69
EDUCA	-29.75	5.25	-0.23	0.12	0.26	1.32
t	-1.07	1.00	-0.93	0.85	3.20	2.68
TRANS	60.02	-14.90	0.88	1.22	0.35	1.39
t	0.96	-1.25	1.56	3.86	1.91	1.25
TOBAC	-34.51	7.59	-0.38	-0.16	-0.19	-1.03
t	-1.83	2.13	-2.28	-1.71	-3.46	-3.09
LEISU	15.45	-4.25	0.26	0.79	0.04	0.40
t	0.72	-1.04	1.35	7.28	0.69	1.04

Dependent variable (share)	SOR $\alpha i1$	RICE $\alpha i2$	BRD $\alpha i3$	CAS $\alpha i4$	SWPT $\alpha i5$	WHPT $\alpha i6$	BAN $\alpha i7$	CSFL $\alpha i8$	BEAN $\alpha i9$	PEAS $\alpha i10$	VEG $\alpha i11$
SORGH	-0.48	0.20	-0.03	0.09	0.07	0.59	-0.36	0.13	0.70	-0.19	-0.30
t	-1.37	0.26	-0.09	0.29	0.22	0.84	-1.64	0.38	1.29	-0.55	-0.87
RICE	0.46	-3.77	0.26	-0.56	1.32	-0.89	0.11	0.13	2.09	0.00	0.32
t	0.82	-3.00	0.57	-1.14	2.54	-0.79	0.31	0.25	2.41	0.00	0.58
BREAD	0.18	0.25	0.23	0.01	0.16	-0.51	-0.05	0.39	0.40	0.34	-0.18
t	0.92	0.56	1.47	0.06	0.89	-1.30	-0.39	2.06	1.33	1.79	-0.94
CASSA	-0.30	-1.94	-0.36	2.01	-0.15	1.73	-0.22	0.20	-1.03	-0.31	0.20
t	-0.55	-1.56	-0.79	4.15	-0.29	1.55	-0.64	0.38	-1.20	-0.57	0.37
SWPOT	-2.82	3.79	0.02	0.52	-1.88	5.84	-0.91	-0.06	-0.88	3.36	-1.15
t	-2.95	1.76	0.03	0.62	-2.11	3.03	-1.51	-0.07	-0.60	3.58	-1.20
WHPOT	-0.03	1.69	0.47	-0.01	-1.07	-1.61	-0.70	-1.80	2.50	-2.93	-1.45
t	-0.04	0.84	0.65	-0.01	-1.29	-0.90	-1.24	-2.09	1.80	-3.34	-1.62
BANAN	-0.35	0.53	0.14	-0.28	-0.96	1.38	-0.90	0.54	0.29	-0.02	-0.22
t	-0.46	0.31	0.23	-0.42	-1.37	0.91	-1.89	0.74	0.25	-0.02	-0.29
CASFL	0.67	0.42	0.01	-0.35	0.80	1.10	-0.35	-1.19	-0.35	0.03	0.27
t	1.06	0.29	0.01	-0.64	1.36	0.86	-0.89	-1.95	-0.35	0.05	0.43
BEANS	-2.06	-0.67	-0.39	-0.45	-3.45	1.19	-0.99	-0.18	2.98	-2.63	0.14
t	-1.35	-0.19	-0.31	-0.34	-2.42	0.39	-1.03	-0.12	1.26	-1.76	0.09
PEAS	-0.03	0.20	-0.16	-0.00	0.07	-1.75	-0.10	-0.52	0.48	-0.16	-0.16
t	-0.14	0.39	-0.84	-0.00	0.33	-3.74	-0.71	-2.35	1.34	-0.69	-0.67
VEGET	0.43	-0.60	0.20	-0.11	0.45	0.45	0.06	-0.16	0.29	0.15	-0.21
t	1.72	-1.08	1.01	-0.51	1.95	0.90	0.38	-0.67	0.77	0.63	-0.84
BEEF	0.20	-0.53	0.44	1.26	1.70	-0.30	-0.36	0.28	0.22	-0.80	0.19
t	0.34	-0.40	0.93	2.48	3.15	-0.26	-0.99	0.51	0.24	-1.40	0.33
MEAT	0.83	-3.20	-1.24	0.07	0.53	0.52	0.28	-0.10	-0.94	-0.57	0.17
t	1.53	-2.60	-2.79	0.14	1.03	0.47	0.80	-0.19	-1.11	-1.06	0.31
MILK	-0.67	2.55	0.28	1.41	-0.22	-1.06	-1.03	-0.12	3.18	1.22	-0.08
t	-0.95	1.62	0.49	2.29	-0.34	-0.75	-2.33	-0.18	2.92	1.78	-0.11
BBEER	-0.41	7.06	0.66	0.86	1.13	3.17	0.85	3.25	-2.83	0.42	-0.52
t	-0.34	2.55	0.66	0.80	0.99	1.28	1.10	2.74	-1.49	0.35	-0.43
SBEER	-0.20	-1.15	0.06	0.03	-0.98	0.28	0.20	0.81	0.48	-1.02	-0.62
t	-0.42	-1.05	0.15	0.07	-2.16	0.29	0.66	1.74	0.64	-2.15	-1.29
FBEER	0.78	0.14	-0.88	-2.78	0.90	-3.04	1.00	0.46	-3.53	-0.80	0.18
t	0.62	0.05	-0.86	-2.52	0.76	-1.20	1.26	0.38	-1.81	-0.65	0.15
OIL	0.45	-0.70	-0.14	0.23	0.71	0.14	-0.26	-0.10	0.28	-0.00	-0.24
t	1.40	-0.98	-0.55	0.82	2.39	0.22	-1.29	-0.33	0.56	-0.01	-0.77
SALT	-0.11	0.10	-0.01	0.01	0.05	0.00	-0.09	0.05	-0.01	-0.07	-0.12
t	-1.17	0.49	-0.08	0.12	0.61	0.02	-1.46	0.59	-0.06	-0.77	-1.24
SUGAR	0.69	-2.04	0.50	-0.09	1.08	-0.74	-0.87	-1.00	0.88	0.86	-0.25
t	1.37	-1.81	1.22	-0.20	2.32	-0.73	-2.76	-2.09	1.13	1.75	-0.49
MEALS	3.13	-2.58	0.09	-0.59	0.61	-6.09	3.73	-1.26	-4.43	2.31	3.79
t	1.79	-0.66	0.06	-0.38	0.37	-1.73	3.38	-0.75	-1.63	1.35	2.17

Dependent variable (share)	BEEF $\alpha i12$	MEAT $\alpha i13$	MILK $\alpha i14$	BBR $\alpha i15$	SBR $\alpha i16$	FBR $\alpha i17$	OIL $\alpha i18$	SALT $\alpha i19$	SUGR $\alpha i20$	MEAL $\alpha i21$
SORGH	0.11	0.10	-0.06	0.17	-0.65	0.15	-0.47	0.03	0.13	-0.12
t	0.36	0.33	-0.20	0.57	-1.92	0.30	-2.35	0.06	0.61	-0.74
RICE	0.56	-0.04	0.43	0.51	-0.91	0.43	0.08	-0.57	0.35	-0.01
t	1.19	-0.08	0.91	1.08	-1.67	0.54	0.25	-0.67	1.02	-0.02
BREAD	-0.02	0.14	0.25	-0.01	-0.23	-0.07	0.15	0.06	-0.04	0.22
t	-0.13	0.84	1.53	-0.06	-1.20	-0.26	1.34	0.20	-0.30	2.32
CASSA	-0.69	-0.27	1.02	0.26	1.98	0.31	0.22	0.08	0.36	0.12
t	-1.48	-0.58	2.18	0.55	3.67	0.39	0.70	0.10	1.05	0.47
SWPOT	-0.14	-0.26	-0.20	-0.22	-1.06	-1.58	-0.29	0.61	0.71	0.34
t	-0.18	-0.32	-0.25	-0.27	-1.13	-1.15	-0.54	0.42	1.20	0.74
WHPOT	0.03	-0.91	-1.17	-0.75	-0.29	-2.55	0.39	1.55	-1.00	-1.12
t	0.04	-1.22	-1.55	-0.98	-0.34	-1.99	0.76	1.14	-1.81	-2.59
BANAN	0.93	-0.35	-0.52	0.93	2.09	0.10	-0.33	0.10	-0.20	0.40
t	1.46	-0.56	-0.82	1.44	2.84	0.09	-0.76	0.08	-0.44	1.09
CASFL	-0.34	-0.03	-0.32	0.04	1.36	-0.45	-0.03	2.59	0.60	-0.21
t	-0.64	-0.06	-0.59	0.08	2.20	-0.49	-0.08	2.69	1.55	-0.68
BEANS	1.08	0.39	-0.17	0.05	-5.43	-1.87	0.29	2.51	-0.30	-1.36
t	0.85	0.30	-0.14	0.04	-3.65	-0.85	0.33	1.08	-0.32	-1.84
PEAS	-0.05	-0.09	-0.06	-0.03	-0.40	-0.24	0.10	-0.23	0.15	0.02
t	-0.24	-0.45	-0.29	-0.15	-1.75	-0.73	0.73	-0.65	1.07	0.13
VEGET	0.05	0.05	0.25	0.34	-0.09	-0.28	-0.05	-0.19	0.19	0.22
t	0.24	0.23	1.18	1.63	-0.38	-0.80	-0.35	-0.51	1.26	1.84
BEEF	-0.25	-0.18	0.23	0.28	-0.19	-0.78	0.39	-0.04	0.01	0.59
t	-0.51	-0.38	0.46	0.57	-0.34	-0.94	1.19	-0.05	0.03	2.11
MEAT	-0.35	-0.34	0.46	0.38	-1.03	1.68	0.05	0.65	0.23	-0.04
t	-0.76	-0.74	0.99	0.82	-1.93	2.15	0.16	0.78	0.69	-0.14
MILK	0.65	-0.58	0.71	0.49	1.73	-0.95	-0.01	0.79	-0.60	0.88
t	1.11	-0.99	1.20	0.83	2.53	-0.95	-0.02	0.74	-1.40	2.61
BBEER	-1.67	-1.49	-0.48	-6.30	2.98	1.11	0.24	-1.57	0.04	-0.53
t	-1.62	-1.45	-0.47	-6.03	2.49	0.63	0.34	-0.84	0.05	-0.90
SBEER	-0.19	-0.10	-0.26	-0.31	-0.98	2.29	0.06	-0.50	0.65	-0.22
t	-0.47	-0.24	-0.63	-0.75	-2.08	3.30	0.21	-0.68	2.20	-0.95
FBEER	0.46	2.64	1.12	1.11	-0.71	0.74	-0.15	-2.75	0.62	1.09
t	0.44	2.51	1.06	1.04	-0.58	0.41	-0.21	-1.44	0.80	1.80
OIL	0.11	-0.07	-0.21	0.20	-0.10	-0.66	0.21	-0.65	0.24	0.24
t	0.41	-0.25	-0.79	0.74	-0.33	-1.45	1.13	-1.33	1.22	1.56
SALT	0.03	-0.05	0.01	-0.03	-0.09	-0.05	-0.00	0.60	0.05	-0.08
t	0.38	-0.64	0.19	-0.35	-1.00	-0.36	-0.01	4.26	0.82	-1.73
SUGAR	0.25	-0.19	-1.42	0.55	1.27	-0.91	0.15	-0.38	0.19	0.52
t	0.61	-0.46	-3.38	1.31	2.61	-1.27	0.53	-0.50	0.62	2.16
MEALS	-1.27	-0.03	0.97	0.56	1.43	0.10	-0.53	-2.86	-2.11	-0.99
t	-0.86	-0.02	0.66	0.38	0.84	0.04	-0.53	-1.08	-1.97	-1.17

Table C-4: Coefficients of the SUR model of urban demand under symmetry restrictions

Dependent variable (share)	constant ß0	lnexp ß1	lnexp2 ß2	adults γ1	children γ2	fem hh γ3
SORGH	12.43	-1.59	0.06	-0.13	-0.03	-0.07
t	0.85	-0.59	0.44	-1.67	-0.80	-0.28
RICE	-99.28	18.87	-0.88	-0.05	0.13	-0.02
t	-4.23	4.39	-4.34	-0.41	1.99	-0.05
BREAD	-33.80	5.24	-0.24	0.09	0.06	0.11
t	-3.99	3.37	-3.23	1.97	2.47	0.77
CASSA	-20.51	4.49	-0.26	-0.35	0.14	-0.69
t	-0.91	1.06	-1.33	-3.01	2.12	-1.76
SWPOT	200.36	-35.19	1.48	-0.49	-0.19	-0.06
t	5.05	-4.72	4.22	-2.40	-1.67	-0.08
WHPOT	-2.46	8.50	-0.49	-0.31	0.10	0.19
t	-0.07	1.22	-1.50	-1.59	0.93	0.29
BANAN	15.19	-1.06	-0.02	-0.12	0.04	0.88
t	0.50	-0.19	-0.07	-0.77	0.48	1.64
CASFL	36.55	-5.32	0.18	-0.02	0.15	0.64
t	1.42	-1.11	0.81	-0.12	2.08	1.42
BEANS	196.84	-25.85	0.86	-1.35	-0.48	-0.82
t	2.99	-2.09	1.47	-4.00	-2.55	-0.71
PEAS	4.61	0.02	-0.01	-0.03	0.01	-0.20
t	0.48	0.01	-0.07	-0.68	0.22	-1.20
VEGET	-25.46	4.29	-0.20	0.13	0.01	0.57
t	-2.36	2.16	-2.19	2.35	0.45	3.04
BEEF	-112.44	22.18	-1.05	-0.10	0.11	-0.37
t	-4.74	4.99	-5.02	-0.84	1.57	-0.89
MEAT	-24.00	5.36	-0.24	0.28	0.08	0.28
t	-1.07	1.27	-1.23	2.41	1.24	0.70
MILK	-60.41	9.42	-0.45	0.29	0.09	0.63
t	-2.07	1.72	-1.75	1.95	1.02	1.23
BBEER	-92.91	22.52	-1.14	-1.46	-0.63	-5.03
t	-1.82	2.34	-2.51	-5.59	-4.26	-5.57
SBEER	6.49	-0.98	0.02	-0.24	-0.15	-0.65
t	0.32	-0.26	0.13	-2.29	-2.54	-1.84
FBEER	-66.84	12.18	-0.45	-0.10	-0.14	-1.93
t	-1.27	1.24	-0.98	-0.36	-0.95	-2.09
OIL	-57.60	11.15	-0.53	-0.01	0.11	0.55
t	-4.29	4.46	-4.47	-0.11	2.98	2.35
SALT	3.49	-0.45	0.01	-0.01	-0.01	0.11
t	0.86	-0.62	0.26	-0.44	-1.34	1.54
SUGAR	-58.70	11.41	-0.54	0.00	0.17	1.40
t	-2.82	2.92	-2.94	0.01	2.80	3.83
MEALS	99.00	-17.51	0.84	-0.79	-0.75	-2.24
t	1.44	-1.34	1.36	-2.24	-3.75	-1.82

Dependent variable (share)	constant ß0	lnexp ß1	lnexp2 ß2	adults γ1	children γ2	fem hh γ3
CLOTH	-47.60	9.81	-0.46	0.22	0.09	-0.36
t	-1.24	1.35	-1.33	1.13	0.83	-0.53
HOUSE	290.47	-63.88	3.49	1.26	0.22	1.67
t	2.81	-3.26	3.77	2.42	0.73	0.91
EQUIP	-16.53	1.41	0.03	0.21	0.17	0.37
t	-0.53	0.24	0.11	1.32	1.87	0.67
ENERG	-120.65	22.05	-0.98	0.44	0.22	0.92
t	-3.09	2.98	-2.80	2.25	1.98	1.33
HEALT	-38.72	7.42	-0.34	0.38	0.11	0.69
t	-1.69	1.71	-1.65	3.29	1.63	1.69
EDUCA	-29.75	5.25	-0.23	0.12	0.26	1.32
t	-1.07	1.00	-0.93	0.85	3.20	2.68
TRANS	60.02	-14.90	0.88	1.22	0.35	1.39
t	0.96	-1.25	1.56	3.86	1.91	1.25
TOBAC	-34.51	7.59	-0.38	-0.16	-0.19	-1.03
t	-1.83	2.13	-2.28	-1.71	-3.46	-3.09
LEISU	15.45	-4.25	0.26	0.79	0.04	0.40
t	0.72	-1.04	1.35	7.28	0.69	1.04

Dependent variable (share)	SOR α_{i1}	RICE α_{i2}	BRD α_{i3}	CAS α_{i4}	SWPT α_{i5}	WHPT α_{i6}	BAN α_{i7}	CSFL α_{i8}	BEAN α_{i9}	PEAS α_{i10}	VEG α_{i11}
SORGH	-0.28	0.03	-0.07	0.00	-0.19	0.32	-0.23	0.16	0.41	-0.08	0.11
t	-0.88	0.07	-0.45	0.01	-0.65	0.67	-1.14	0.59	0.85	-0.43	0.63
RICE	0.03	-3.04	0.22	-0.93	1.19	0.37	0.06	0.50	1.92	0.23	-0.07
t	0.07	-2.91	0.79	-2.28	2.55	0.45	0.20	1.12	2.46	0.70	-0.21
BREAD	-0.07	0.22	0.15	-0.02	0.16	-0.14	-0.03	0.39	0.18	0.06	0.08
t	-0.45	0.79	1.03	-0.15	0.95	-0.44	-0.28	2.30	0.65	0.51	0.63
CASSA	0.00	-0.93	-0.02	1.50	-0.10	0.98	-0.25	-0.49	0.63	0.23	-0.20
t	0.01	-2.28	-0.15	3.33	-0.25	1.77	-0.86	-1.39	0.97	1.28	-1.12
SWPOT	-0.19	1.19	0.16	-0.10	-2.60	1.06	-0.08	0.48	2.66	0.42	0.35
t	-0.65	2.55	0.95	-0.25	-3.17	1.54	-0.18	1.04	2.92	2.09	1.73
WHPOT	0.32	0.37	-0.14	0.98	1.06	-0.16	0.07	0.04	1.57	-1.89	0.10
t	0.67	0.45	-0.44	1.77	1.54	-0.11	0.15	0.07	1.43	-4.94	0.27
BANAN	-0.23	0.06	-0.03	-0.25	-0.08	0.07	-0.85	-0.12	0.01	0.03	0.14
t	-1.14	0.20	-0.28	-0.86	-0.18	0.15	-1.91	-0.35	0.02	0.21	0.97
CASFL	0.16	0.50	0.39	-0.49	0.48	0.04	-0.12	-0.96	0.03	-0.18	-0.07
t	0.59	1.12	2.30	-1.39	1.04	0.07	-0.35	-1.72	0.04	-0.93	-0.36
BEANS	0.41	1.92	0.18	-0.63	-2.66	1.57	0.01	0.03	1.59	0.06	0.33
t	0.85	2.46	0.65	-0.97	-2.92	1.43	0.02	0.04	0.79	0.20	0.98
PEAS	-0.08	0.23	0.06	0.23	0.42	-1.89	0.03	-0.18	0.06	-0.13	0.16
t	-0.43	0.70	0.51	1.28	2.09	-4.94	0.21	-0.93	0.20	-0.62	1.07
VEGET	0.11	-0.07	0.08	-0.20	0.35	0.10	0.14	-0.07	0.33	0.16	-0.12
t	0.63	-0.21	0.63	-1.12	1.73	0.27	0.97	-0.36	0.98	1.07	-0.59
BEEF	-0.03	0.19	-0.04	0.32	0.72	-0.64	-0.13	-0.31	0.48	-0.04	0.03
t	-0.15	0.49	-0.27	1.04	1.77	-1.20	-0.47	-0.89	0.74	-0.25	0.20
MEAT	0.10	-0.42	0.01	-0.22	0.53	-1.05	0.24	-0.12	0.69	-0.21	0.04
t	0.42	-1.10	0.08	-0.73	1.35	-1.98	0.85	-0.36	1.09	-1.22	0.22
MILK	-0.18	0.47	0.21	1.09	0.49	-1.26	-0.65	-0.06	0.50	0.05	0.25
t	-0.69	1.15	1.43	3.18	1.04	-2.15	-1.92	-0.15	0.67	0.29	1.40
BBEER	0.14	0.68	-0.01	0.39	-0.13	-0.55	1.06	0.58	0.86	-0.05	0.41
t	0.51	1.54	-0.03	0.96	-0.22	-0.83	2.31	1.27	0.91	-0.27	2.11
SBEER	-0.39	-0.80	-0.30	1.05	-0.90	-0.08	0.70	1.33	0.96	-0.45	-0.05
t	-1.55	-1.86	-1.86	3.40	-2.36	-0.15	2.66	3.92	1.56	-2.38	-0.27
FBEER	0.12	0.49	-0.17	-1.07	-0.41	-1.24	0.26	-0.33	1.87	0.01	-0.35
t	0.28	0.70	-0.65	-1.82	-0.51	-1.25	0.45	-0.50	1.45	0.02	-1.15
OIL	-0.25	-0.12	0.09	0.26	0.67	0.07	-0.18	0.01	0.08	0.07	-0.14
t	-1.62	-0.44	0.90	1.36	2.81	0.22	-1.06	0.05	0.21	0.62	-1.24
SALT	-0.01	0.01	0.00	-0.02	0.12	0.03	-0.05	0.09	0.03	-0.05	-0.11
t	-0.15	0.06	0.04	-0.21	1.41	0.18	-0.86	1.11	0.21	-0.60	-1.41
SUGAR	0.19	-0.17	0.05	0.14	1.43	-1.03	-0.52	0.13	0.44	0.24	0.10
t	1.02	-0.59	0.44	0.57	4.34	-2.48	-2.21	0.49	0.83	1.84	0.77
MEALS	-0.04	-0.10	0.20	-0.01	0.30	-0.83	0.55	-0.37	0.49	0.04	0.16
t	-0.27	-0.38	2.19	-0.06	0.71	-2.02	1.69	-1.28	0.73	0.38	1.40

Dependent variable (share)	BEEF αi12	MEAT αi13	MILK αi14	BBR αi15	SBR αi16	FBR αi17	OIL αi18	SALT αi19	SUGR αi20	MEAL αi21
SORGH	-0.03	0.10	-0.18	0.14	-0.39	0.12	-0.25	-0.01	0.19	-0.04
t	-0.15	0.42	-0.69	0.51	-1.55	0.28	-1.62	-0.15	1.02	-0.27
RICE	0.19	-0.42	0.47	0.68	-0.80	0.49	-0.12	0.01	-0.17	-0.10
t	0.49	-1.10	1.15	1.54	-1.86	0.70	-0.44	0.06	-0.59	-0.38
BREAD	-0.04	0.01	0.21	-0.01	-0.30	-0.17	0.09	0.00	0.05	0.20
t	-0.27	0.08	1.43	-0.03	-1.86	-0.65	0.90	0.04	0.44	2.19
CASSA	0.32	-0.22	1.09	0.39	1.05	-1.07	0.26	-0.02	0.14	-0.01
t	1.04	-0.73	3.18	0.96	3.40	-1.82	1.36	-0.21	0.57	-0.06
SWPOT	0.72	0.53	0.49	-0.13	-0.90	-0.41	0.67	0.12	1.43	0.30
t	1.77	1.35	1.04	-0.22	-2.36	-0.51	2.81	1.41	4.34	0.71
WHPOT	-0.64	-1.05	-1.26	-0.55	-0.08	-1.24	0.07	0.03	-1.03	-0.83
t	-1.20	-1.98	-2.15	-0.83	-0.15	-1.25	0.22	0.18	-2.48	-2.02
BANAN	-0.13	0.24	-0.65	1.06	0.70	0.26	-0.18	-0.05	-0.52	0.55
t	-0.47	0.85	-1.92	2.31	2.66	0.45	-1.06	-0.86	-2.21	1.69
CASFL	-0.31	-0.12	-0.06	0.58	1.33	-0.33	0.01	0.09	0.13	-0.37
t	-0.89	-0.36	-0.15	1.27	3.92	-0.50	0.05	1.11	0.49	-1.28
BEANS	0.48	-0.69	0.50	-0.86	-0.96	-1.87	0.08	-0.03	-0.44	-0.49
t	0.74	-1.09	0.67	-0.91	-1.56	-1.45	0.21	-0.21	-0.83	-0.73
PEAS	-0.04	-0.21	0.05	-0.05	-0.45	0.01	0.07	-0.05	0.24	0.04
t	-0.25	-1.22	0.29	-0.27	-2.38	0.02	0.62	-0.60	1.84	0.38
VEGET	0.03	0.04	0.25	0.41	-0.05	-0.35	-0.14	-0.11	0.10	0.16
t	0.20	0.22	1.40	2.11	-0.27	-1.15	-1.24	-1.41	0.77	1.40
BEEF	-0.07	-0.28	0.18	0.36	-0.03	-1.27	0.13	0.02	-0.18	0.45
t	-0.18	-0.97	0.54	0.89	-0.08	-2.22	0.73	0.22	-0.74	1.71
MEAT	-0.28	-0.43	0.18	0.41	-0.75	1.62	-0.12	-0.05	-0.03	-0.14
t	-0.97	-1.05	0.56	1.04	-2.59	2.90	-0.67	-0.66	-0.15	-0.56
MILK	0.18	0.18	1.25	0.40	0.12	-0.46	-0.02	0.04	-0.87	0.67
t	0.54	0.56	2.32	0.83	0.38	-0.69	-0.09	0.52	-3.18	2.15
BBEER	0.36	0.41	0.40	-5.51	-0.38	0.91	0.31	-0.01	0.45	-0.63
t	0.89	1.04	0.83	-5.72	-1.03	1.08	1.31	-0.09	1.34	-1.21
SBEER	-0.03	-0.75	0.12	-0.38	-0.39	2.31	-0.07	-0.10	0.89	-0.06
t	-0.08	-2.59	0.38	-1.03	-0.93	4.24	-0.38	-1.17	3.88	-0.27
FBEER	-1.27	1.62	-0.46	0.91	2.31	-0.54	-0.61	-0.05	-0.27	1.00
t	-2.22	2.90	-0.69	1.08	4.24	-0.34	-1.80	-0.37	-0.58	1.78
OIL	0.13	-0.12	-0.02	0.31	-0.07	-0.61	0.04	-0.01	0.05	0.11
t	0.73	-0.67	-0.09	1.31	-0.38	-1.80	0.26	-0.14	0.38	0.79
SALT	0.02	-0.05	0.04	-0.01	-0.10	-0.05	-0.01	0.49	0.01	-0.07
t	0.22	-0.66	0.52	-0.09	-1.17	-0.37	-0.14	3.86	0.14	-1.52
SUGAR	-0.18	-0.03	-0.87	0.45	0.89	-0.27	0.05	0.01	0.04	0.35
t	-0.74	-0.15	-3.18	1.34	3.88	-0.58	0.38	0.14	0.14	1.55
MEALS	0.45	-0.14	0.67	-0.63	-0.06	1.00	0.11	-0.07	0.35	-1.25
t	1.71	-0.56	2.15	-1.21	-0.27	1.78	0.79	-1.52	1.55	-1.57