AN ABSTRACT OF THE DISSERTATION OF

Paul A. Lewin for the degree of Doctor of Philosophy in Applied Economics, presented on March 14, 2011.

Title: Three Essays on Food Security, Food Assistance, and Migration

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Bruce A. Weber

This dissertation's three essays explore the determinants of food insecurity for rural farm households, the influence of rainfall variability and long-run changes in rainfall levels on the migration decisions of working-age household heads, and the distributional impacts in core and periphery regions of food assistance to households in the hinterland.

The first essay examines how socio-economic characteristics of households, local conditions, and public programs are associated with the probability that a farm household in rural Malawi is food insecure. The statistical analysis uses nationally representative data for 7,965 randomly-selected households interviewed during 2004/05 for the second Malawi Integrated Household Survey (IHS-2). Regressions are estimated separately for households in the north, center, and south of Malawi to account for spatial heterogeneity. Results of a Probit regression model reveal that households are less likely to be food

insecure if they have more cultivated land per capita, receive agricultural field assistance, reside in a community with an irrigation scheme, and are headed by an individual with a high school degree. Factors that positively correlate with a household's food insecurity are number of household members and distance to markets.

The second essay uses nationally representative data from Malawi's 2004/05 Integrated Household Survey (IHS-2) to examine whether rainfall conditions influence a rural worker's decision to make a long-term move to an urban or another rural area. Results of a Full Information Maximum Likelihood regression model reveal that (1) rainfall shocks constrain migration, most likely by making it difficult for prospective migrants to cover costs of migration, (2) migrants choose to move to communities where rainfall variability is lower, and (3) rainfall shocks have larger negative effects on the earnings of recent migrants than on long-time residents' earnings.

The third essay examines how benefits from food assistance programs to needy households spillover between areas and among household income groups in the United States. We study the effect of the Supplemental Nutrition Assistance Program (SNAP) in the Portland Oregon metro Core and its Periphery trade area, using a Multiregional Input-Output (MRIO) model based on a Social Accounting Matrix (SAM). The analysis captures direct, indirect and induced effects of SNAP on each region and spillover effects on the other region. SNAP benefits to the lower income household classes in each region are traced to their effects on the local economy in each region, and to the effects on household income by income class. The analysis finds that (1) the economic impact on the Portland Core from a given level of SNAP benefits to households in the Periphery is greater than the economic impact in the Periphery from the same level of SNAP benefits to households in the Core; (2) high-income households benefit more than low-income households from the indirect and induced economic impact of SNAP.

# Three Essays on Food Security, Food Assistance, and Migration

by

Paul A. Lewin

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Major Professor, representing Applied Economics

Director of the Applied Economics Graduate Program

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University Libraries. My signature below authorizes release of my dissertation to any reader upon request.

Paul A. Lewin, Author

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# CONTRIBUTION OF AUTHORS

Monica Fisher contributed to the writing and preparation of the manuscripts, "Household, Community, and Policy Determinants of Food Insecurity in Rural Malawi" (Chapter 2) and "Do Rainfall Conditions Push or Pull Rural Migrants? Evidence from Malawi" (Chapter 3).

David Holland direction was instrumental to developing of the methodology of the MRIO-SAM model in Chapter 4. He also contributed to the writing of the section "Building the MRIO-SAM model".

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# CHAPTER ONE

# INTRODUCTION AND OVERVIEW

In 2010, there were 925 million undernourished people in the world, including 906 million in the developing countries and 19 million in the industrialized countries FAO (2010). Unfortunately, the current food security situation is worse than it was ten years ago. Between 2000 and 2010, the number of undernourished people in the world increased by 92 million; that implies that one out of every six human beings is undernourished (FAO, 2010). Hunger has increased in the last years because of weather shocks and soaring food prices. Also, it has been exacerbated by the financial and economic crisis that has affected the world during 2008 and 2009. Currently, there are 32 countries in a situation of serious food crisis requiring emergency assistance, of which 20 are in Africa (FAO, 2010).

Agriculture plays an essential role in food security, particularly in the lowest-income countries. Three of every four people undernourished or in poverty in the world live in rural areas, and most of them depend on agriculture for their daily livelihoods (FAO). In many developing countries, agriculture is the most important sector of the economy because of its contribution to GDP (about 30% in agriculture-based countries), jobs (50% of employment in the developing world), exports and overall economic strength (FAO, 210).

Currently there are about 500 million small farms in developing countries, supporting the foods needs of almost 2 billion people – one third of humanity (IFAD, 2010). However, due to the fact that farming is dependent on climate, farm households are one of the groups most vulnerable to the effects of climate change. In rainfed agricultural systems, unfavorable rainfall conditions can have far-reaching and devastating impacts on farm households and their food security, because insurance to mitigate the effects of adverse weather are absent to the most vulnerable groups. Thus, farmers use a number of informal risk-coping strategies, such as selling physical assets, planting a diversity of crops, diversifying into non-farm activities, and migrating for employment.

This dissertation's three essays explore the determinants of food insecurity for rural farm households, how weather rainfall variability and long-run change in rainfall levels matter to the migration decisions of working-age household head, and how much the urban centers and high-income households benefit from food assistance to households in the hinterland. Understanding how household, community, and policy determinants influence food insecurity of rural farm households can help in the design of policies aimed at alleviating food insecurity. In addition, isolating how weather shocks affect a household's income and its probability to migrate, as an informal risk-coping strategy, is central to the design of policy interventions that make rural farm households less vulnerable to rainfall events. Until recently, the available information has been weak. Finally, understanding how rural and urban economie work together and how benefits from poverty reduction programs spillover between areas and among households groups would aid policymakers to seek new strategies for increasing economic well-being.

The first essay *Household, Community, and Policy Determinants of Food Insecurity in Rural Malawi* examines how socio-economic characteristics of households, local conditions, and public programs are associated with the probability that a farm household in rural Malawi is food insecure. Malawian smallholder farmers face significant challenges from small landholdings; nitrogen-deficient soils; climate variability; poor market access; and limited availability of improved farm inputs, technical assistance, credit, and agricultural insurance. The results provide insights into policy changes that have the potential to reduce food insecurity in African countries. For example, households are less likely to be food insecure if they have larger cultivated land per capita, receive agricultural field assistance, reside in a community with an irrigation scheme, and are headed by an individual with a high school degree.

The second essay *Do Rainfall Conditions Push or Pull Rural Migrants? Evidence from Malawi* studies whether rainfall conditions influence a rural worker's decision to make a long-term move to an urban or another rural area. The present study contributes to the literature in two ways. First, like Mueller and Osgood (2009), this study is one of the few allowing for the isolation of climate from the multitude of other factors that affect rural people's migration decisions. Second, the study models precipitation anomalies as a push and a pull factor for prospective migrants; previous studies have considered climate as a push factor only. Results show that rainfall shocks constrain migration, most likely by making it difficult for prospective migrants to cover costs of migration. The results also show that migrants choose to move to communities where rainfall variability is lower, and that rainfall shocks have larger negative effects on the earnings of recent migrants than on long-time residents' earnings. If these findings are corroborated by future research, then there is additional justification for policy interventions to make farm households less vulnerable to rainfall events.

The third essay *Distributional Impacts of Food Assistance: How Much Do Urban Households Benefit from Rural SNAP Payments?* studies how benefits from food assistance programs spill over between trade regions and among household income groups. People in poverty or food insecure often are viewed as a burden for their societies. Wealthy people often believe that they finance policies that help poor people in depressed regions but are insulated from the benefits of these programs. However, not very much is known about rural–urban linkages. From production to consumption, the food system comprises complex interrelated and interdependent parts: social and economic elements, agencies, processes, and structures. Understanding how rural and urban economies work together and how benefits from food programs spillover across regions and income classes would aid policymakers explain the distributional impacts of these programs to their constituents.

The three essays together improve our understanding about rural farm household vulnerability to food insecurity and rainfall events and the distributional impacts of food security programs. The results have important policy implications, especially by way of insights into how food security programs can be combined with regional development policies, such as improving infrastructure and local markets, to improve farm household economic conditions and general economic well-being.

# CHAPTER TWO

# HOUSEHOLD, COMMUNITY, AND POLICY DETERMINANTS OF FOOD INSECURITY IN RURAL MALAWI

## 2.1. Introduction

In Malawi, as in many other southern African countries, food security at the national and household level is highly dependent on productivity of the staple food - maize. Smallholder agriculture is characterized by small landholdings; dependence on highly variable rainfall (McSweeney et al, 2008); nitrogen-deficient soils; limited use of modern agricultural inputs, due to the high cost of inputs and low purchasing power of farm households (Masters and Fisher, 1999); and heavy reliance on the labor of household members, which tends to be in short supply during the peak agricultural period (Wodon and Beegle, 2006). These factors prevent most smallholder farmers from meeting their subsistence requirements; therefore, about 80% are net buyers of maize. Because Malawi is a landlocked country with poor transport infrastructure, maize imports are prohibitively expensive for many smallholder farmers (Harrigan, 2008). These conditions have led to acute and chronic food insecurity: a recent survey estimated that almost one-third of Malawi’s households are unable to meet their daily per capita calorie requirements (FAO, 2009). The Malawi Government has long viewed food insecurity as a high priority problem. However, reliable information on the determinants of food insecurity and on the impacts of policies is necessary to design appropriate interventions and target assistance to those most in need, and until recently, the available information has been weak.

The goal of the present study is to provide new information that can be used to design policies aimed at alleviating food insecurity in Malawi, with a specific focus on rural farm households. Household, community, and policy determinants of food insecurity are evaluated using nationally-representative data from Malawi's second Integrated Household Survey (IHS-2) and a Probit regression model. A household is considered food secure if its daily per capita calorie consumption was greater than or equal to the energy requirements for basal metabolic function and light activity of all household members (Smith et al, 2006).

In the economics literature, food security is generally studied with two main approaches. One approach uses economic theory of consumers to derive price and income elasticities for food, calories, and nutrients, either based on reduced-form calorie demand equations (e.g., Subramanian and Deaton, 1996; Dawson and Tiffin, 1998; Abdulai and Aubert, 2004), or on estimated calorie elasticities for different food groups (e.g., Pitt, 1983; Strauss, 1984; Pitt and Rosenzweig, 1985; Strauss, 1986; Garrett and Ruel, 1999). A second approach identifies the probability that a household is food insecure, based on home-energy production, then identifies the determinants of food insecurity using a reduced-form model. This approach allows evaluation of the effects of household demographics and endowments; local economic, agronomic, and social conditions; and specific public policies (e.g., Rose et al, 1998; Bernell et al, 2006). This empirical approach is employed in the current study.

A recent study of food security in Malawi developed a food demand system model with data from the Integrated Household Survey (IHS), and concluded that calorie consumption in Malawi could be increased through policies that reduce food prices or increase household income (Ecker, 2009). Ecker also predicted that policies targeting household income would be more effective at reducing micronutrient deficiencies than policies targeting food prices. The present study complements Ecker's study by examining household and community factors that are associated with food security, and by evaluating public policies that are currently being implemented in Malawi: irrigation schemes, fertilizer subsidies, and agricultural extension.

The essay is organized as follows. The next section describes a theoretical model of home-energy production and derives a reduced form energy demand equation. Section 3 presents the Probit regression model that is used to examine the determinants of food insecurity in Malawi. This is followed by a description of the dataset. In section 5 of the essay, we present and discuss the regression results. The regression model is then used to run simulations using different combinations of parameters to predict how changes in selected variables might affect the probability of household food insecurity in Malawi. Finally, the concluding section of the essay summarizes the key findings of the study and highlights their policy implications.

### 2.2 Economic Framework

A theoretical model of food insecurity is developed, drawing on household production theory (Becker, 1965) and the theory of demand for characteristics (Gorman, 1959; Lancaster, 1966; Pollak and Wachter, 1975). The model integrates producer, consumer, and worker decisions into a household problem, assuming perfect markets (Singh et al, 1986; Sadoulet and de Janvry, 1995).

Households seek to maximize utility defined over the commodity space $Z: Z = (z_1, \ldots, z_N)$, where $z_1$ represents energy found in food and $z_{n \neq 1}$ is other commodities. The utility function $U(Z)$ is assumed quasi-concave and monotonic. Each commodity is produced by a separate constant returns to scale production process, which combines market goods $X: X = (x_1, \ldots, x_M)$, including food, with time spent on non-work activities $(T_c)$.[1] Thus, the household production function is represented by

$$z_n = Z(X, T_c; D_z), \qquad (2.1)$$

where $D_z$ is a vector of characteristics that influence the environment in which production takes place, for example, household demographics and local economic opportunity.

We assume that, if household labor is spent producing $z_n$, that reduces the availability of leisure, but has no direct effect on utility. As a result, only the output of the production process enters the household's utility function.[2] Note also that some of the *z*'s can be identical to some of the market goods *x*.

Since food energy price is endogenous to the household, it is convenient to use duality results to define it. The household's cost function for producing the commodity vector $Z$ at the minimum cost, subject to the technological constraint $Z \in \Omega(X, T_c)$, is given by,

[1] Following Becker (1965) and Pollak and Wachter (1975), we do not distinguish between time spent on consumption and time spent on household production of commodities.
[2] These assumptions disable joint production and allow us to identify the inputs used to produce food energy.

$$C(P,\omega,Z;D_z) = min_{X,T_c} \sum_{m=1}^{M} p_m x_m + \omega T_c \quad s.t.\ \ Z \in \Omega(X,T_c) \qquad (2.2)$$

where $P: P = (p_1, \dots, p_M)$ is a vector of prices of goods, and $\omega$ is the effective wage.

The commodity implicit or shadow prices $s_n$ are defined as the partial derivatives of the cost function,[3]

$$s_n(P,\omega,Z;D_z) = \frac{\partial C(P,\omega,Z;D_z)}{\partial z_n} \qquad (2.3)$$

and the budget constraint is given by,

$$\sum_{n=1}^{N} s_n(P,\omega;D_z) z_n = y \qquad (2.4)$$

where $y$ is total budget.

The agricultural production technology is denoted by

$$G(Q,V,L;D_a) = 0 \qquad (2.5)$$

where $Q$ is a vector of agricultural goods produced, $V$ is purchased non-labor inputs (e.g., fertilizer), $L$ is effective hired labor, and $D_a$ is a vector of variables that influence agricultural production, such as the household's land endowment and agricultural policies. Agricultural inputs are acquired from the market only, with the exception of labor, which is provided by the household or hired in local markets. The agricultural goods produced by households are crops ($Q$), which may be sold on the market or home consumed. The agricultural production function is assumed to be quasi-convex, increasing in outputs and decreasing in inputs.

The agricultural profit function is convex in all prices and is denoted by,

$$\pi(q_c,\omega,q_v;D_a) = q_c Q - \omega L - q_v V \qquad (2.6)$$

[3] If the household's technology exhibits constant returns to scale and no joint production, then shadows prices do not depend on the commodity bundle consumed. See Pollak and Wachter (1975) for a formal proof.

where $q_c$ and $q_v$ are vectors of prices of agricultural outputs and inputs, respectively. We assume that hired labor and family labor are perfect substitutes, and that the supply of hired labor to an individual household is perfectly elastic at the efficiency market wage, $\omega$.

The household's full income $(y)$ is equal to the value of its working time $(T_w)$, plus the value of its agricultural profit $\pi$, plus any exogenous income $R$.

$$y = \omega T_w + \pi + R. \tag{2.7}$$

The total time available for the household is given by

$$T = T_w + T_c. \tag{2.8}$$

Thus, we can re-write the budget constraint as follows

$$\sum_{n=1}^{N} s_n(P, \omega; D_z) z_n = \omega T_w + \pi + R. \tag{2.9}$$

Hence, the household maximization problem is

$$Max_{X,T_c,Q,V,L}\, U(Z) \tag{2.10}$$

s.t.

$$\sum_{n=1}^{N} s_n(P, \omega; D_z) z_n = \omega T_w + q_c Q - \omega L - q_v V + R \quad \text{(cash income constraint)} \tag{2.11}$$

$$G(Q, V, L; D_a) = 0 \quad \text{(agricultural production technology)} \tag{2.12}$$

$$z_n = Z(X, T_c; D_z) \quad \text{(household commodity production technology)} \tag{2.13}$$

$$T = T_w + T_c \quad \text{(time constraint)} \tag{2.14}$$

The Lagrangian associated with this maximization problem is:

$$\mathcal{L} = U\big(Z(X, T_c; D_z)\big) + \lambda[\omega(T - L) + q_c Q - q_v V + R - PX - \omega T_c] + \eta G(Q, V, L; D_a) \tag{2.15}$$

since at the optimum $C(P, \omega, Z; D_z) = \sum_{n=1}^{N} s_n(P, \omega; D_z) z_n$.

If we assume an interior solution, the first order conditions of the system are:

$$\frac{\partial \mathcal{L}}{\partial X} = \frac{\partial U}{\partial Z}\frac{\partial Z}{\partial X} - \lambda P = 0 \tag{2.16}$$

$$\frac{\partial \mathcal{L}}{\partial T_c} = \frac{\partial U}{\partial Z}\frac{\partial Z}{\partial T_c} - \lambda \omega = 0 \tag{2.17}$$

$$\frac{\partial \mathcal{L}}{\partial Q} = \lambda q_c + \eta \frac{\partial G}{\partial Q} = 0 \tag{2.18}$$

$$\frac{\partial \mathcal{L}}{\partial V} = -\lambda q_v + \eta \frac{\partial G}{\partial V} = 0 \tag{2.19}$$

$$\frac{\partial \mathcal{L}}{\partial L} = -\lambda \omega + \eta \frac{\partial G}{\partial L} = 0 \tag{2.20}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = \omega(T - L) + q_c Q - q_v V + R - PX - \omega T_c = 0 \tag{2.21}$$

$$\frac{\partial \mathcal{L}}{\partial \eta} = G(Q, V, L; D_a) = 0 \tag{2.22}$$

Conditions (2.16) and (2.17) indicate how changes in the consumption of market goods and non-work activity time indirectly augment utility by changing the level of commodities. They establish that marginal indirect utility of market goods and non-work activity time are equal to market good prices and the efficiency market wage, respectively. Equation (2.17) also influences income indirectly by altering the time available for work. Conditions (2.18) and (2.19) are the profit maximization conditions for the production of agricultural goods and the use of non-labor inputs. They show that marginal productivity of non-labor inputs and marginal production of agricultural goods are equal to their respective market prices. Expression (2.20) is the profit maximization condition for the use of farm labor input. It establishes that the efficiency market wage is equal to marginal productivity of labor. Thus, farm production and consumption allocation are separable because labor time can be hired at constant cost per unit to substitute for changes in household's labor supply. Finally, expressions (2.21) and (2.22) are, respectively, the cash income constraint and the agricultural production technology constraint faced by the household.

The reduced form energy demand equation resulting from household utility maximization is: [4]

$$z_1 = Z(S(P, \omega; D_z), y) = Z(P, q_c, q_v, \omega, R, D_a, D_z) \quad (2.23)$$

## 2.3. Empirical Model

In order to evaluate the various contributions of the factors affecting the demand for energy (2.23) to the likelihood of food insecurity we use a Probit model. The dependent variable for the model (*F*) is a dummy variable indicating whether the household consumed sufficient dietary energy to meet the requirements of all of household members. When the household's energy consumption($z_1$) falls below some minimum level ($z_{min}$), the household is food insecure, and $F = 1$. Otherwise, $F = 0$. Household food insecurity (*F*) is a function of prices ($P$, $q_c$, $q_v$), wages ($\omega$), non-labor income ($R$), and non-price factors ($D_a$ and $D_z$) that influence agricultural production, purchasing power, and preferences. The model takes the form

$$F = E(z_1 = 1 | P, q_c, q_v, \omega, R, D_a, D_z) = \Phi(z_1) \quad (2.24)$$

$$z_1 = Z(P, q_c, q_v, \omega, R, D_a, D_z). \quad (2.25)$$

where $\Phi$ is the standard normal cumulative distribution function.

[4] These demand functions satisfy all the properties of traditional demand theory since the production function places no special restrictions on the utility function $U(Z)$.

### 2.3.1 Explanatory Variables

*Prices, Wages, and Non-labor Income*

We use a price index that accounts for spatial and temporal price differences as a proxy for prices of goods (*P*), and local prices of some representative items as a proxy for agricultural outputs ($q_c$) and farm inputs ($q_v$). The price of maize, Malawi's staple crop, is chosen to represent agricultural output prices. The association between the price of maize and food security is expected to depend on whether the household was a net seller or buyer of maize. For farm inputs, we include the price of urea, the most common fertilizer used by Malawian farmers (Goverment of Malawi and World Bank, 2006) and provided in recent free-input programs, such as the Starter Pack Scheme (SPS) and the Targeted Inputs Programme (TIP). We expect a negative association between food security and the price of urea. To estimate wages, we use the average local wage for *ganyu*, which is defined as piecework labor, usually of an agricultural nature, for which remuneration is often in the form of food (e.g., a bag of maize), but sometimes in cash (Kerr, 2005). Participation in *ganyu* is widespread in Malawi: over 50% of rural households engaged in such casual work in 2004, according to data from the IHS2. The effect of the *ganyu* wage on a household's food security situation should depend on whether the household supplied or demanded *ganyu* labor. Non-labor income (*R*) includes income from savings accounts (interest), pensions, rental of property, and other sources. We expect a positive association between non-labor income and a household's food security.

*Household-level Variables*

Vectors $D_a$ and $D_z$ incorporate household-level factors: local economic, social, and agronomic conditions; agricultural policies; and social safety-net programs. These variables influence the calories available to a household, through their effects on the household's agricultural output, purchasing power, and preferences. The following discussion does not differentiate between the variables in the two vectors, because some variables belong to both.

Household-level factors that are part of $D_a$ or $D_z$ include age, gender, and education of the householder; household size and structure; health status of adult members; the size of the landholding; and the stock of liquid assets. We expect age of the household head to have a positive association with food security, because age is a proxy for accumulated skills in crop husbandry and management, and marketing experience. We include a dummy variable for householder gender. Women may have superior managerial skills (Chavas et al, 2005), but are also burdened by child care, household maintenance, and economic production. Malawian women suffer from gender inequities in the labor market (Buvinic and Gupta, 1997), and males have better employment opportunities than women (Mukherjee and Benson, 2003). Householder education is expected to have a positive effect on food security. Education imparts greater knowledge regarding food choices, cooking methods, and nutrition (Rose et al, 1998; Abdulai and Aubert, 2004; Bernell et al, 2006), and influences both present and future income (Psacharopoulos, 1981; Lau et al, 1991; Buchmann and Hannum, 2001).

We evaluate the impact of illness and disabilities using two variables: a dummy variable indicating whether the householder or wife had a serious illness that prevented participation in activities, and a dummy variable indicating whether the householder or wife was disabled. Recent research indicates that families with adult members who are disabled or chronically ill are more likely to be food insecure (Tarasuk, 2001; Bernell et al, 2006), probably due to effects of health status on labor supply, worker productivity, farm output, and earnings.

We expect that household size and structure affect food security in a number of ways. A greater number of dependent household members increases food requirements, although economies of size in food purchasing may reduce the associated increase in food costs. An increase in the number of working adults may have a positive effect on agricultural production and income, and ultimately on calorie availability. Therefore, we include the following variables in the model: number of children (<14 years old), number of adult males and females (15-64 years old), and number of elders (≥65 years old).[5]

The model includes the total land cultivated per capita by the household in the previous cropping year, which we expect to provide an indication of a household's agricultural capacity and degree of food security (Ellis et al, 2003). Households with larger farms should have a higher probability of being food secure, since farm size is positively associated with cash crop income (Tschirley and Weber, 1994). Furthermore,

[5] We classify adult members as those aged 15-64 years, following the convention of the IHS-2. Furthermore, although Malawi is party to several international conventions against child labor, the official minimum working age in the country is 14 years.

household production of agricultural products is particularly important where food markets are not well developed. In Malawi, many smallholders want to be self-sufficient in maize, partly due to concerns about market unreliability (Alwang and Siegel, 1999).

To provide a measure of household liquid assets in the model, we create a livestock index variable, based on the number of livestock holdings by type.[6] Livestock acquisition is a key form of wealth accumulation in rural Africa (Dercon, 1998), and ownership influences food security, because livestock are a relatively liquid asset that can be consumed or sold during seasonal food shortages or when misfortune strikes. Livestock can also be sold to take advantage of rises in price or to provide the financial capital needed to start a business (Dercon, 1998).

*Community-level Variables*

In addition to household variables, the model incorporates local economic, social, and agronomic conditions. We expect poor market access to increase food insecurity by making it difficult for consumers to buy food, increasing a farmer's production costs, and reducing farm profits. Previous studies measured market access as a combination of distance to market(s), utility of the market (based on supply or demand attributes), quality of the route, and capacity of the agent to travel to markets (Staal et al, 2002). We use the following community-level variables to measure market access: distance to the nearest weekly market, distance to an Agricultural Development Marketing Corporation

[6] Although the IHS2 data include information on the respondent's estimate of current value of livestock holdings, this information is expected to be measured with considerable error. We thus follow Filmer and Pritchett (1999) and construct the livestock index using Principal Components Analysis. The first principal component is used to determine weighting factors for each type of livestock and define the livestock index.

(ADMARC) depot, and a binary variable indicating whether or not the most common road surface is tar.[7]

Social supports influence food security by providing access to food or production resources (Bernell et al, 2005). Therefore, the model includes dummy variables that indicate whether or not there was a credit club or agricultural cooperative group in the community.

The model includes a set of dummy variables for Malawi's eight agricultural development districts, which correspond to the agro-economic zones of the country. The variables provide information regarding the agronomic endowment of an area in terms of soil fertility, climate, and natural resources, as well as economic features, such as the degree of market access. A variable measuring the millimeters of rainfall received by each district during the last year is also included.

*Policy Variables*

The model includes three variables that represent important components of the government's current agricultural policies. The first is a binary variable that indicates household participation in the Starter Pack Scheme (SPS) in at least one of the last three cropping seasons, i.e., receipt of a free packet of maize seed, legumes, and fertilizer, sufficient to cultivate 0.1 ha. Such subsidy programs have existed in Malawi since the late 1990s, and have helped to stimulate maize output and to improve household and national food security (Longley et al, 1999; Levy and Barahona, 2002; Dorward and

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[7] ADMARC is a government parastatal that operates throughout Malawi. It buys surplus maize from farmers at competitive and remunerative prices and sells maize, among other products, at affordable prices (Harrigan, 2008; ADMARC, 2009).

Chirwa, 2009). However, agricultural input subsidies are expensive – in 2006-07, for example, Malawi's agricultural input subsidy program represented 45% of the Ministry of Agriculture and Food Security's budget and 5.2% of the national budget (Minot and Benson, 2009) – so it is important to estimate their impact.

A second binary variable indicates another agriculture policy – the presence of an irrigation scheme in the community. The impacts of irrigation on agricultural productivity and, therefore, on calorie availability, are well known. For example, the success of the Asian Green Revolution of the 1960s and 1970s has been attributed to the rapid expansion of irrigated areas. Irrigation has a long history in Malawi, and although adoption by smallholders has not been widespread to date (Wiyo and Mthethiwa, 2008), the government plans to expand smallholder irrigation through the Greenbelt Irrigation Scheme.

A third agricultural policy variable included in the model is the number of visits from an agricultural field assistant that the household received in the last cropping season. Agricultural extension has had a positive effect on agricultural production worldwide (Birkhaeuser et al, 1991; Owens and Hoddinott, 2003), and technical assistance not only enhances the productivity of peasant farmers (Lewin, 2005), but also helps reduce the technological and economic disparity between capitalist and family farming (Kay, 1997).

In addition to government agricultural policies, social programs may have a significant effect on food insecurity. Two social program variables are included in the model. The first is a binary variable representing the presence or absence of the Malawi

Social Action Fund (MASAF), which finances self-help community projects and transfers cash through safety-net activities, like rehabilitation and maintenance of rural roads, construction of small-scale irrigation dams, water projects, and land conservation efforts (MASAF, 2010). MASAF targets communities that are chronically poor or food insufficient, through food- and cash-for-work activities (Harrigan, 2008).

A second social program variable in the model indicates whether or not the community has a feeding program in its primary school(s). A few non-governmental organizations (NGOs) and donors support school feeding programs in Malawi, such as the World Food Program (WFP), which feeds about 500,000 children each school day. These programs increase school attendance and improve child nutrition. Although there is little evidence that school feeding programs impact household food security (Glewwe and Jacoby, 1994; Grantham-McGregor, 2005; World Bank, 2006), Malawi is currently developing a Nutrition and School Feeding Policy, so we include the variable in the model.

*Seasonal Variables*

Finally, variables are included in the model to indicate the year (2004 vs. 2005) and time period during which the household was interviewed, because there is seasonal variability in household income and the availability of food in local markets (Garrett and Ruel, 1999). The seasons are categorized as planting (Dec-Feb), harvest (Mar-May), post-harvest (Jun-Aug), and pre-planting (Sep-Nov). The most food insecure time is the planting period, and extends into the pre-planting period for households that are highly food insecure. Income and food are generally most abundant during the post-harvest period.

### 2.3.2 Accounting for Regional Differences

We assume that the determinants of the food security model are not the same everywhere in the country; on the contrary they will vary by location. Therefore, the food security model described above is estimated separately for households in the north, center, and south of Malawi to account for spatial heterogeneity.

There are important cultural differences, mainly between north and center/south. In the north, the Tumbuka tribe and its language Chitumbuka predominate. The Chewa and Nyanja people are the main ethnic groups in the southern and central parts of the country, and Chichewa is the main language spoken. Other important differences across regions are in terms of population density, agriculture, education, and poverty, which we briefly illustrate below using data from the 2008 Malawi Census and the IHS-2. Population density is much higher in the south (185 people per square kilometer) than in the center (154) and north (63). Likewise agricultural landholdings are considerably larger in the north, where 59% of households have more than one hectare of land, while the corresponding figures are 50% and 32% in the center and south, respectively. There are also some differences in crops cultivated, with a higher share of households in the north growing hybrid maize and root crops compared to households in other parts of the country. The main smallholder cash crops in Malawi are tobacco and sugar in the north and center, and cotton in the south. Educational attainment also differs by region, with

23%, 16%, and 16.5% of household heads having a secondary education or higher in the north, central, and south, respectively. As for poverty incidence, this is highest in the south (60%), followed by the north (54%), and lowest in the center (44%).

**2.4. The Data**

The model of food insecurity is estimated using nationally representative data from the second Malawi Integrated Household Survey (IHS-2), a World Bank Living Standards Measurement Study (LSMS) of 11,280 randomly selected households interviewed during 2004/2005. The IHS-2 data cover a wide range of topics, including household demographics, health, education, time use, agriculture, expenditures, and social safety nets. The dataset is considered to be of high quality (Malawi National Statistics Office, 2005) and offers many research opportunities. Means and standard deviations are presented for the economic, demographic, social, and agronomic variables used in empirical model (Table 2.1).

Table 2.1. Descriptive statistics of model variables, 2004/05

| Variable | Northern region (*n* = 1,143) | | Central region (*n* = 3,028) | | Southern region (*n* = 3,794) | |
|---|---|---|---|---|---|---|
| | Mean | S.d. | Mean | S.d. | Mean | S.d. |
| Food energy deficiency | 0.41 | 0.49 | 0.37 | 0.48 | 0.46 | 0.50 |
| Price Index | 109.61 | 10.57 | 95.23 | 7.63 | 97.32 | 6.99 |
| District maize price (Mk/kg)[a] | 22.51 | 6.31 | 22.85 | 4.29 | 20.03 | 2.08 |
| District fertilizer price (Mk/kg)[a] | 52.67 | 4.78 | 51.56 | 3.50 | 48.20 | 2.35 |
| District *ganyu* wage (Mk/day)[a] | 132.81 | 22.01 | 98.00 | 26.30 | 73.06 | 24.22 |
| Non-labor income (1,000 MK/year) | 0.14 | 1.87 | 0.17 | 1.70 | 0.19 | 3.55 |
| Age of householder (yrs) | 44.35 | 16.35 | 43.20 | 16.43 | 43.85 | 16.79 |
| Female householder | 0.23 | 0.42 | 0.22 | 0.42 | 0.26 | 0.44 |
| Education of householder (yrs) | 6.15 | 3.57 | 4.01 | 3.80 | 3.68 | 3.74 |
| Householder or wife is ill | 0.25 | 0.43 | 0.27 | 0.44 | 0.28 | 0.45 |
| Householder or wife is disabled | 0.02 | 0.15 | 0.06 | 0.25 | 0.05 | 0.21 |
| No. of children (0-14 yrs) | 2.39 | 1.81 | 2.27 | 1.68 | 2.07 | 1.68 |
| No. of male adults (15-64 yrs) | 1.06 | 0.77 | 1.08 | 0.81 | 0.96 | 0.79 |
| No. of female adults (15-64 yrs) | 1.24 | 0.74 | 1.16 | 0.68 | 1.12 | 0.66 |
| No. of elders (65 yrs +) | 0.21 | 0.50 | 0.18 | 0.46 | 0.19 | 0.46 |
| Cultivated land per capita (ha/person) | 0.28 | 0.24 | 0.27 | 0.24 | 0.27 | 0.29 |
| Livestock index[b] | 0.47 | 2.32 | 0.03 | 1.23 | -0.10 | 0.75 |
| Distance to weekly market (km) | 12.65 | 15.30 | 9.76 | 12.15 | 5.39 | 6.73 |
| Distance to ADMARC (km) | 13.53 | 14.12 | 13.88 | 64.06 | 9.06 | 12.11 |
| Main road surface is tar | 0.21 | 0.41 | 0.10 | 0.30 | 0.13 | 0.33 |
| Community has credit club | 0.32 | 0.47 | 0.36 | 0.48 | 0.18 | 0.39 |
| Community has agric. cooperative | 0.25 | 0.43 | 0.36 | 0.48 | 0.14 | 0.35 |
| ADD Karonga | 0.34 | 0.47 | - | - | - | - |
| ADD Mzuzu | 0.66 | 0.47 | - | - | - | - |
| ADD Kasungu | - | - | 0.33 | 0.47 | - | - |
| ADD Salima | - | - | 0.15 | 0.35 | - | - |
| ADD Lilongwe | - | - | 0.53 | 0.50 | - | - |
| ADD Machinga | - | - | - | - | 0.43 | 0.49 |
| ADD Blantyre | - | - | - | - | 0.41 | 0.49 |
| ADD Ngabu | - | - | - | - | 0.16 | 0.37 |
| Rainfall (mm/yr) | 1023 | 3391 | 1076 | 161 | 949 | 156 |
| Household received starter pack | 0.19 | 0.40 | 0.28 | 0.45 | 0.38 | 0.49 |
| Community has irrigation scheme | 0.05 | 0.23 | 0.11 | 0.32 | 0.22 | 0.41 |
| No. of agric. field assistance visits per yr | 0.82 | 1.98 | 0.35 | 1.32 | 0.36 | 1.48 |
| MASAF in community | 0.08 | 0.27 | 0.09 | 0.29 | 0.22 | 0.41 |
| School feeding program in community | 0.03 | 0.18 | 0.10 | 0.31 | 0.07 | 0.26 |
| Interview in Dec, Jan, or Feb | 0.29 | 0.46 | 0.19 | 0.39 | 0.18 | 0.38 |
| Interview in Mar, Apr, or May | 0.22 | 0.42 | 0.31 | 0.46 | 0.33 | 0.47 |
| Interview in Jun, Jul, or Aug | 0.25 | 0.44 | 0.26 | 0.44 | 0.25 | 0.43 |
| Interview in Sep, Oct, or Nov | 0.23 | 0.42 | 0.24 | 0.43 | 0.24 | 0.43 |
| Interview in 2005 | 0.24 | 0.43 | 0.21 | 0.41 | 0.24 | 0.43 |

a. District-level prices are calculated due to many missing values for prices at the village level. Prices are the average for the villages in the given district. For two districts, the fertilizer price was unavailable and replaced by the mean for the region.
b. In constructing the livestock index, six influential outliers were dropped for livestock variables

The first step to develop the food insecurity variable was to measure the amount of energy in the food obtained by the household, based on data from the food consumption module of the IHS-2, which estimated the quantities of or expenditures for 115 individual food items consumed by household members, in or away from home, during the week prior to the interview. Recorded food consumption included purchases, self-production, and food items received as gifts. The total energy of the acquired food was then compared to the sum of the daily energy requirements of household members. The data in the IHS-2 were often reported in "local" units of measure, which were converted to metric quantities using a metric weights conversion table provided by the Malawi National Statistics Office (NSO). The energy value of each food item was calculated by multiplying the metric quantity acquired by the food's edible portion and then by its food energy value (kcal/gram), based on the USDA food composition table (U.S. Department of Agriculture, 2009) and the FAO's Africa food composition tables (Leung et al, 1968; Latham, 1979). The food energy values were added for each household, then divided by seven to obtain the household's total daily available energy.

The household's total energy demand was calculated as the sum of the energy requirements of all members. The energy requirement of each individual was assumed to be equal to the average energy requirement for basal metabolic function and light activity given for specific age-sex groups by the FAO, WHO, and UNU (Smith et al, 2006: Table 3.4). We added 500 kcal to the total energy demand of the household for each child younger than one year old, to account for the energy demands of breastfeeding women (Smith et al, 2006).

The number of household members at the time of the survey was taken from the IHS-2 data, then modified based on recent or past absences from the household. If an individual was absent for more than two weeks at the time of the survey, they were not included as household members. If information on the length of current absence was not available, absence for more than 6 months during the past year excluded the individual from the household size calculation. When no information on absences was available, the IHS-2 count was used. Daily energy availability and daily energy requirement per capita were estimated by dividing the totals calculated for the household by the number of household members at the time of the survey.

The IHS-2 data are subject to non-sampling errors that could have affected the accuracy of the empirical model.[8] For example, some respondents had difficulty remembering their household's food consumption during the reference period. The respondent may have omitted food that was bought during the period, or included items that were acquired earlier. This source of error should not be great in this case, because the IHS-2 recall period was only seven days. Previous studies showed that data collected on a single visit with a one-week reference period provides an unbiased estimate of mean household energy consumption (Deaton and Grosh, 2000), especially if interviews are conducted randomly throughout the year to account for seasonal variation in food consumption (Smith et al, 2006).

A second source of error was that the IHS-2 collected information on food availability, rather than food intake. Although the IHS-2 data generally do not include

[8] The discussion about issues concerning the food consumption module of the IHS-2 survey draws heavily from Smith et al (2006).

food given to non-household members or pets, some of the available food could have been discarded. Overestimation of energy availability is expected to be greater for wealthier households than for low income households (Bouis et al, 1992; Bouis, 1994). Food consumed after the recall period could also account for a significant amount of available food. Nevertheless, acquisition of food should agree fairly well with consumption, because people try to equalize their consumption over time. Furthermore, mean household calorie consumption for a large population should theoretically be the same as mean household calorie availability, because households are as likely to be drawing down as accumulating food stocks (Smith et al, 2006).

Estimates of individual energy requirements may have been affected by the model's reliance on age and sex classifications, rather than on individual activity level, body size, and physiology. Some individuals may have below-average energy requirements or consumption; others may be above-average. If these two groups are about the same size, the population mean of household calorie demand will be unbiased (Mason, 2003; Smith et al, 2006).

Another potential source of error in the model was the estimation of food in metric weight, because non-standardized local units are imprecise and vary with location. In converting pots, pails, spoons, or bags of various foods into kilograms, we may have overestimated or underestimated the amount of food acquired.

The IHS-2 data used in the empirical analyses were rigorously checked and cleaned. Outlying values for food energy availability were identified by histograms and direct observation. Unreasonable values for calorie availability (>12,000 kcal per capita) and consumption of single food items (>100 kg) were excluded. Case deletion was used to exclude observations with missing values.[9] Case deletion and exclusion of surveyed households that were not engaged in farming in rural areas reduced sample size from 11,280 to 7,965.

## 2.5. Empirical Results

### 2.5.1 Goodness-of Fit and Specification Tests

The overall fit of the model is good: the goodness-of-fit measure comparing predicted with actual outcomes show that 73%, 72%, and 74% of the observations are correctly classified for the northern, central, and southern regions, respectively. Another goodness-of-fit measure, the Hosmer and Lemeshow's test, also indicates that the model fits the data well in the three regions.

[9] Case deletion is the standard approach to deal with missing values in the social sciences. One problem is it can reduce the sample size considerably, with subsequent loss of precision in parameter estimation. This should not present much problem in the case of the IHS-2, due to the large sample size. More worrisome is that excluded subjects may differ systematically from included subjects in terms of model variables. In such case, the reduced sample is not representative of the population of interest leading to biased statistical results. The obvious advantage of case deletion is it is easy to use and is the default in most statistical packages. In addition, methods to impute missing values can still lead to biased parameter estimates with the extent of bias depending on several factors including the missing data mechanism, the proportion of data that are missing, and the variables in the dataset. Also at issue is that although imputed missing values are estimates with corresponding random error, these values are treated as actual observations in statistical analyses (King et al, 2001). A more promising approach is multiple imputation (Rubin, 1977; Rubin, 1987), but the use of this approach for the many variables that are part of the analysis is beyond the scope of the present study.

Table 2.2. The determinants of household food insecurity for farm households in rural Malawi, 2004/2005

| Variable | Agr. rural household in northern region | | Agr. rural household in central region | | Agr. rural household in southern region | |
|---|---|---|---|---|---|---|
| | Marginal Effect | Robust Std. Error | Marginal Effect | Robust Std. Error | Marginal Effect | Robust Std. Error |
| Price Index | 0.0120 | 0.0091 | 0.0260*** | 0.0062 | 0.0165*** | 0.0045 |
| Dist. maize flour price (Mk/kg) | 0.0431** | 0.0133 | 0.0074** | 0.0027 | 0.0373*** | 0.0047 |
| District fertilizer price (Mk/kg) | 0.0045 | 0.0192 | 0.0445*** | 0.0049 | 0.0303*** | 0.0044 |
| District *ganyu* wage (Mk/day) | 0.0019 | 0.0017 | 0.0050*** | 0.0005 | 0.0006 | 0.0005 |
| Non-labor income (1,000 MK) | -0.0053 | 0.0150 | -0.0238 | 0.0132 | -0.0575*** | 0.0167 |
| Age of householder (yrs) | -0.0022 | 0.0015 | 0.0019* | 0.0008 | 0.0010 | 0.0008 |
| Female householder | -0.0187 | 0.0444 | -0.0080 | 0.0254 | -0.0173 | 0.0241 |
| Education of householder (yrs) | -0.0159** | 0.0056 | -0.0118*** | 0.0027 | -0.0137*** | 0.0028 |
| Householder or wife is ill | 0.0433 | 0.0383 | -0.0269 | 0.0211 | -0.0730*** | 0.0205 |
| Householder or wife is disabled | 0.0179 | 0.1057 | -0.0044 | 0.0383 | -0.0102 | 0.0438 |
| No. of children (0-14 yrs) | 0.0864*** | 0.0112 | 0.0822*** | 0.0068 | 0.1221*** | 0.0071 |
| No. of male adults (15-64 yrs) | 0.1123*** | 0.0247 | 0.0702*** | 0.0137 | 0.1117*** | 0.0155 |
| No. of female adlts (15-64 yrs) | 0.0433 | 0.0270 | 0.0562*** | 0.0154 | 0.0922*** | 0.0165 |
| No. of elders (65 yrs +) | 0.1054* | 0.0463 | 0.0330 | 0.0281 | 0.1106*** | 0.0289 |
| Cult. land per capita (ha/per.) | -0.3950*** | 0.1138 | -0.3823*** | 0.0617 | -0.3465*** | 0.0522 |
| Livestock index | -0.0058 | 0.0072 | -0.0238* | 0.0104 | -0.0414* | 0.0184 |
| Dist. to weekly market (km) | 0.0042** | 0.0016 | 0.0009 | 0.0008 | 0.0019 | 0.0015 |
| Distance to ADMARC (km) | 0.0011 | 0.0014 | 0.0004** | 0.0002 | -0.0000 | 0.0008 |
| Main road surface is tar | -0.0420 | 0.0561 | -0.0714* | 0.0318 | -0.0607* | 0.0282 |
| Community has credit club | -0.0407 | 0.0462 | 0.0689** | 0.0229 | -0.0844*** | 0.0247 |
| Comm. has agric. cooperative | 0.0068 | 0.0532 | -0.0646** | 0.0228 | 0.0041 | 0.0289 |
| ADD Mzuzu | -0.0123 | 0.1340 | - | - | - | - |
| ADD Salima | - | - | 0.0341 | 0.0382 | - | - |
| ADD Lilongwe | - | - | 0.2075*** | 0.0317 | - | - |
| ADD Blantyre | - | - | - | - | -0.0988*** | 0.0293 |
| ADD Ngabu | - | - | - | - | -0.2114*** | 0.0313 |
| Rainfall (mm/yr) | -0.0006*** | 0.0002 | 0.0003** | 0.0001 | 0.0005*** | 0.0001 |
| HH received starter pack | -0.0142 | 0.0421 | 0.0416 | 0.0216 | -0.0162 | 0.0193 |
| Comm. has irrigation scheme | -0.0943 | 0.0730 | 0.0244 | 0.0321 | -0.0558* | 0.0229 |
| No. of agric. field assist. visits | -0.0029 | 0.0089 | -0.0264** | 0.0083 | -0.0236** | 0.0080 |
| MASAF in community | 0.0375 | 0.0816 | -0.1323*** | 0.0296 | 0.1055*** | 0.0233 |
| School feeding in community | 0.1108 | 0.1132 | 0.0167 | 0.0339 | -0.0724* | 0.0367 |
| Interview in Dec, Jan, or Feb | -0.2108 | 0.1336 | -0.1201* | 0.0580 | 0.0050 | 0.0476 |
| Interview in Mar, Apr, or May | -0.0733 | 0.0563 | -0.1403* | 0.0561 | -0.0386 | 0.0366 |
| Interview in Sep, Oct, or Nov | -0.1555 | 0.0797 | -0.0377 | 0.0442 | 0.0330 | 0.0413 |
| Interview in 2005 | -0.0296 | 0.1310 | -0.2313*** | 0.0625 | -0.0425 | 0.0609 |
| *N* | 1143 | | 3028 | | 3794 | |
| chi2 | 261.9693 | | 548.0576 | | 855.2149 | |
| df_m | 32 | | 33 | | 33 | |

$^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$

To account for possible heteroskedasticity, a common specification error for cross-sectional data, the *z*-statistics reported in Table 2.2 are based on heteroskedasticity-robust standard errors (White, 1980). To assess problems due to multicollinearity, variance inflation factors (VIFs) were computed for each independent variable. The VIFs for variables related to the 2005 price index and interview exceed 10 in all three regions, suggesting potential multicollinearity problems. The VIFs also exceed 10 for two additional variables in the northern region – fertilizer price and interview in Dec-Feb. However, comparison of model results for each region, with and without the multicollinearity variables, reveal only minor differences in the magnitude of coefficients and standard errors.

### 2.5.2 Results for Explanatory Variables

*Prices, Wages, and Non-labor Income*

Results for the explanatory variables generally agree with the theory that prices matter to household food security in Malawi (Table 2.2). The price index variable has a significant ($p < 0.05$) positive association with food insecurity in the central and southern regions. Higher prices for goods and services reduce a household's purchasing power and, subsequently, increase the probability of food insecurity. District-level maize flour prices are positively related to food insecurity in all three regions, consistent with evidence that the majority of Malawian smallholder households are net buyers of maize. Fertilizer prices are positively correlated with food insecurity in the central and southern regions. This may reflect the relative importance of agricultural intensification in these two regions, where possibilities for agricultural extensification are limited compared to the northern region.

Contrary to the expectation that higher wages would boost household purchasing power and improve food security, the district-level *ganyu* wage shows a significant positive relationship with food insecurity in the central region. Error in measurement of this variable may explain the unexpected result. Remuneration for *ganyu* is often in goods (e.g., as maize), and survey enumerators and respondents may have had difficulty assigning a monetary value. In contrast, non-labor income shows a negative relationship to food insecurity in all three regions, although it is only significant in the south.

*Household-level Variables*

Among the socio-economic variables, model results indicate that age of the household head has essentially no relationship with food security. The coefficient for age is small and only significant for the central region, where households headed by older individuals tend to be slightly more food insecure. On the other hand, education of the household head has a significant negative association with food insecurity in all three regions.

The number of individuals in the household is positively associated with the probability of food insecurity, regardless of age group or gender, according to the model. A Wald test shows no significant difference between the coefficients for children and for working adults in the three regions. The number of elders is also positively correlated with the probability of household food insecurity in the northern and southern regions, where elderly members and children have a similar effect.

As predicted, households that are well off in terms of land and livestock are less likely to be energy deficient. The area of land cultivated per capita in the previous cropping year has a significant negative association with food insecurity in all three regions. The association between livestock holdings and household energy deficiency is also negative and significant in the central and southern regions, although the marginal effects are relatively small.

*Community-level Variables*

The association between market access and food insecurity is generally as anticipated for all three regions, although the marginal effects are small and not all of the regression coefficients are significant. In northern Malawi, for example, the probability of being food insecure is significantly higher for households located at greater distances from a weekly market. In the central region, food insecurity increases with increasing distance to an ADMARC depot. In both the central and southern regions, households in communities where the main road surface is tar are less likely to be energy deficient.

Model results for the relationship between social supports and food insecurity are mixed. The existence of a credit club in the community is negatively associated with the probability of food insecurity in the southern region, as expected, but has the opposite effect in the central region. However, the presence of an agricultural cooperative group in the community is associated with a lower probability of food insecurity in the central region.

As expected, location-specific agronomic endowment matters to food insecurity, as indicated by the statistical significance of the agricultural development district (ADD) variables. Results of the model indicate that annual rainfall is negatively correlated with food insecurity in the northern region, but is positively correlated with food insecurity in the central and southern regions of Malawi; in all instances, however, the marginal effects are small. The mixed results may reflect rainfall patterns during the 2003/2004 and 2004/2005 rainy seasons. The 2003/2004 rainy season was characterized by a late onset of the rains and erratic rainfall; some areas of the central and southern regions suffered floods in February and long dry spells after March and consequent reductions in maize production (Department of Meteorological Services, 2004). Central and southern Malawi had above average rain at the beginning of the 2004/2005 rainy season, but then experienced damaging dry spells when maize was at the tasseling and cobbing stages (Department of Meteorological Services, 2005).

*Policy Variables*

Of the three agricultural policy variables included in the model, two have significant relationships with food insecurity, although not in all regions. In the southern region, the probability of household food insecurity is lower for households if their communities have an irrigation scheme. The number of visits from an agricultural field assistant is associated with a decreased probability of household energy deficiency in the central and southern regions. The results do not provide evidence that Malawi's SPS influences household food insecurity. A plausible explanation is that low and erratic rainfall during the years of the IHS-2 prevented the households that received the free packets of seed and fertilizer from realizing the productivity gains that would be possible under more favorable weather conditions.

The parameter estimates for social safety net programs show that only the MASAF program is related to food insecurity in Malawi. MASAF has a negative association with food insecurity in the southern region, as expected, but a positive association with food insecurity in the central region, possibly due to relocation of food insecure households to communities where MASAF is intervening.

*Seasonal Variables*

Of the seasonal variables examined by the model, the only two that have a significant influence on food insecurity are the planting (Dec-Feb) and harvest (Mar-May) seasons in the central region: households tend to be less food insecure during those periods than during the rest of the year. Food is abundant and prices are lower during the harvest months of March to May; thus this result is expected. However, we would expect households to be most food insecure during the December to February planting season, which is considered the peak hungry period. A plausible explanation is that government often comes through with various forms of food assistance during these months. Seasonal effects appear to vary from year to year: households in the central region that were interviewed during 2005 were less food insecure than households interviewed during 2004.

**2.6. Food Insecurity Simulations**

In this section, the regression model is used to run seven simulations using different combinations of parameters to predict how changes in selected variables might affect the probability of household food insecurity in Malawi. Since our empirical results indicate association not causality, simulation results should be taken as illustrative of how policies could affect outcomes if causality runs from the explanatory variable to household food security. The variables of interest in the simulations are number of children, householder education level, type of road surface, total cultivated land, and agricultural extension. These were selected on the basis of whether or not model runs indicate that they are significantly related to food insecurity in at least two regions, and whether or not they are amenable to policy change. The simulations hold all the other variables not studied at their mean values, assuming that changes in the variable of interest will not affect other model parameters. Note that the simulation results in Table 2.3 are reported in terms of expected percentage point rather than percentage change. To arrive at percentage figures, one must divide the change by the average predicted probability of food insecurity, which is 38%, 33%, and 45% for the northern, central, and southern regions, respectively.

The first simulation explores the effect of family planning policies, by adding a child between the ages of 0 and 14 years to all households. The expected probability of food insecurity exceeds baseline values by 22%, 24%, and 27% in the northern, central, and southern regions, respectively (Table 2.3).

Table 2.3. Simulation results based on the determinants of food insecurity model

| Simulation | Expected percentage point change in food insecurity | | |
|---|---|---|---|
| | North | Central | South |
| Add child to household, for all households | 8.63 | 8.12 | 12.06 |
| Increase avg. edu. of householder to 8 yrs (PSLC) | -2.9 | -4.45 | -6.07 |
| Increase avg. edu. of householder to 10 yrs (JCE) | -5.96 | -6.57 | -8.8 |
| Increase avg. edu. of householder to 12 yrs (MSCE) | -8.9 | -8.61 | -11.45 |
| Asphalt main community road surface | - | -6.04 | -8.3 |
| Increase per capita land cultivated by 1/4 ha | -9.85 | -9.99 | -9.51 |
| Add one agric. field visit if HH did not receive a visit | - | -2.45 | -2.3 |

In 2004/05 the average education level of household heads was six years in the northern region and four years in the other two regions. The second, third, and fourth simulations examine the effects of increasing the average education level of householders in each region to 8, 10, and 12 years. Food insecurity probability in the northern, central, and southern regions decreases by 15%, 19%, and 20%, respectively, when the household head has at least 10 years of education (Junior Certificate of Education), and by 23%, 25%, and 26%, respectively, when he or she has at least 12 years of education, i.e., a Malawian School Certificate. Thus, the results suggest that food insecurity could be dramatically reduced, if the average householder were to attend or complete secondary school.

The fifth simulation measures the change in food insecurity, if market access was improved by asphalting the main roads in the communities. The results indicate that asphalting main roads could reduce the probability of energy deficiency by 18% in the central region and 19% in southern region.

The last two scenarios examine the potential impact of agricultural policies. The simulation results indicate that an increase in the average total cultivated land per capita by 0.25 ha would reduce the probability of food insecurity by 25%, 30% and 21% in northern, central, and southern regions, respectively. Such a land increase is unlikely to occur, especially in central and southern Malawi, where land is scarce. However, expanded use of modern inputs that increase productivity per unit area could bring about a similar reduction in food insecurity. Results of the final scenario predict that, if all households received at least one visit from an agricultural field assistant during each cropping season, the probability of food insecurity would decline by 5-7%.

**2.7. Conclusions**

This study examined determinants of food insecurity for rural farm households in Malawi, where smallholder farmers face significant challenges from small landholdings; nitrogen-deficient soils; climate variability; poor market access; and limited availability of improved farm inputs, technical assistance, credit, and agricultural insurance. The results provide insights into policy changes that have the potential to reduce food insecurity. However, in order to prioritize these policies much research should be done.

Total cultivated land per capita is identified as one of the strongest predictors of food insecurity in Malawi, and model simulations suggest that enhancing land productivity, for example through the use of improved seed and soil fertility technologies, would reduce food insecurity by about 25%. Since the late 1990s, the Malawi government has employed a variety of input subsidy programs to spread the use of hybrid maize seed and chemical fertilizers. The import of chemical fertilizers into a landlocked country, such as Malawi, is expensive, so other complementary soil-fertility technologies (e.g., maize-legume intercrops, compost, and green manures) should also be developed and promoted. Agricultural extension will be important to ensure that farmers achieve the maximum benefit of improved technologies. Indeed, our simulations predict that the expansion of agricultural extension services to provide all farmers with at least one annual visit would reduce the probability of energy deficiency by 7%.

The expanded use of agricultural technologies should be supported by increased investment in human capital, i.e., secondary education. Previous research showed that combining general education with training specific to the individual's labor market – in this case, the agricultural labor market – is more effective than simply improving general education (Becker, 1994; Acemoglu and Pischke, 1999). The objective would be to improve the quality, and therefore, the competitiveness, of workers in farm households, and potentially to support future industrial growth in rural areas.

It will also be important for government to develop policies to reduce the vulnerability of farm households to rainfall variability. Regression results indicate that annual rainfall levels influence food insecurity in Malawi, although the direction of the association differs across regions. The negative impacts on farm households of future droughts and floods can be reduced through a variety of agriculture-related investments. Irrigation infrastructure will likely be a necessary component of climate change adaptation in Malawi, and study findings indicate that households are less likely to be food insecure if they reside in a community that has an irrigation scheme. Other proven approaches include agricultural extension activities that encourage farmers to plant some of their land in drought-resistant crops, such as cassava; investments in soil and water conservation practices, such as terracing and construction of earth dams; and group weather-insurance schemes that provide financial protection from weather-related crop failure.

Improved market access and asphalting main roads should significantly reduce household food insecurity in rural communities by reducing transport costs. Improved market access would also increase the returns from improved inputs, enhancing the probability that farmers will use them in the production process.

Finally, results of the present study indicate that larger household size increases the probability of food insufficiency, regardless of age group or gender, and that adding just one child increases the probability of food insecurity by about 25%. These results imply that families would benefit from choosing the number of children that they can support. We acknowledge, however, that family planning policies have a mixed record of success in developing countries. In practice, the most successful approach to reducing population growth has been through the development process, itself (Easterly, 2002).

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# CHAPTER THREE

# DO RAINFALL CONDITIONS PUSH OR PULL RURAL MIGRANTS? EVIDENCE FROM MALAWI

## 3.1. Introduction

Climate variability and change pose tremendous challenges to the ingenuity and resilience of farmers around the world (Anderson & Dillon, 1992; Wilken, 1987). In rainfed agricultural systems, unfavorable rainfall conditions can have far-reaching and devastating impacts on farm households, because insurance and credit markets to mitigate the effects of adverse weather are absent, ill functioning, or inaccessible to the most vulnerable groups. Given these circumstances, farmers have to be resourceful. Studies document the use of a number of informal risk-coping strategies, such as selling physical assets, planting a diversity of crops, diversifying into non-farm activities, and migrating for employment (Maddison, 2006; McLeman & Smit, 2006; Thomas, Twyman, Henny, & Hewitso, 2007).

The present essay examines whether rainfall conditions influence a rural worker's decision to migrate permanently to an urban or another rural area. There is some evidence for a link between rainfall variability and human migration patterns. In Sudan, for example, male members migrate temporarily to the capital in search of work, when low rainfall negatively affects agricultural production (Afolayan & Adelekan, 1999). Families in Ethiopia have been found to migrate out of dry-land areas during times of prolonged drought (Meze-Hausken, 2000). In Mozambique, the devastating floods of 2007 displaced over 100,000 people (Warner, Hamza, Oliver-Smith, Renaud, & Julca, 2009). A study in Brazil showed that large precipitation shocks induced workers to migrate from rural to urban areas in search of employment (Mueller and Osgood, 2009). The present study contributes to the literature on climate and human migration in two ways. First, like Mueller and Osgood (2009) our study is one of the few in this literature that is quantitatively rigorous, allowing for the isolation of climate from the multitude of other factors that affect migration decisions. Second, our study models precipitation anomalies as a push and a pull factor for prospective migrants; previous studies have considered climate as a push factor only.

Our research investigates the links between migration probability and household and community characteristics by using the “revealed preference” approach in which the circumstances of migrants are contrasted with those of non-migrants (Lucas, 2000). Migration is considered an investment through which earnings can be augmented (Becker, 1962), family or individual resources can be allocated efficiently (Sjaastad, 1962), or economic risk can be reduced (McLeman & Smit, 2006; Rosenzweig & Stark, 1989). An individual or household would migrate whenever the benefits of migration exceed its costs (Tsegai, 2007).

To study how rainfall conditions influence rural out-migration, we use data from Malawi’s second Integrated Household Survey (IHS-2), a World Bank Living Standards Measurement Study (LSMS) conducted in 2004/2005. The IHS-2 dataset has a large sample size (11,280 households and 52,707 individuals), is nationally representative, and includes a rich set of variables. Although the data are not longitudinal, several retrospective questions allow for the study of migration: (a) Have you always lived in this village or urban location? (b) How long ago is it you came to stay here? (c) Where did you move from? A further merit of this dataset is it includes variables indicating whether households and communities suffered climate events in recent years. A key drawback is the IHS-2 does not provide information about migrants' specific places of origin; the question "Where did you move from?" only specifies if migrants moved from a rural or urban area in the same or different district. This precludes estimation of migration costs and measurement of labor market and other characteristics of a migrant's place of origin. The dataset does, however, include information on the attributes of a respondent's current place of residence. We can thus measure the degree to which community characteristics, including rainfall conditions, attract or deter prospective migrants from rural areas.

Malawi is an interesting setting for a study on the links between rainfall conditions and migration. According to IHS-2 data, 4% of household heads reported moving in a single year. Migration is thus substantial and, interestingly, the majority of migration is from one rural locality to another, a pattern that contrasts with the rural-urban transformations occurring in many developing countries (Montgomery & Balk, 2008). Malawi is also a useful setting for the present study because rainfall is highly variable and increasingly so. The country experienced 31 droughts and floods between 1960 and 2009, with 60% of these occurring in the period 2000-2009 (Figure 3.1).

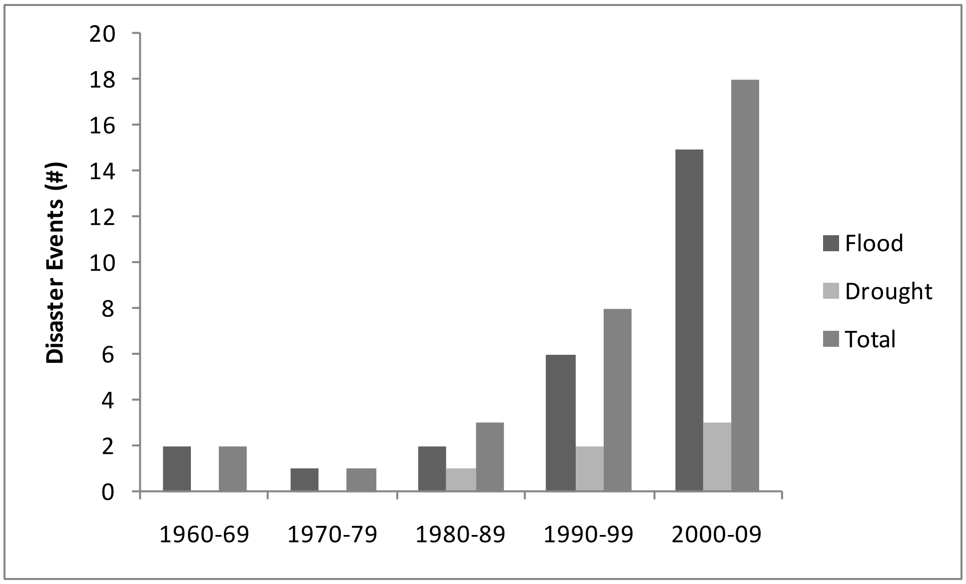


Figure 3.1. Trend: floods & droughts in Malawi, 1960-2009

Source: "EM-DAT: The OFDA/CRED International Disaster Database. www.emdat.be - Université Catholique de Louvain - Brussels – Belgium

The essay is organized as follows: The next section develops a theoretical model to understand migrant behavior in contexts where livelihoods depend on rainfall conditions and rainfall is highly variable. We then present the empirical model, establish the set of regressors, and discuss some estimation issues. The next section provides details about the IHS-2 dataset. Empirical results follow and the final section summarizes the paper's key findings and the implications for policy.

### 3.2. Conceptual Model

This section develops a model of choice to explain the migration decisions of rural people in low-income settings where rainfall is highly variable and rainfall events can have devastating effects on human welfare. The model draws on the disequilibrium theory of migration (Becker, 1962; Sjaastad, 1962), which assumes that potential migrants seek to maximize the present value of lifetime net benefits resulting from location change (Nakosteen & Zimmer, 1980; Polachek & Horvath, 1977). We modify the standard migration model to account for the push and pull that rainfall conditions can exert on prospective rural migrants.

Consider an individual who at time *t* lives in community $i$ and is contemplating a move to community $j$ where earnings are higher. The individual will migrate if the present value of the net expected benefits of migration is positive, thus

$$m = \begin{cases} 0 & if \;\; PV \leq 0 \\ 1 & if \;\; PV > 1 \end{cases} \text{ where } PV = \sum_0^T \left[ \left( p_j w_{jt} - p_i w_{it} \right) / (1 - a)^t \right] - c_{ij} \,, \quad (3.1)$$

where *p* represents the probability of a rainfall shock occurring in a given community; $w$ and c are, respectively, the individual's expected earnings adjusted for cost of living differentials and expected moving costs; $a$ is the implicit discount rate; and $T$ represents the total amount of time the individual will remain in the labor force.

As shown in equation (3.1), we assume that in choosing the location that maximizes the present value of the net expected benefits, prospective migrants consider the risk of rainfall events, or their perceptions of such risk, at different locations. A lower probability of rainfall shocks in a destination area may encourage individuals to move, if wages are similar between the place of origin and the destination location. Or, a relatively low probability of rainfall shocks in a destination area may compensate for lower wages such that migration is attractive.[10] Thus, stable rainfall conditions in a destination area acts as a pull factor, while erratic rainfall conditions in the origin location works as a migration push factor.

To complete the model, we specify the earnings equation as $w = w(X, R)$, where $X = (x_1, \dots, x_h)$ is a vector of household characteristics and $R = (r_1, \dots, r_c)$ is a vector of community characteristics where the individual currently resides. This allows us to examine analytically the indirect effect of rainfall variability on migration. To see this, we denote $r_r$ as rainfall and $x_k$ as the household's capital endowment and then evaluate how an individual's expected earnings is affected by a precipitation shock in a community with the following equation (Mueller & Osgood, 2009):

$$w_t\left(x_{k,t}\left(r_{r,t-1}, x_{k,t-1}\right)\right) - w_t\left(x_{k,t}\left(\overline{r_r}, x_{k,t-1}\right)\right) \approx \frac{1}{2}\frac{\partial w_t}{\partial x_{k,t}}\frac{\partial^2 x_{k,t}}{\partial\left(r_{r,t-1}\right)^2}\bigg|_{r_{r,t-1}=\overline{r_r}}\left(\overline{r_r} - r_{r,t-1}\right)^2 \qquad (3.2)$$

In the equation, $r_{r,t-1}$, $\overline{r_r}$ and $x_{k,t-1}$ represent, respectively, last season's rainfall, average rainfall, and the household's capital endowment, respectively. Last season's rainfall refers to the volume and distribution of rain during the last rainy season, and average rainfall is the "normal" volume and "normal" distribution of rain during the rainy season. Both variables are measured for the community where the individual currently lives.

The first term on the right-hand side of equation (3.2) $\left(\frac{\partial w_t}{\partial x_{k,t}}\right)$ is expected to be positive. All else being equal, an increase in an individual's level of capital (human,

[10] The probability of suffering a rainfall shock in the destination place is positive for migrants that move between rural areas and is zero for migrants that move from a rural to an urban area since their work will not be connected with agriculture.

physical, or financial) should increase his expected earnings. The term $\left(\overline{r_r} - r_{r,t-1}\right)^2$ is also positive in sign. But, the second term on the right-hand side of equation (3.2) $\left(\frac{\partial^2 x_{k,t}}{\partial\left(r_{r,t-1}\right)^2}\right)$ should have a negative sign, since rainfall variability, particularly a severe drought or flood, reduces an individual's capital stock. The signs of the three elements of the equation discussed above together imply that rainfall shocks lower expected earnings. This reduction in expected earnings occurs as a result of a loss of capital, such as that used for agricultural production. Whether the reduction in expected earnings pushes individuals to move is indeterminate *ex ante*. On the one hand, lower expected earnings may encourage individuals to move, if earnings in other places which were formerly unacceptably low now become attractive (Mueller & Osgood, 2009). However, if the drought- or flood-induced reduction in household capital is very severe, individual members of the household may be unable to finance moving costs and thereby forced to stay in place. In short, the indirect effect of rainfall shocks on migration is indeterminate.

In summary, migration is directly and indirectly influenced by rainfall conditions. Better rainfall conditions at a possible destination location or variable weather conditions in a current location may directly stimulate an individual to move in order to reduce the risk of weather shocks. The indirect influence of rainfall conditions on migration occurs as a result of the negative effect of rainfall shocks on an individual's assets and stream of earnings. The reduction in assets and expected earnings might encourage migration by making an individual willing to accept otherwise unacceptably low earnings in other places. On the other hand, the reduction in household capital resulting from rainfall shocks may be to such a degree as to prevent migration, because the individual is left unable to finance moving costs. Thus, the effect of rainfall shocks on migration is an empirical question and one we investigate below.

**3.3. Empirical Model**

In the economic framework developed above, a rational individual *i* elects to migrate if the present value of the net expected benefits of migration is positive. The individual's migration decision *m* is a function of the difference between earnings upon migration $w_{m,i}$ and earnings if the individual does not migrate $w_{n,i}$; personal attributes of the individual $X_i : X_i = (x_{1i}, \cdots, x_{ki})$; and characteristics of the individual's current community of residence $R : R_i = (r_{1i}, \cdots, r_{li})$. We are able to observe the wage upon migration $w_{m,i}$ for migrants and the wage in the absence of migration $w_{n,i}$ for non-migrants, but we cannot observe both wages for migrants and non-migrants. To draw valid conclusions about the population, we must therefore account for self-selection bias. One approach is to estimate a probit-type selection equation for the probability of migration and two earnings equations, one for migrants and another for non-migrants (Lokshin & Sajaia, 2006; Maddala, 1983; Nakosteen & Zimmer, 1980)

$$\begin{bmatrix} m_i \\ w_{m,i}^* \\ w_{n,i}^* \end{bmatrix} = \begin{bmatrix} \beta_0 + X_i\beta_1 + R_i\beta_2 \\ \alpha_{m0} + X_i\alpha_{m1} + R_i\alpha_{m2} \\ \alpha_{n0} + X_i\alpha_{n1} + R_i\alpha_{n2} \end{bmatrix} + \begin{bmatrix} \varepsilon_i \\ \mu_{mi} \\ \mu_{ni} \end{bmatrix} \tag{3.3}$$

where the variables $w_{\bullet,i}^{*}$ are unobserved endogenous variables with observed counterpart $w_{\bullet,i}$. Data on $w_{m,i}$ are missing for non-migrant households when $m_i = 1$ and data on $w_{n,i}$ are missing for migrants when $m_i = 0$. That is,

$$w_{mi} = \begin{cases} w_{mi}^{*} \text{ if } m_i > 0 \\ \text{unobserved other wise} \end{cases} \quad \text{for migrants, and,} \tag{3.4}$$

$$w_{ni} = \begin{cases} w_{ni}^{*} \text{ if } m_i \leq 0 \\ \text{unobserved other wise} \end{cases} \quad \text{for non-migrants} \tag{3.5}$$

For equation (3.3), the disturbance terms $\mu_{mi}$ and $\mu_{ni}$ are assumed to be normally distributed with variance $\sigma_{m1}^2$ and $\sigma_{n1}^2$, respectively. The selection of migrant and non-migrant households may be partially a function of household attributes, some of which are unobservable. As a result, $\mu_{\bullet i}$ and $\varepsilon_i$ are expected to be positively correlated. The correlated errors ($\sigma_{m\varepsilon}$ and $\sigma_{n\varepsilon}$) are assumed to be jointly normally distributed and homoskedastic (Lokshin & Sajaia, 2006; Maddala, 1983). The covariance between $\mu_{mi}$ and $\mu_{ni}$ is not defined since $w_{m,i}$ and $w_{n,i}$ are never observed simultaneously, thus

$$\begin{bmatrix} \varepsilon_i \\ \mu_{mi} \\ \mu_{ni} \end{bmatrix} \sim N\left( \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_{\varepsilon}^2 & \sigma_{m\varepsilon} & \sigma_{n\varepsilon} \\ \sigma_{m\varepsilon} & \sigma_m^2 & \cdot \\ \sigma_{n\varepsilon} & \cdot & \sigma_n^2 \end{bmatrix} \right) \tag{3.6}$$

It is common practice in the literature to estimate models with sample selection using Heckman’s (1976, 1979) two-step method. An alternative is maximum likelihood estimation (MLE), which is preferred over the Heckman two-step approach, because MLE is consistent and efficient, whereas the two-step method is not fully efficient

(Nawata, 1994). We therefore estimate a migration probability equation and two earnings equations using Full-Information Maximum Likelihood (FIML).

The dependent variable in the migration probability equation is a dummy variable that takes the value of one when the household head migrated during the last five years and zero otherwise. In the earnings equations, we employ as the dependent variable the natural log of total annual household expenditures per capita. This variable is the sum of total food consumption, total nonfood durable goods expenditure, estimated use-value of durable consumer goods, and rental value of housing (actual or imputed). We use a consumption-based measure of earnings because it is a smoother measure through time than is income. In an agriculture-based economy like Malawi, most households receive relatively large amounts of cash during the maize (the staple crop) harvest season (May-June) and very little during the rest of the year. However, households continuously expend their income for consumption throughout the year (Mukherjee & Benson, 2003).

### 3.3.1 Independent Variables

The set of variables that we expect to be associated with migration or earnings is shown in Table 3.1 and described below. Selection of independent variables was based on reviews of previous empirical studies and on data availability (Adepoju, 1995; Afolayan & Adelekan, 1999; Lucas, 1997; Lucas, 2000; de Haan, 1999).[11]

[11] Readers may notice that social networks variables are missing from the migration model. We are aware of the importance of social networks to an individual's probability of migration, but data are not available in the IHS-2. Similarly, we are conscious that owning a certain level of assets makes it easier to cover migration costs. Land and livestock are two key measures of household wealth available in the IHS-2, but these variables are very likely endogenous to migration. The land and livestock holdings of someone who migrated are unlikely to be the same holdings they had prior to the move.

Table 3.1. Descriptive statistics of variables used in the migration model of rural Malawi

| Variable | Migrants | | Non-migrants | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Total exp per capita (Mk/person) | 28,056 | 23,973 | 22,147 | 17,306 |
| Age (yrs) | 32.379 | 9.581 | 37.907 | 11.585 |
| PSLC (0/1) | 0.124 | 0.330 | 0.164 | 0.370 |
| JCE (0/1) | 0.177 | 0.382 | 0.090 | 0.286 |
| MSCE (0/1) | 0.100 | 0.300 | 0.030 | 0.171 |
| Graduate (0/1) | 0.020 | 0.139 | 0.004 | 0.062 |
| Nº of children (0-14 yrs) | 1.761 | 1.495 | 2.525 | 1.756 |
| Nº of female adults (15-64 yrs) | 1.042 | 0.563 | 1.232 | 0.673 |
| Nº of male adults (15-64 yrs) | 1.240 | 0.583 | 1.396 | 0.753 |
| Nº of elders (65 yrs +) | 0.019 | 0.137 | 0.035 | 0.202 |
| Main road surface is tar (0/1) | 0.200 | 0.400 | 0.112 | 0.315 |
| Distance to the nearest urban center (km) | 30.579 | 31.084 | 39.003 | 31.343 |
| Distance to the nearest mkt (km) | 2.932 | 4.989 | 4.332 | 7.714 |
| Services index | 0.222 | 1.475 | -0.143 | 1.366 |
| Land in bush (%) | 9.483 | 14.066 | 12.095 | 14.502 |
| Agricultural land in estates (%) | 11.747 | 23.569 | 9.405 | 20.866 |
| Comm. Land flat or slightly sloping (0/1) | 0.660 | 0.474 | 0.638 | 0.481 |
| Local ganyu wage (10,000 Mk/day) | 10.126 | 6.413 | 8.521 | 5.472 |
| MASAF in community (0/1) | 0.139 | 0.347 | 0.134 | 0.341 |
| HH suffer weather shock in last 5 yrs (0/1) | 0.401 | 0.490 | 0.541 | 0.498 |
| Comm. suffer weather shock in last 5yrs (0/1) | 0.704 | 0.457 | 0.770 | 0.421 |
| Avg. coef. of var. of last 10 rainy season | 2.202 | 0.152 | 2.219 | 0.178 |
| Change of rainfall volume during the last 10 rainy seasons | 1.018 | 0.043 | 1.005 | 0.051 |
| ADD Karonga (0/1) | 0.019 | 0.137 | 0.072 | 0.259 |
| ADD Mzuzu (0/1) | 0.140 | 0.347 | 0.140 | 0.347 |
| ADD Kasungu (0/1) | 0.117 | 0.322 | 0.155 | 0.362 |
| ADD Salima (0/1) | 0.023 | 0.149 | 0.050 | 0.217 |
| ADD Machinga (0/1) | 0.171 | 0.376 | 0.121 | 0.327 |
| ADD Blantyre (0/1) | 0.228 | 0.420 | 0.151 | 0.358 |
| ADD Ngabu (0/1) | 0.046 | 0.210 | 0.069 | 0.254 |
| Interview in 2005 (0/1) | 0.178 | 0.382 | 0.183 | 0.387 |
| Number of observations | 1413 | | 5186 | |

*Rainfall Variables*

The probability of a rainfall shock is a function of the average annual volume of rainfall and the average annual variability of rainfall. It has been shown in controlled experiments that more rainfall correlates with higher yield and lower yield variability (Koo, 2010). However, the same amount of seasonal rainfall may produce a wide range of yields. This is mostly due by the influence of location-specific rainfall patterns throughout the season on a daily basis (Koo, 2010). Therefore, both rainfall distribution and rainfall volume impose crop production risks, especially in rainfed subsistence cultivation systems.

We include in the migration and earnings models a set of variables that measure these two important attributes of local rainfall patterns: rainfall variability, including shocks such as droughts and floods, and change in the average volume of rainfall in recent years. Rainfall variability is measured in three ways. First, we include a dummy variable indicating whether the household reported economic damages due to a drought or flood in the last five years. In the case of migrants, this variable takes a value of one if the household suffered economic damages from a rainfall shock before moving and zero otherwise. Rainfall shocks are likely to negatively impact earnings not only in the year of the drought or flood, but for several subsequent years, if the resulting damage to household assets was substantial. As described in the economic framework, how rainfall shocks affect migration is an empirical question. We also include in the models a community-level rainfall-shocks variable: whether a community was hit by a severe drought or flood in the last 5 years. We anticipate that earnings and in-migration will be lower in communities recently affected by precipitation shocks. The third rainfall variability variable is the average for the last ten rainy seasons of the coefficient of variation (CV) of daily rainfall.[12] This variable is at the district level and relies on data from the Malawi Meteorological Services. We expect that people migrate to those communities with less rainfall variability during the rainy season, since the risk would be lower for a long dry or wet spell during critical stages of the agricultural growing season. Finally, we proxy long-run change in rainfall as the ratio of the average annual rainfall for the last ten years rainy seasons over the average annual rainfall during the rainy season over a 30-year period (1972-2002). This district-level variable is based on data from the Malawi Meteorological Services. Note that the latter two rainfall variables are not included in the earnings equations, as they are used as instruments to identify the migration equation. We discuss the identifying instruments in more detail later in this section.

*Household-level Control Variables*

We include age of the household head as an explanatory variable in the migration and the earnings equation. The likelihood of migration among workers has been found to have an inverse-U shaped association with age, with migration probability reaching its peak in early adult years (Rogers & Castro, 1984; de Haan, 1999). This is because the expected future benefits upon migration decreases as a worker ages and his potential length of time devoted to working diminishes (Lucas, 1997; Marré, 2009). Age is also a

[12] The cropping season in Malawi goes from November to April.

proxy for an individual's accumulated skills in the labor market and on the farm and thereby should have a positive influence on earnings (Lucas, 2000).

Economic theory suggests that education is an investment that makes a worker more productive and thereby able to earn more (Becker, 1993), and there is abundant empirical evidence in support of the theory (Buchmann & Hannum, 2001; Psacharopoulos, 1981; Lau, Jamison, & Loua, 1991). Education should increase the probability of migration because workers may need to migrate to find jobs that match their skill levels (de Haan, 1999; Marré, 2009; Närman, 1995). We include in the migration and earnings equations a set of dummy variables for highest education qualification acquired by the household head.[13]

Household composition is another factor likely to affect earnings and migration. The number of working-age adults relative to dependent members (i.e., elders and children) is expected to have a positive association with agricultural production and thereby earnings/income. We also anticipate that household composition influences migration. Caldwell (1969) reports that only two-fifths of migrants in Ghana had children at the time of migration. Other research shows that married people are less likely to migrate (Hare, 1999; Zhao Z. , 1999; Zhu, 2002). We include the following variables in the model: number of children (<14 years old), number of adult males and females (15-64 years old), and number of elders (≥65 years old).

[13] This is a categorical variable that we transformed in six dummies; these are: Primary School Learning Certificate (PSLC) received after completing the first 8 years of compulsory education; Junior Certificate of Education (JCE) accredited after two years of Secondary education; Malawian School Certificate Exam (MSCE) endorsed at the end of secondary school; and Graduate degree, which include non-university diploma University diploma, and Post-grad degree.

*Community-level Control Variables*

In addition to household variables, the model incorporates local economic conditions including market access, access to services, and availability of economic opportunities. Since the IHS-2 dataset does not provide information about migrants' specific places of origin, we can only examine the community characteristics that encourage people to move into a community.

A community's access to markets may affect the likelihood of migration and earnings. People living in isolated communities face higher costs of migration (Zhao Y. , 1999). Worker's earnings should be lower in remote rural areas, as their labor markets generally offer fewer employment opportunities. And, in the case of Malawi, where 89% of the labor force works on smallholder farms or farm estates (Wobst, Lofgren, & Tchale, 2004), poor market access is associated with lower farm profits and income.

Previous studies measured market access as a combination of distance to market(s), utility of the market (based on supply or demand attributes), quality of the route, and capacity of the agent to travel to markets (Staal, Baltenkweck, Waithaka, de Wolff, & Njoroge, 2002). We use the following community-level variables to measure market access: distance to the nearest *boma*[14] or city (whichever is closer), distance to the nearest daily or weekly local market, and a binary variable indicating if the most common road surface in the community is tar/asphalt.

We anticipate that in communities where access to services is relatively good, earnings and in-migration will be higher (Mukherjee & Benson, 2003). We measure

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[14] District administrative headquarters.

access to services using an index based on the presence in the community of a health center, post office, commercial bank, and telephone service. We construct the service index using Principal Components Analysis (Filmer & Pritchett, 1999).[15]

Economic opportunities at the community level should influence the level of earnings of community residents and the attractiveness of the community to prospective migrants. To examine this, we include in the earnings and migration models variables measuring the availability and quality of land, wages, and the existence of job programs. The availability and quality of land in the community may pull or push migrants. A study in western Burkina Faso found that family movements were mainly associated with the settlement of lands (Cordell, Gregory, & Piché, 1996). And there is evidence that in Nigeria most moves between rural areas during the seventies were driven by opportunities to gain access to fertile farmland (Aina, 1995). We measure land availability with two variables. One is the percentage of community land that is in bush, that is, land that was farmed years ago, but is now not used for agriculture except for pasture. A second variable for land availability is the percentage of agricultural land in the community that is owned by a commercial estate. As an indicator of land quality, we construct a dummy variable with a value of one when the land of the community is flat or slightly slopping, and zero when it is moderately slopping, steeply sloping, or both flat and hilly.

To estimate inter-community wage differences that may pull migrants, we use the average local wage for *ganyu*, which is piecework labor, usually of an agricultural nature.

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[15] The first principal component is used to determine weighting factors for each type of service and define the service index.

Participation in *ganyu* is widespread in Malawi: over 50% of rural households engaged in such casual work in 2004, according to data from the IHS-2. The existence of job creation programs in a community may attract migrants and we therefore include a dummy variable for whether there is a Malawi Social Action Fund (MASAF) program in the community. MASAF finances self-help community projects and transfers cash through safety-net activities, like rehabilitation and maintenance of rural roads, construction of small-scale irrigation dams, water projects, and land conservation efforts (MASAF, 2010). MASAF should also affect worker's earnings since it targets communities that are chronically poor or food insufficient, through food- and cash-for-work activities (Harrigan, 2008).

*Spatial and Time Heterogeneity*

To capture additional spatial variability not controlled for by the community-level variables discussed above, we include in the earnings and migration equations a set of dummy variables for Malawi's eight agricultural development districts, which correspond to the agroeconomic zones of the country. The variables account for the agronomic endowment of an area in terms of soil fertility, climate, and natural resources, as well as economic features, such as the degree of market access. The reference agricultural development district is Lilongwe, the capital city. Finally, a variable is included to indicate the year (2004 vs. 2005) during which the household was interviewed, to control for annual variation.

*Instrumental Variables*

The parameters of the earnings equations are identified if the migration equation (the switching equation) contains at least one independent variable which does not appear in the earnings equations. This variable is used as an identifying instrument. We satisfy the condition for model identification using the following variables as instruments in the migration equation: the ten-year average CV for rainy season rainfall, and change in rainfall volume during the last 10 years. These two precipitation variables represent long-run weather patterns in the migrant's destination area and are unlikely to affect current earnings.

### 3.4. Data And Sampling Issues

The empirical analysis of this paper focuses on a sub-sample of the IHS-2 data: male household heads that are of working-age (15-64 years).[16] This is an appropriate analysis unit, given our interest in studying migration decisions that are driven by earnings' differentials across space. Female heads who migrated reported reasons for moving that were connected to life-cycle events, such as marriage and divorce, and were thus not included.[17] Additionally, we dropped from the sample all household heads that are currently attending or enrolled in school as our interest is to understand the migration decisions of people who make location decisions in pursuit of immediate economic gains.

[16] We classify adult members as those aged 15-64 years, following the convention of the IHS-2. Furthermore, although Malawi is party to several international conventions against child labor, the official minimum working age in the country is 14 years.

[17] For the 189 households where the female head was married, the information for the male spouse was used.

We consider as migrants male householders of working age who moved during the last five years from towns or villages in the same or in other districts.[18] Non-migrants are people who always lived in the same town or village, came to the town or village more than five years ago, or moved only inside the town or village (this type of mobility is commonly referred to as residential mobility).

Since our interest is to evaluate how rainfall conditions influence a rural household's decision to migrate, we further reduced our sample to those individuals who lived in rural areas five years ago. Therefore, the sample does not include individuals who moved from urban to rural areas during the last five years or who lived in urban areas for at least five years. In addition, we drop from our sample all the individuals with missing information on variables included in the empirical model.

The number of individuals for analysis is 6,599, of which 1,413 are defined as migrants and 5,186 as non-migrants. Of the non-migrants, 44% have never moved and the 56% who have migrated at some stage have, on average, lived 17 years in their current place of residence. Among the migrants, 82% moved between rural areas and 18% migrated to urban areas. Rural and urban migrants have lived an average of 2.7 years in their new place of residence. Rural-rural migrants tended to move close to their original place of residence, with 65% of them moving between villages located in the same district. In contrast, rural-urban migrants migrated to more distant destinations, 75% of them moved to their current city from villages or towns located in different districts. This is as expected since there are only four cities in Malawi: Mzuzu in the northern

[18] We set this five-year limit because it is common in the migration literature, see for example: Bowles (1970), Lucas (2000) and Marré (2009).

region, Lilongwe in the central region, and Zomba and Blantyre in the southern region. Given the small number of rural-urban migrants ($n$ = 255), we estimate the migration model for the combined sub-sample of rural out-migrants, that is, we do not distinguish between migrants that ended up in rural versus urban areas.

**3.5. Results**

Prior to estimating the model, we conducted an indirect test to examine whether our two identifying instruments are valid. Instrumental variables should be correlated with migration and uncorrelated with the earning's equation error term. First, we estimated a probit model in which the dependent variable is migration and explanatory variables are the two identifying instruments. We found that the marginal effect of the ten-year average CV for rainy season rainfall and the change in rainfall volume during the last 10 years are both good predictors of migration and significant at the 0.001 probability level. Second, we estimated an ordinary least squares (OLS) model in which the dependent variable is the natural log of total annual household expenditures per capita and explanatory variables are the two instrumental variables. Both instrumental variables are not significant at conventional test levels, having $p$-values of 0.22 0.41, respectively. This suggests that the identifying instruments do not have direct effect on earnings, although we are unable to test statistically for correlation between the instrumental variables and the earning's equation error term.

Table 3.2. Model of determinants of migration and earnings in rural Malawi

| | Migration | | Migrants' earnings | | Non-migrants' earnings | |
|---|---|---|---|---|---|---|
| | Coef[a, b] | Mg. Eff | Coef[a, b] | Mg. Eff | Coef[a, b] | Mg. Eff |
| Age (yrs) | -0.015***<br>(0.002) | -0.004 | -0.006***<br>(0.002) | 0.001 | 0.001<br>(0.001) | 0.001 |
| PSLC (0/1) | 0.015<br>(0.054) | 0.004 | 0.197***<br>(0.044) | 0.191 | 0.104***<br>(0.020) | 0.104 |
| JCE (0/1) | 0.396***<br>(0.056) | 0.116 | 0.394***<br>(0.042) | 0.225 | 0.103***<br>(0.026) | 0.104 |
| MSCE (0/1) | 0.696***<br>(0.079) | 0.204 | 0.929***<br>(0.057) | 0.632 | 0.313***<br>(0.042) | 0.314 |
| Graduate (0/1) | 1.145***<br>(0.194) | 0.335 | 1.405***<br>(0.120) | 0.917 | 0.781***<br>(0.111) | 0.784 |
| Nº of children (0-14 yrs) | -0.109***<br>(0.013) | -0.032 | -0.228***<br>(0.011) | -0.182 | -0.132***<br>(0.005) | -0.132 |
| Nº of female adults (15-64 yrs) | -0.118**<br>(0.037) | -0.034 | -0.202***<br>(0.028) | -0.152 | -0.091***<br>(0.012) | -0.092 |
| Nº of male adults (15-64 yrs) | -0.100**<br>(0.031) | -0.029 | -0.117***<br>(0.025) | -0.075 | -0.012<br>(0.011) | -0.012 |
| Nº of elders (65 yrs +) | -0.181<br>(0.112) | -0.053 | -0.162$^{+}$<br>(0.097) | -0.085 | -0.129***<br>(0.036) | -0.129 |
| Main road surface is tar (0/1) | 0.257***<br>(0.056) | 0.075 | 0.188***<br>(0.041) | 0.079 | 0.057*<br>(0.024) | 0.058 |
| Distance to the nearest urban center (km) | -0.003***<br>(0.001) | -0.001 | -0.000<br>(0.001) | 0.001 | 0.000$^{+}$<br>(0.000) | 0.000 |
| Distance to the nearest mkt (km) | -0.005<br>(0.003) | -0.001 | -0.002<br>(0.003) | 0.000 | 0.003***<br>(0.001) | 0.003 |
| Services index | 0.046***<br>(0.014) | 0.013 | 0.050***<br>(0.011) | 0.030 | 0.022***<br>(0.006) | 0.022 |
| Land in bush (%) | 0.001<br>(0.001) | 0.000 | -0.000<br>(0.001) | 0.000 | -0.000<br>(0.001) | 0.000 |
| Agricultural land in estates (%) | -0.000<br>(0.001) | 0.000 | -0.001<br>(0.001) | -0.001 | 0.000<br>(0.000) | 0.000 |
| Comm. Land flat or slightly sloping (0/1) | 0.091*<br>(0.041) | 0.027 | 0.034<br>(0.032) | -0.005 | 0.081***<br>(0.016) | 0.081 |
| Local ganyu wage (10,000 Mk/day) | 0.020***<br>(0.003) | 0.006 | 0.006*<br>(0.003) | -0.003 | -0.003*<br>(0.001) | -0.003 |
| MASAF in community (0/1) | 0.042<br>(0.055) | 0.012 | 0.009<br>(0.043) | -0.009 | -0.041$^{+}$<br>(0.022) | -0.041 |
| HH suffer weather shock in last 5 yrs (0/1) | -0.184***<br>(0.038) | -0.054 | -0.160***<br>(0.031) | -0.081 | -0.026$^{+}$<br>(0.015) | -0.026 |
| Comm. suffer weather shock in last 5yrs (0/1) | -0.315***<br>(0.052) | -0.092 | -0.200***<br>(0.039) | -0.066 | -0.028<br>(0.022) | -0.029 |
| Avg. coeff. of var. of last 10 rainy seasons | -0.552***<br>(0.153) | -0.162 | | | | |
| Change of rainfall volume during the last 10 rainy seasons | 0.599<br>(0.795) | 0.175 | | | | |
| Sigma migrants | 0.650 | (0.029) | | | | |
| Sigma non-migrants | 0.531 | (0.010) | | | | |
| Rho migrants | 0.845 | (0.029) | | | | |
| Rho non-migrants | -0.668 | (0.047) | | | | |
| N | 6599 | | | | | |
| Wald $\chi^2(30)$ | 1049.23 | | | | | |
| LR $\chi^2(1)$ test of indep. eqns. | 61.62 | | | | | |

Notes: a. Standard errors in parentheses; + p<0.10, * p<0.05, ** p<0.01, *** p<0.001

b. Not shown in the table are parameter estimates for seven binary variables for the ADDs.

Table 3.2 presents coefficients, standard errors, and marginal effects for the migration and earnings equations. The likelihood-ratio tests reveal that the estimated correlations between the earnings equation error and the migration equation error are significantly different from zero. Thus, the hypothesis that the earnings equations and migration equation are independent can be rejected. It is positive for migrants and negative for non-migrants.

The dependent variable in the migrant and non-migrant earnings equations is in natural logarithm form. Therefore, the estimated regression coefficients in Table 3.2 measure the percentage change in per capita earnings resulting from a unit change in the independent variable. Also, these parameters are marginal distributions ($\partial E(w_m)/\partial X_{mj}$), so they measure the direct effect of the independent variable on the mean of each earnings equation. The parameters of the conditional distribution ($\partial E(w_m|m=1)/\partial X_{mj}$) include an indirect effect if the independent variable also appears in the selection equation. Thus, we need to transform the parameter under the assumption of normality of the residuals, as follows (Maddala, 1983):

$$\frac{\partial E(w_m|m=1)}{\partial X_{mj}} = \alpha_{mj} - \beta_j \sigma_{m\varepsilon} \frac{\phi(Z\alpha)}{\Phi(Z\alpha)}\left(Z\alpha + \frac{\phi(Z\alpha)}{\Phi(Z\alpha)}\right),$$

where *X* is the set of variables used in the earnings equations. Marginal effects are presented on the second column of each regression in Table 3.2. In our reporting of empirical results, we first summarize the findings for control variables and then turn to discussion of the results for the variables of primary interest, those that relate to precipitation anomalies.

*Migration*

As shown in Table 3.2, the probability of migration is negatively associated with the household head's age and positive related with his education level. Family size and composition influence the probability of migration. For example number of children and number of adults are negatively linked with the probability of migration. In short, Malawian migrants tend to be young, educated, and without dependents.

Among the community variables, the presence of tar roads has a positive effect on the probability of migration into that community. Distance to urban centers or *bomas* is negative. Thus, communities located at a greater distance from an urban center are less likely to receive migrants. Individuals also tend to migrate to those communities where basic services, such as health or banking facilities, are better developed. Availability of land is not significant, but migrants tend to move to places where land is flat or slightly slopping. Difference in wages among communities is found to be a migration pull factor. And location-specific agronomic endowments matter to migration, as evidenced by the statistical significance of several of the ADD binary variables (not shown in the table). Finally, individuals interviewed in 2005 were more likely to report migration than those interviewed in 2004 (not shown in the table).

*Earnings*

Turning now to results for the control variables in the earnings equation, an individual's age has a negative and small impact on the earnings of migrants but has no effect on the earnings of non-migrants. The former finding may imply that migration presents fewer economic opportunities for older compared with younger individuals. As expected, education has a positive association with earnings for both migrants and non-migrants, and the benefit of education is higher upon migration. Also, greater family size is negatively correlated with earnings per capita of migrants and non-migrants.

The earnings of migrants and non-migrants are higher when the main roads in their community of residence are tar. Distance to the nearest weekly or daily local market is positively related to earnings of migrants. According to expectations, the service index variable has a positive coefficient in both earnings equations. Non-migrants are found to have higher earnings when they reside in communities with land that is flat or slightly slopping. Interestingly, the average *ganyu* wage in a community is positively associated with the earnings of migrants, but negatively linked with the earnings of non-migrants. This might be explained by the observation that 23% of migrants in the sample are workers that do not own land, while 96% of non-migrants own land and hire *ganyu* workers. Location-specific agronomic endowment influences earnings of migrants and non-migrants. Finally, individuals interviewed in 2005 have lower earnings than those interviewed in 2004.

*The Effects of Rainfall Variability and Change on Migration and Earnings*

Our results indicate that rainfall variability is associated with a lower probability of migration and reduced earnings for both migrants and non-migrants. Referring first to the household-level rainfall shock variable, individuals were less likely to migrate if their household suffered precipitation shocks in the last five years. This result contrasts with other research in low-income settings that has found that weather shocks push people to migrate (Mueller & Osgood, 2009). The finding is, however, consistent with a very plausible hypothesis: that severe weather shocks reduce a household's stock of capital to such a degree that household members are left with insufficient funds to migrate. For example, it is estimated that Hurricane Mitch resulted in average real agricultural losses per household of US$277, which in 1998 represented more than 115 % of Nicaraguan households' average monthly income (Baez & Santos, 2007). In Ethiopia, a series of severe rainfall events in 1998 and 1999 had devastating effects on agricultural production and livestock holdings of rural households such that by August 1999 about 90% of the households in one region of the country were reliant on food aid (Mogues, 2004).

As for the earnings equations, the household-level rainfall shock variable is negative for migrants and non-migrants, although the magnitude of the coefficient is relatively small for non-migrant earnings. Recall that for migrant households, the rainfall shock variable measures whether the household suffered from a weather shock prior to migration of the household head. Thus the finding suggests that weather shocks reduce the expected benefits of migration, probably by lowering an individual's level of capital.

The community-level rainfall shock variable has a negative sign in the migration equation, which suggests that people are attracted to communities with lower probabilities of droughts and floods. Results also show that community-level rainfall shocks are negatively associated with the earnings of migrants, but there is no association between such shocks and non-migrant earnings. This suggests that migrants are more exposed than non-migrants to the economic effects of community-wide rainfall shocks. A conceivable explanation is that migrants deplete their assets and borrow money to cover costs of relocation, making them more vulnerable to the effects of shocks in their new community.

The third measure of rainfall variability is the coefficient of variation of daily rainfall during the rainy season of the last 10 years in the individual's current community of residence. The negative sign of the coefficient indicates that people choose to move to communities where the distribution of rain during the rainy season is relatively even, that is, there is an absence of long spells of dry or wet conditions, which are unfavorable for agricultural production.

Finally, we turn to the finding on the influence on migration of long-run changes in rainfall. The deviation of the last 10-year's average rainfall volume from the long-run average is not statistically significant at standard test levels. This may reflect that, while rainfall is highly variable in Malawi (Figure 1), with droughts and floods causing much devastation, particularly in rural areas, long-run changes in rainfall are rather small and less noticeable to people. In fact, the only statistically significant change in rainfall during 1960-2006 was a 5.8 mm per decade decline during December, January, and February, the middle of the November to March/April agricultural season; but this is almost irrelevant given that average monthly rainfall is 217 mm for these months (McSweeney, New, & Lizcano, 2008).

### 3.6. Conclusion

This study examined whether rainfall variability and long-run change in rainfall levels matter to the migration decisions of working-age household heads in rural Malawi.

We find that weather shocks, such as a drought or a flood, reduce an individual's probability of migration, which we explain as being related to the fact that severe weather shocks can reduce a household's stock of capital to such a degree that household members are unable to cover the costs of migration. In addition, results indicate that the earnings of recent migrants are harder hit than those of long-time residents when droughts or floods affect their community. The observed higher vulnerability of migrants to weather events may reflect that migration is costly and often financed in ways that increase vulnerability to future adverse shocks, for example, by incurring debt or drawing down one's stock of liquid assets. Migrants appear to be forward thinking in this respect, as results show that they are less likely to move into communities that suffered droughts or floods in the last five years or those that had higher rainfall variability during the rainy season. Finally, our findings suggest that long-run changes in rainfall levels are not associated with the probability of migration. Future research using a panel dataset (Anderson & Dillon, 1992) that includes information on the characteristics of migrants' communities of origin is needed to better assess the patterns observed in the current study.

If the findings presented here are corroborated by future research, then there is additional justification for policy interventions to make people less vulnerable to rainfall events. The Malawian government could reduce rural households' vulnerability to future droughts and floods through a variety of agriculture-related projects: investments in irrigation infrastructure; agricultural extension activities that encourage farmers to plant some of their land in drought-resistant crops, such as cassava; investments in soil and water conservation practices, such as terracing and construction of earth dams; and support for group weather-insurance schemes that provide financial protection from weather-related crop failure. In addition, government could promote economic diversification in rural communities to reduce dependency on agriculture, which is a climate-sensitive sector. Finally, increased financial support to the Department of Climate Change and Meteorological Services should improve the reliability, responsiveness, and accuracy of weather warning systems.

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# CHAPTER FOUR

# DISTRIBUTIONAL EFFECTS OF FOOD ASSISTANCE: HOW MUCH DO URBAN HOUSEHOLDS BENEFIT FROM RURAL SNAP PAYMENTS?

## 4.1 Introduction

People in poverty often are viewed as a burden to their communities. Wealthy people in urban areas often believe that they finance policies that help poor people in rural communities but are insulated from the benefits of these programs. However, not very much is known about the economic relationship between urban centers and the rural hinterland, and about the distribution of direct and indirect benefits of social safety net programs among income classes.

A better sense of how rural and urban economies work together and how benefits from poverty reduction programs spillover between areas and among households groups would aid policymakers to seek new strategies for increasing economic well-being by clarifying the distributional impacts of current programs. There is some evidence that certain policy proposals directed to the rural economy have feedback effects on the urban economy. For example, Waters, Holland, and Weber (1994) established significant economic linkages between Portland and rural western Oregon when they researched the impact from timber harvest reduction on federal land. Similarly, Holland, Lewin, Sorte, and Weber (2010) showed that even though the Portland Core has been growing faster than its Periphery trade area and their economic linkages in 2006 are smaller than in 1982, yet the fortunes of each region are affected by growth or decline in the other.

There has been a long interest about measuring the effect of federal food assistance programs on the economy and on the distribution of income. McKee and Day (1968), for example, examined the effect of USDA programs on income distribution, and found that Food Stamps had the effect of equalizing the distribution of income between rich and poor states. During the early 2000s, using a general equilibrium model, Hanson and Golan (2002) researched how SNAP expenditures increase economic activity (GDP) and found that SNAP redistributes income from mid-high income households to low income households. More recently, Hanson (2010) using the Food Assistance National Input-Output Multipliers (FANIOM) model estimated the multiplier effects of the Supplemental Nutrition Assistance Program (SNAP) on agriculture and the U.S economy, but did not examine the impacts on the distribution of income. This essay takes a regional perspective in examining the relative importance of food assistance in generating demand in each sub-region for products and services from the other, and in changing the distribution of income in each region. We study the effect of SNAP in the Core and Periphery of the Portland Oregon trade area on both Core and Periphery regions. The analysis captures direct, indirect and induced effects of SNAP on each region and spillover effects on the other region. Furthermore, SNAP payments made to the lower income household class in each region are traced to their effects on the local economy in each region, and to the effects on household income by income class (i.e. for low-, middle- and high- income households). The analysis considers SNAP transfer payments as an exogenous shock to the economy and the model is static assuming no time lag in the response.

SNAP is an interesting program for a study of the linkages between regions and among household groups because it is one of the largest public assistance programs in the nation. In 2009, it benefited approximately 33.5 million people in the country (U.S. Department of Agriculture, Food and Nutricion Service, 2010) and represented 1.6% of the total direct expenditures of the Federal Government (U.S. Department of Commerce, Bureau of the Census, 2011).

Oregon is an attractive setting to study the spillover of this program because during the last ten years, it has ranked among the top-ten states in SNAP participation rates by comparing the state's SNAP caseload to the size of its eligible population (U.S. Department of Agriculture, Food and Nutricion Service, 2010). For example, in 2009, about 87% of Oregon's eligible population participated in SNAP (Porter, 2010). This implies that about 538,000 people in Oregon in 279,000 households received an average monthly food benefit of $173 per household (Oregon Department of Human Services, 2010).

To study how food assistance to poor households spills over between regions and among household groups we built a Multiregional Input-Output Social Accounting Matrix model (MRIO-SAM)[19] in which households are treated as endogenous (i.e., the spending from increases in households income has the effect of increasing regional demand and output which increases households income). We use data from IMPLAN

[19] This type of model is sometimes referred to as a "multi-regional social accounting matrix (SAM) models" rather than a "multi-regional input-output model". See, for example, Robinson, Dennis P. and Zuoming Liu, "The Effects of Interregional Trade Flow Estimating Procedures on Multiregional Social Accounting Matrix Multipliers". Journal of Regional Analysis and Policy, 36(1): 94-114

regional trade reports to derive possible Core-Periphery trade, and from the U.S. Department of Commerce to estimate labor and earnings flows.

The essay is organized as follows. The next section describes the structure of Multiregional input-output models that incorporate Social Accounting Matrices (SAMs). Then, we define the study area, build the Multiregional SAM model, and discuss some of the linkages between the regions in the study area. Analysis of the impacts of SNAP follows and the final section summarizes the paper's key findings.

**4.2 The Multiregional SAM Model**

Multiregional input-output models (MRIO) allow quantifying the contribution from different economic sectors in various regions to the demand for any product in each region (Hertwich & Peters, 2010). Thus, MRIOs allow the impact vector to capture not only the multiplier effects of any exogenous shock in that particular region, but also the spillover effects onto another region and the feedback effects of the second region's changes in demand back to the first region.

Our analysis expands the MRIO model by introducing a Social Accounting Matrix. In a typical IO accounting only the industry linkages are formally specified. Thus, the Leontief inverse (Type I multipliers matrix) is a matrix of total requirement coefficients that summarizes the direct effect (impact introduced) plus the indirect effect (the additional economic activity from industries buying from other local industries) (Leontief, 1936; Leontief, 1941). On the other hand, the SAM accounting includes the interindustry linkages of the IO model but embeds the matrix of these linkages in a broader accounting framework that incorporates linkages between the interindustry matrix and household income and household expenditures, government revenues and government spending, and saving and investment (Holland & Wyeth, 2008). Therefore, the type SAM multipliers estimate the direct, indirect (Type I) plus induced effects, where the induced effect is based on information in the social accounting matrix.

The primary elements of the SAM are: industries, factors of production, institutions (households and government), investment, commuting and trade with the rest of the world[20] (Table 4.1). In a SAM, rows represent receipts and columns represent expenditures. Thus, it is possible to read across the industry row to determine total industry demand, which is composed of outputs consumed by industries, household, government, investment, and exports. The industry column shows expenditures on inputs used in the production process, value-added payments to primary factors, and indirect taxes paid to government. (Holland & Wyeth, 2008). The SAM is partitioned into endogenous sectors (industries, and certain factors and institutions, shaded in Table 4.1) and exogenous sectors. The exogenous columns and rows are excluded when we calculate the matrix of SAM multipliers.

[20] For furthering discussion of these accounts see Holland & Wyeth (2008) and Watson & Beleiciks (2009)

Table 4.1: Social Accounting Matrix (SAM)

| | Endogenous Accounts | | | Exogenous Accounts | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Industries | Factors | Households | Government | Investment | Commuting | Rest of World | |
| Industries | Inter-industry demand | | Household consumption | Gov. demand | Investments | | Exports | Total industry output |
| Factors | Payment to labor & capital | | | | | | | Total factor receipts |
| Households | | Factor payments to HH | | Transfer payments (Ex. SNAP) | | HH income from out commuters | HH remittance income | Total HH income |
| Government | Indirect business taxes | | Income tax, prop. tax | | | | | Total Gov. revenue |
| Investment | | | HH savings | | | | | |
| Commuting | | Labor payment to in commuters | | | | Commuting balance | | Commuting outflows |
| Rest of World | Imports | Factor income transfer out of region | | | | | | Flows out of region |
| Total | Total industrial outlays | Total factor payments | Households payments | Government payments | Investment payments | Commuting inflows | Flows into the region | |

In summary, the MRIO-SAM framework includes intraregional linkages and links between regions (Waters, Holland, & Weber, 1994) according to industry, factor of production, and household income classes. The model is able to show how an exogenous income transfer to households in one economic region affects industry output, payments to households across the size distribution of income in the region, and also how that same shock affects industry output and households in the various income classes in the other region (Holland, Lewin, Sorte, & Weber, 2009).

The general MRIO-SAM model structure is represented in Table 4.2, where each cell of the table corresponds to the SAM model presented in Table 4.1.

Table 4.2: MRIO-SAM model structure

| | |
|---|---|
| CORE-CORE<br>Social Accounting Matrix | PERIPHERY-CORE<br>Social Accounting Matrix |
| CORE-PERIPHERY<br>Social Accounting Matrix | PERIPHERY - PERIPHERY<br>Social Accounting Matrix |

## 4.3 The Portland, Oregon, Trade Area[21]

The Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce has mapped principal trading regions of the U.S. into economic areas (EA) (U.S. Department of Commerce, Bureau of Economic Analysis, 1975). The EAs use counties as the basic building block and provide a convenient picture of functional economic regions consistent with central place perspectives. According to central place theory

[21] This section draws heavily on the working paper of Holland, Lewin, Sorte, & Weber (2009).

(Christaller, 1966), regions are organized in a geographic hierarchy of central places. A place at a given level on the hierarchy provides not only goods and services that are specific to its level, but also all other goods and services of lower order. Goods and services supplied only by major central places are referred to as "central place goods and services." The rural Periphery will not be self-sufficient in the supply of these goods and services and must, to some degree, depend on the central place for their supply. The EAs can be thought of as trade areas served by major central places.

The Portland, Oregon, trade area examined here includes (1) a metropolitan Core defined as the four counties in the Standard Metropolitan Statistical Area: Multnomah, Washington, and Clackamas Counties in Oregon and Clark County in Washington and (2) a Periphery: the trade area that is served by Portland, combining the EAs of Portland and Eugene. The Periphery trade area consists of Benton, Clatsop, Columbia, Coos, Crook, Curry, Deschutes, Douglas, Hood River, Jackson, Jefferson, Josephine, Klamath, Lake, Lane, Lincoln, Linn, Marion, Polk, Sherman, Tillamook, Wasco, and Yamhill Counties in Oregon plus Cowlitz, Klickitat, Skamania, and Wahkiakum Counties in Washington. This region is bounded on the north by the Seattle trade area, which extends into southwestern Washington (Figure 4.1). The western boundary is defined by the Pacific Ocean, while the eastern boundary extends to the Boise trade area that dominates eastern Oregon. The region extends south down the 1-5 corridor until the southern border of Oregon. The region includes Eugene and portions of Southern Oregon, which have increasingly been drawn into the Portland trade area as a result of ease of north-south travel on 1-5.

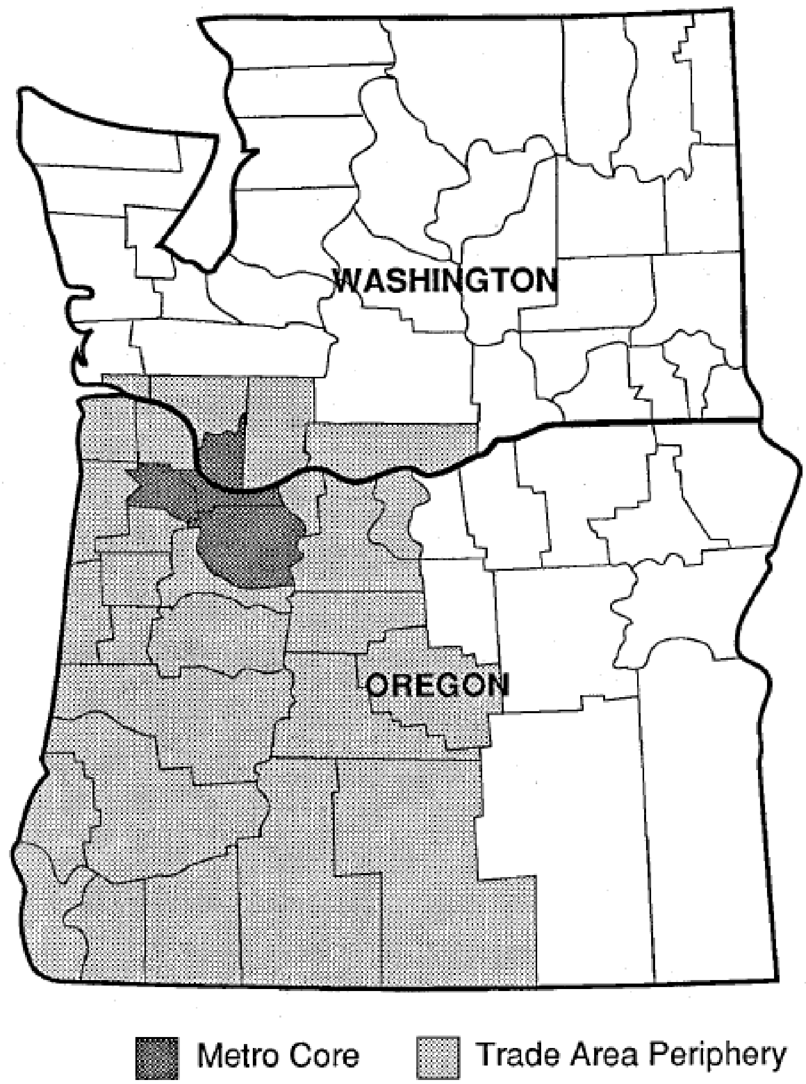


Figure 4.1: The Portland, Oregon trade area: Core and Periphery

## 4.4 Building the MRIO-SAM Model[22]

To construct the MRIO-SAM model of the Portland Metro-Trade Area Periphery labor services flows were combined with estimates of commodity trade flows and information from the IMPLAN social accounting matrix (SAM).

[22] The model building outline in this section draws heavily from Holland, Lewin, Sorte, & Weber (2009).

<u>4.4.1 Labor Flows Estimation</u>

A potentially important set of economic linkages between the urban Core and its Periphery is the commuting into the Core of workers who live in the Periphery and the commuting of those living in the Core to the Periphery. The jobs and income flows between the Core and Periphery were estimated using data from the Bureau of Economic Analysis and the US Census Bureau.[23] A detailed explanation about our estimation procedures and assumptions is in 4.8 Appendix A: Procedure for Estimating Labor and Earnings.

Our estimates of labor and earnings flows between Core and Periphery for 2006 are shown in Table 4.3. The number of Periphery-to-Core commuters is about 45,000 workers and the number of Core-to-Periphery commuters is about 18,500. In terms of percentage, the Core residents that work in the Periphery are 2.3% of the Periphery work force and the proportion of Periphery residents who work in the Core is 4.9% of the Core workforce. We see that the Core and the Periphery are not strongly linked through flows of labor commuting.

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[23] We calculated labor flows using the information published by the US Census Bureau in the "United Stated Census 2000, County-To-County Worker Flow Files". Specifically, we used the tables "Residence County to Workplace County Flows Sorted by Residence State and County" and "Residence County to Workplace County Flows Sorted by Workplace State and County". Then, we constructed earnings flows using data from the Bureau of Economic Analysis, Regional Economics Accounts, in "CA04 — Personal income and employment summary".

Table 4.3: Labor and earnings flows between the Core and Periphery, 2006 ($000)

| Place of Residence | Flows | Place of Work | | | | |
|---|---|---|---|---|---|---|
| | | Core | Periphery | Elsewhere | Total Labor by P.o.R. | Total Earnings by P.o.R. |
| Core | Labor | 866,761 | 18,575 | 7,839 | 893,175 | |
| | $ Earnings | 50,287,477 | 888,001 | 575,514 | | 51,750,992 |
| Periphery | Labor | 44,932 | 793,472 | 9,166 | 847,570 | |
| | $ Earnings | 2,368,396 | 34,463,113 | 464,318 | | 37,295,827 |
| Elsewhere | Labor | 6,151 | 5,949 | | | |
| | $ Earnings | 281,640 | 224,448 | | | |
| Total Labor by P.o.W. | | 917,844 | 817,996 | | | |
| Total Earnings by P.o.W $ | | 52,937,512 | 35,575,563 | | | |

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Economic Accounts (2006); U.S. Census Bureau, Journey to Work and Place of Work (2000)

### 4.4.2 Interregional Trade in Goods and Services

Trade in goods and services also provide linkages between Core and Periphery regions. The trade in goods and services between the Core and its Periphery trade area, and between those two regions and the rest of the U.S. was estimated using Regional Commodity Reports from IMPLAN following procedures summarized by Holland & Pirnique (2000).[24]

Table 4.4 presents our estimate of interregional trade between the Portland Core and its trade area Periphery. In 2006, the Core was one and a half times as large as the Periphery in terms of total sales. The Portland Core dominates in service trade with service exports of $5,533 million while its imports of services from the Periphery totaled $855 million. The Core's exports to the Periphery were estimated to be $7,402 million and its imports from the Periphery were $1,807 million, which means a net trade surplus

[24] The study was based on the expectation that central place goods will flow down the central place hierarchy from core to Periphery. A detailed explanation can be found in Holland and Pirnique, 2000.

of more than five billion dollars in favor of the Core.

When Core-Periphery trade is viewed in relative terms, we see that their trade linkages are not strong. In 2006, the proportion of Core's exports to the Periphery was 4% and to the rest of the world was 34%. Correspondingly, the fraction of Periphery's exports to the Core was 2% and to the rest of the world was 30%. The proportion of goods and services produced and consumed in the Core was 62% and in the Periphery 68%.

In 2006, the Portland Core was an export-driven economy with a positive surplus of exports over imports. The Periphery, on the other hand, with its mix of resource-based goods was a regional economy with a negative trade balance, where exports are less than imports.

Table 4.4: Portland Core - Trade Area Periphery goods and services trade (2006, $000)

| From | | To | | | |
|---|---|---|---|---|---|
| | | Core | Periphery | ROW | TOTAL SALES |
| Core | Total | 115,271 | **7,402** | 65,044 | 187,716 |
| | Goods | 19,610 | **1,869** | 40,667 | 62,146 |
| | Services | 95,661 | **5,533** | 24,377 | 125,570 |
| Periphery | Total | **1,816** | 81,874 | 36,331 | 120,022 |
| | Goods | **961** | 14,372 | 25,379 | 40,712 |
| | Services | **855** | 67,503 | 10,952 | 79,310 |
| ROW | Total | 61,712 | 46,900 | | |
| | Goods | 36,191 | 31,116 | | |
| | Services | 25,521 | 15,784 | | |
| TOTAL PURCHASES | Total | 178,799 | 136,176 | | |
| | Goods | 56,762 | 47,357 | | |
| | Services | 122,037 | 88,820 | | |

Source: 2006 IMPLAN data.

4.4.3 Households and Income Distribution in the Multi-Regional SAM Model

In creating the Core-Periphery MRIO-SAM model, household income and household expenditures that occur in the two regions were treated as endogenous. Nine distinct household income classes were identified for each region from IMPLAN data.

The model is closed under the assumption that regional consumption for each household income class is a function of the personal income received by that household group. Personal income is the sum of employee compensation, proprietors' income, government transfers, and property income. The regional contribution to regional personal income is measured as the sum of employee compensation and proprietors' income from the IMPLAN input-output accounts.

All "other property income" generated in the region is assumed paid to capital owners outside the combined region. Payments of interest, dividends, and rent to households and government transfers in each region were treated as exogenous and were derived from the IMPLAN SAM constructed for each region.

In the MRIO-SAM model, each industry is assumed to pay a fixed proportion of earnings to commuting workers from each region. The proportion is assumed constant for all industries in the region. (The standard IO assumption of fixed proportion distribution functions is used.) As is conventional in SAM-type models, employee compensation and proprietors' income are assumed distributed in fixed but different proportions across the size distribution of households in each region. The marginal propensity to consume is assumed equal to the average propensity to consume for each household income class. The average propensity to consume for each household income class is estimated by normalizing each regional household consumption vector with respect to the claim by that household income class on personal income in the region. Personal income is composed of an endogenous portion derived from earnings within the combined region, and an exogenous portion made up of government transfers and returns to capital outside the region. As is true for the standard input-output analysis, this model is static and does not trace the time path of changes generated by external economic shocks.

In order to verify the distribution of households among income group used in IMPLAN, we compare it with the income distribution of the 2005-2007 Public Use Microdata Sample files (PUMS)[25] and the 2005-2007 American Community Survey (ACS) 3-Year Estimates. The three data sets show similar percentage of households in each income group. We observe that the percentages of households reported by IMPLAN are a little larger than those reported by the 2005-2007 ACS and 2005-2007 PUMS for income groups below \$50,000-\$74,999 and smaller for income group over \$50,000-\$74,999 (Figure 4.2)[26]. However, the difference between IMPLAN and these two datasets is very small and should not affect our results.

[25] Since 2000, the PUMS is a subsample of households from the American Community Survey, from which household level data can be obtained for geographies as small as a Public Use Microdata Areas (PUMA)
[26] The difference between estimates from the 2005-2007 PUMS the 2005-2007 ACS estimates is because 2005-2007 PUMS are subject to additional sampling error and further data processing operations. The additional sampling error is a result of selecting the PUMS housing and person records through an additional stage of sampling (U.S. Census Bureau. 2005-2007 PUMS Accuracy of the Data. http://www.census.gov/acs/www/Downloads/data_documentation/pums/Accuracy/2005_2007AccuracyPUMS.pdf)

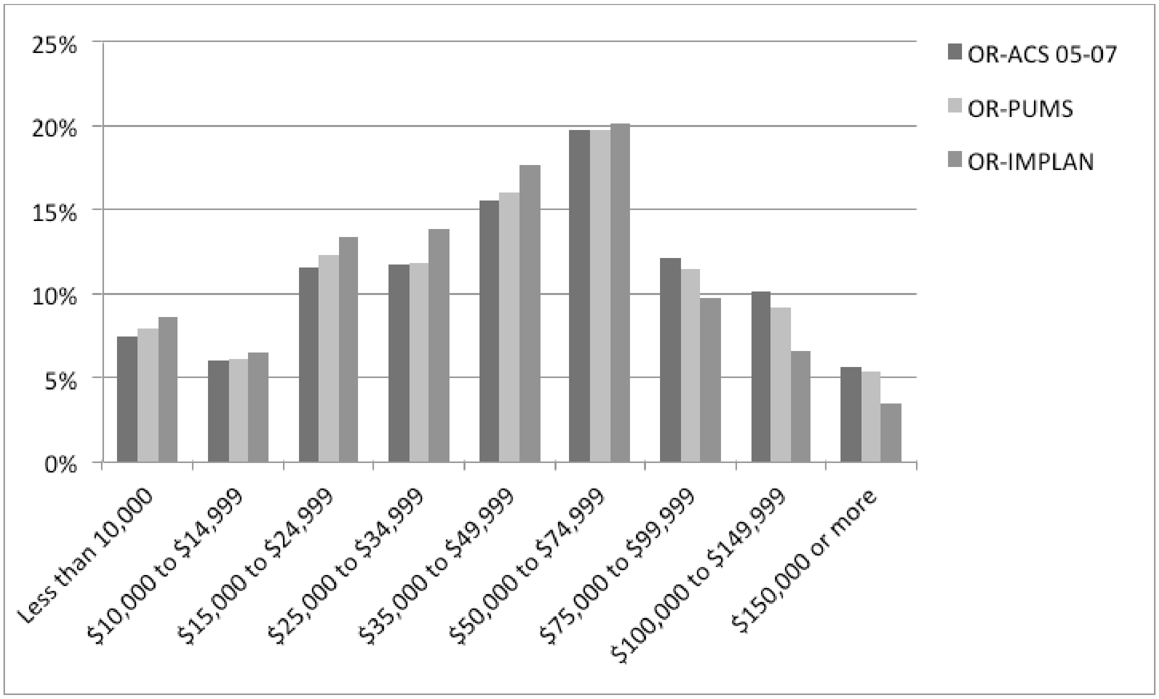


Figure 4.2: Comparison of household income groups

4.4.4 Impact Analysis

In order to do multiplier analysis of the impacts of changes in final demand, one needs to create a matrix of impact coefficients using the procedures of input-output analysis pioneered by Leontief. The MRIO-SAM model is summarized in the following equation:

$$Z = (I - S)^{-1}E \tag{4.1}$$

where $Z$ is a *nxn* matrix of total contributions (sector supply, value added, and household income), $I$ is an *nxn* identity matrix, $E$ is an *nxn* diagonal matrix of exogenous industry demand, exogenous value added, and exogenous household income, and $S$ is an *nxn* matrix of expenditure coefficients for the normalized endogenous partitioned regional

SAM (accounts in gray in Table 4.1). Using *C* and *P* to indicate Core and Periphery, respectively. Then, the normalized endogenous part of the MRIO-SAM model can be represented as

$$S = \begin{bmatrix} S^{CC} & S^{PC} \\ S^{CP} & S^{PP} \end{bmatrix} \tag{4.2}$$

where $S^{CC}$ and $S^{PP}$ represent the intraregional SAMs and $S^{CP}$ and $S^{PC}$ characterize the interregional SAMs.

*Total Expenditure Impact Coefficients*

Household expenditure impact coefficients[27] for in goods and services are derived from the MRIO-SAM inverse normalized matrix of the multiregional transactions matrix ($(I-S)^{-1}$ in equation 4.1). They indicate the change in output in the economy generated by a one unit increase in household income from outside the region (income from federal transfer payments or external dividends or rent, for example). These coefficients differ from the traditional sectorial output multipliers and can be less than one because households can and do make expenditures on imported goods and services.[28]

The own-region total expenditure impact coefficients are the column sums of individual household expenditure impact coefficients in the diagonal blocks of this matrix. These coefficients capture both within-region linkages and feedback effects from changes in other-region activity induced by a shock in the first region. The cross-regional

[27] In this paper, the term expenditure impact coefficient is used for individual elements of the goods and services rows of the household columns of the $(I-S)^{-1}$ (see Appendix A); and the term total expenditure impact coefficient is used to denote the column sum of the goods and services rows of household columns of the $(I-S)^{-1}$ (see Table 4.5).

[28] Sectorial output multipliers are always greater than one, and indicate the change in output in the economy generated by one unit change in final demand for that sector's output.

total expenditure impact coefficients are the column sums of individual household expenditure coefficients in the off-diagonal blocks of the inverse matrix. They show the expenditure change across regions for a one-unit change in the exogenous demand of the opposite region.

Table 4.5: Own-region and Cross-region total expenditure impact coefficients for Portland Oregon Trade Area Core and Periphery, 2006

| Household | Core | | | Periphery | | |
|---|---|---|---|---|---|---|
| | Core | Periphery | Total | Periphery | Core | Total |
| Less than 10,000 | 1.16 | 0.05 | 1.22 | 1.10 | 0.18 | 1.28 |
| $10,000 to $14,999 | 1.14 | 0.05 | 1.19 | 1.08 | 0.18 | 1.25 |
| $15,000 to $24,999 | 1.06 | 0.05 | 1.11 | 1.01 | 0.16 | 1.17 |
| $25,000 to $34,999 | 0.89 | 0.04 | 0.93 | 0.87 | 0.14 | 1.01 |
| $35,000 to $49,999 | 0.99 | 0.05 | 1.04 | 0.99 | 0.16 | 1.15 |
| $50,000 to $74,999 | 0.86 | 0.04 | 0.90 | 0.89 | 0.14 | 1.03 |
| $75,000 to $99,999 | 0.91 | 0.04 | 0.95 | 0.92 | 0.14 | 1.05 |
| $100,000 to $149,999 | 0.88 | 0.04 | 0.92 | 0.91 | 0.14 | 1.05 |
| $150,000 or more | 0.83 | 0.04 | 0.87 | 0.89 | 0.13 | 1.03 |

Own-and cross-regional total expenditure impact coefficients for the Portland Core and the trade area Periphery regions in 2006 are shown in Table 4.5. A government transfer of $100 to the lowest income households in the Periphery, for example, results in a $110 increase in total demand for goods and services in the Periphery economy. Simultaneously, because the Periphery-to-Core cross-regional expenditure impact coefficient is 0.18, a $100 income increase in households in the lowest income group from the Periphery would result in a $18 increase in total demand from goods and services in the Core. The sum of the own-region and cross-region effects yields the total effect of the increase in expenditures in good and services on the entire trade-area economy. Thus, in our example, a $100 income transfer to households in the lowest income group would generate $128 increase in output demand in the trade area.

The magnitude of the own-region and cross-region goods and services expenditure impact coefficient is smaller for higher household income groups. This reflects that higher income households consume a larger amount of commodities imported from outside the trade area. Core own-region coefficients are larger than Periphery own-region coefficients for households with income below $34,999; but they are smaller than Periphery own-region coefficients for household with income over $35,000. The Periphery-to-Core cross-regional expenditure impact coefficients are uniformly three or more times larger than the corresponding Core-to-Periphery coefficients. This reveals that Periphery is a more important market for the Core than the Core is for the Periphery.

*Income Distribution Impact Coefficients and Income Multipliers*[29]

When households raise their expenditures on commodities, they generate an increase in income in the region. Industries pay households in the form of salary, dividends, interest, and rent. Household income multipliers measure the income spillover among household groups. The household own-region income multipliers are the column sums for each income class of household row coefficients in the diagonal blocks of the

[29] In this section of the paper, the term income distribution impact coefficient is used to denote the individual elements of the submatrix of the $(I - S)^{-1}$ where the household rows and columns intersect (see Table 4.6); and the term income multiplier is used for the column sum of the individual income distribution impact coefficients (these are shaded in Table 4.6).

MRIO-SAM inverse matrix. The household cross-region income multipliers are the corresponding elements in the off-diagonal blocks of the inverse matrix.

Table 4.6 presents the own-and cross-regional income multipliers and distribution impact coefficients for the Portland Core and the trade area Periphery regions in 2006. A government transfer of $100 to the lowest income households (<$10,000 income) in the Periphery will increase Periphery low-income households' (<$25,000) income by $4 above the original injection. In addition, Periphery low-medium-income households ($25,000 to <$50,000) will experience an increase of $10, high-medium-income households ($50,000 to <$100,000) will receive and increase of $18, and high-income households ($100,000 +) obtain a rise of $9. Concurrently, a $100 income increase in households in the lowest income group in the Periphery would result in an increase of income in the Core equal to $1 in low-medium-income households, $3 in high-medium-income households, and $2 in high-income households. Thus, a $100 income transfer to Periphery households in the lowest income group would increase total income by $40 above the original injection in the Periphery, and by $6 in the Core. Approximately one-eighth of the indirect and induced impacts in the whole trade area of a government transfer to the Periphery occurs in the Core region.

Cross-regional multipliers in Table 4.6 are larger for the Periphery than the Core. Thus, the economic linkages from the Periphery to the Core are stronger than the linkages in the opposite direction. This reflects the generally stronger backward linkages from the Periphery to the Core versus the generally weaker backward linkages from the Core to the Periphery.

Table 4.6: Own-region and Cross-region income distribution impact coefficients and multipliers for Portland Oregon Trade Area Core and Periphery, 2006

| Household | ($000) | Core | | | Periphery | | |
|---|---|---|---|---|---|---|---|
| | | Core | Periphery | Total | Periphery | Core | Total |
| Less than $10,000 | < $25 | 1.02 | 0.00 | 1.03 | 1.04 | 0.00 | 1.04 |
| | $25 - $49 | 0.08 | 0.01 | 0.09 | 0.10 | 0.01 | 0.12 |
| | $50 - $99 | 0.18 | 0.02 | 0.20 | 0.18 | 0.03 | 0.20 |
| | >=$100 | 0.13 | 0.01 | 0.14 | 0.09 | 0.02 | 0.11 |
| | Total | 1.41 | 0.04 | 1.45 | 1.40 | 0.06 | 1.47 |
| $10,000 to $14,999 | < $25 | 1.02 | 0.00 | 1.03 | 1.04 | 0.00 | 1.04 |
| | $25 - $49 | 0.08 | 0.01 | 0.08 | 0.10 | 0.01 | 0.11 |
| | $50 - $99 | 0.17 | 0.02 | 0.19 | 0.17 | 0.03 | 0.20 |
| | >=$100 | 0.12 | 0.01 | 0.13 | 0.08 | 0.02 | 0.10 |
| | Total | 1.39 | 0.03 | 1.43 | 1.39 | 0.06 | 1.45 |
| $15,000 to $24,999 | < $25 | 1.02 | 0.00 | 1.02 | 1.03 | 0.00 | 1.04 |
| | $25 - $49 | 0.07 | 0.01 | 0.08 | 0.09 | 0.01 | 0.10 |
| | $50 - $99 | 0.16 | 0.01 | 0.17 | 0.16 | 0.03 | 0.18 |
| | >=$100 | 0.11 | 0.01 | 0.12 | 0.08 | 0.02 | 0.09 |
| | Total | 1.36 | 0.03 | 1.40 | 1.36 | 0.06 | 1.42 |
| $25,000 to $34,999 | < $25 | 0.02 | 0.00 | 0.02 | 0.03 | 0.00 | 0.03 |
| | $25 - $49 | 1.06 | 0.01 | 1.07 | 1.08 | 0.01 | 1.09 |
| | $50 - $99 | 0.13 | 0.01 | 0.15 | 0.14 | 0.02 | 0.16 |
| | >=$100 | 0.09 | 0.01 | 0.10 | 0.07 | 0.02 | 0.08 |
| | Total | 1.30 | 0.03 | 1.33 | 1.31 | 0.05 | 1.36 |
| $35,000 to $49,999 | < $25 | 0.02 | 0.00 | 0.02 | 0.03 | 0.00 | 0.04 |
| | $25 - $49 | 1.07 | 0.01 | 1.07 | 1.09 | 0.01 | 1.10 |
| | $50 - $99 | 0.15 | 0.01 | 0.16 | 0.16 | 0.02 | 0.18 |
| | >=$100 | 0.10 | 0.01 | 0.11 | 0.08 | 0.02 | 0.09 |
| | Total | 1.34 | 0.03 | 1.37 | 1.35 | 0.06 | 1.41 |
| $50,000 to $74,999 | < $25 | 0.02 | 0.00 | 0.02 | 0.03 | 0.00 | 0.03 |
| | $25 - $49 | 0.06 | 0.01 | 0.06 | 0.08 | 0.01 | 0.09 |
| | $50 - $99 | 1.13 | 0.01 | 1.14 | 1.14 | 0.02 | 1.16 |
| | >=$100 | 0.09 | 0.01 | 0.10 | 0.07 | 0.02 | 0.08 |
| | Total | 1.29 | 0.03 | 1.32 | 1.32 | 0.05 | 1.37 |
| $75,000 to $99,999 | < $25 | 0.02 | 0.00 | 0.02 | 0.03 | 0.00 | 0.04 |
| | $25 - $49 | 0.06 | 0.01 | 0.07 | 0.09 | 0.01 | 0.10 |
| | $50 - $99 | 1.14 | 0.01 | 1.15 | 1.15 | 0.02 | 1.17 |
| | >=$100 | 0.10 | 0.01 | 0.10 | 0.07 | 0.02 | 0.09 |
| | Total | 1.32 | 0.03 | 1.34 | 1.34 | 0.05 | 1.39 |
| $100,000 to $149,999 | < $25 | 0.02 | 0.00 | 0.02 | 0.03 | 0.00 | 0.04 |
| | $25 - $49 | 0.06 | 0.01 | 0.07 | 0.09 | 0.01 | 0.10 |
| | $50 - $99 | 0.14 | 0.01 | 0.15 | 0.16 | 0.02 | 0.18 |
| | >=$100 | 1.10 | 0.01 | 1.10 | 1.08 | 0.02 | 1.09 |
| | Total | 1.32 | 0.03 | 1.34 | 1.37 | 0.05 | 1.42 |
| $150,000 or more | < $25 | 0.02 | 0.00 | 0.02 | 0.04 | 0.00 | 0.04 |
| | $25 - $49 | 0.07 | 0.01 | 0.07 | 0.11 | 0.01 | 0.12 |
| | $50 - $99 | 0.15 | 0.01 | 0.16 | 0.19 | 0.02 | 0.21 |
| | >=$100 | 1.11 | 0.01 | 1.11 | 1.09 | 0.01 | 1.11 |
| | Total | 1.35 | 0.02 | 1.37 | 1.44 | 0.05 | 1.48 |

**4.5 Analysis of the Impact of SNAP**

The objective of SNAP is to increase the food budgets of low-income households. Eligibility and benefits amounts are based on family size, income, and resources. According to the U.S. Department of Agriculture, Food and Nutrition Service (2010), beneficiary households must be citizens or immigrants with permanent legal status and meet both the gross and net income tests.[30] The gross income test is based on 130% of the poverty line[31], and the net income (after expenses) test is based on 100% of the poverty line[32]. Beneficiaries receive a debit card they use to purchase only food at authorized retailers.

In order to estimate the economic impact of SNAP, we need to estimate the amount of money transferred to households in each household income group. The Consolidated Federal Funds Report, from the U.S. Census Bureau, provides information by county about the amount of total direct payment of SNAP. In 2006, the amount transferred to households in the Core was $191,223,476 and in the Periphery was $312,946,690.

To distribute these benefits across income groups, we use the 2003-2007 PUMS of the American Community Survey, which offers information about the number of SNAP beneficiary households by income group and the amount of SNAP benefits

[30] The specific criteria for eligibility have varied over time, as for example during the recent implementation of ARRA, in which eligibility threshold was increased temporarily to 185 percent of the federal guideline.

[31] The Federal Poverty Guidelines in 2006 established the poverty line equal to a gross yearly income of $9,800 for a household with one individual and equal to $13,200 for a household with two individuals. Any additional individual in the household increases the poverty threshold by $3200 in (Federal Register Vol. 71, No. 15, 2006, pp. 3848-3849).

[32] Households with elderly and disabled members need only to meet the net income test. The resource limit is $2,000 and $3,000 for a household with an elderly or disabled member

received by each income class. Unfortunately, PUMAs do not match perfectly well with our Core and Periphery geographic areas used in this research. Thus, we use the 2005-2007 American Community Survey (ACS) 3-Year Estimates,[33] which is based on a larger sample households, as a cross-check on the extent to which the PUMS may accurately capture SNAP activity in both the Core and Periphery.

The number of SNAP beneficiaries reported in PUMS is 7.6% larger in the Core and 1% smaller in the Periphery than the numbers reported in the American Community Survey. These differences between the 2005-2007 PUMS and the 2005-2007 ACS are not statistically significant given the standard error of the sum of sample estimates margin of errors.[34] Furthermore, when we estimated the total percentage of SNAP beneficiaries for the entire State of Oregon, both the 2005-2007 PUMS and the 2005-2007 ACS closely match the 11 percent of the Oregon population receiving SNAP reported by the Oregon Department of Human Services (Oregon Housing and Community Services, 2007). These findings suggest that the use of the PUMS data to distribute the SNAP payments among income classes is quite reasonable.

We estimate the amount of SNAP transferred to each household income group in each area multiplying the percentage of SNAP benefits received by each household income group by the total amount of money transferred to the Core and the Periphery.

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[33] The 2005-2007 American Community Survey 3-Year Estimates, from the U.S. Census Bureau, offers information about the number of household receiving SNAP for all counties in the core and most counties in the Periphery. The counties without information in the Periphery are: Lake, Sherman, Skamania, and Wahkiakum.

[34] "Sampling error is the difference between an estimate based on a sample and the corresponding value that would be obtained if the estimate were based on the entire population (as from a census)" (U.S. Department of Commerce, Bureau of the Census, 2010). The standard error of the sum of two sample estimates is the square root of the sum of the two individual standard errors squared plus a covariance term.

Table 4.7: SNAP benefits to each household income group for Portland Oregon Trade Area Core and Periphery

| Household Income Group | Core | | Periphery | |
|---|---|---|---|---|
| | SNAP (%) | SNAP ($) | SNAP (%) | SNAP ($) |
| Less than 10,000 | 31.4% | 60,098,238 | 28.9% | 90,304,423 |
| $10,000 to $14,999 | 14.9% | 28,503,736 | 17.7% | 55,409,271 |
| $15,000 to $24,999 | 20.3% | 38,806,291 | 20.1% | 63,022,759 |
| ***Subtotal Less than $24K*** | ***66.6%*** | ***127,408,265*** | ***66.7%*** | ***208,736,452*** |
| $25,000 to $34,999 | 11.1% | 21,291,947 | 13.0% | 40,605,267 |
| $35,000 to $49,999 | 11.2% | 21,463,656 | 10.1% | 31,722,865 |
| ***Subtotal $25K to 49K*** | ***22.4%*** | ***42,755,604*** | ***23.1%*** | ***72,328,132*** |
| $50,000 to $74,999 | 7.1% | 13,653,307 | 6.1% | 18,998,972 |
| $75,000 to $99,999 | 2.0% | 3,837,376 | 2.6% | 8,151,232 |
| ***Subtotal $50K to $99K*** | ***9.1%*** | ***17,490,682*** | ***8.7%*** | ***27,150,204*** |
| $100,000 to $149,999 | 1.2% | 2,380,920 | 1.3% | 3,971,187 |
| $150,000 or more | 0.6% | 1,188,005 | 0.2% | 760,714 |
| ***Subtotal $100K or more*** | ***1.9%*** | ***3,568,925*** | ***1.5%*** | ***4,731,901*** |
| **Total** | **100.0%** | **191,223,476** | **100.0%** | **312,946,690** |

Source: 2005-2007 3-Year Public Use Microdata Sample files and Consolidated Federal Funds Report

Table 4.7 presents the estimated distribution of SNAP benefits among income household groups. Fully two-thirds (67%) of SNAP benefits are received by households in Core and Periphery with income below $25,000 per year, and approximately the 90% of benefits are received by households with income under $50,000 per year. These percentages are not totally according to expectation since the average household and family size in Oregon are 3 and 2.5 people, respectively (U.S. Department of Commerce, Bureau of the Census, 2001). The official income level of poverty in 2006 for a family of 3 people was $16,600. Thus, we would expect that the entire group of beneficiary households would be below $50,000 per year. Some plausible explanation for finding beneficiary households of SNAP in higher income groups could be ascertained understanding the definition of household in the Census and how this differs from the definition of a household for SNAP eligibility. According to the U.S. Census Bureau (2001)[35]:

"A household includes all the persons who occupy a housing unit. A housing unit is a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied […] as separate living quarters. Separate living quarters are those in which the occupants live and eat separately from any other persons in the building and which have direct access from the outside of the building or through a common hall. The occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated persons who share living arrangements."

On the other hand, the Food and Nutrition Service of the U.S. Department of Agriculture defines households as "individuals who share a residential unit and purchase and prepare food together" (Leftin, Gothro, & Eslami, 2010).

Therefore, it is possible that a wealthy family and a poor family beneficiary of SNAP comprise a single household according to the Census definition of household used in our analysis but not a single household under the SNAP criteria. We can find this situation, for example, when a college student or a retired person rents a room in the house of a wealthy family and the rented room cannot be considered as a separate living

[35] http://quickfacts.census.gov/qfd/meta/long_HSD310200.htm

quarter and they eat separately. Another example is when college students and young professionals share a house and living arrangements but do not share food expenses.[36]

In order to estimate how food assistance to all households impacts the economy, we multiply the amount of benefit received by each household group by its expenditure multiplier. The amount transferred to households in the Core ($191,223,476) boosts Core and Periphery commodity demand by $201,814,073 and $9,247,881, respectively. Similarly, SNAP transfers to households in the Periphery ($312,946,690) expand Core and Periphery consumption of goods and services by $318,288,024 and $51,132,859 respectively. Thus, SNAP transfers drive $580,482,838 of economic activity in the trade area. The transfers to households with income below $25,000 in both Core and Periphery produce approximately the half of this extra economic activity.

Table 4.8 presents the SNAP total impact on incomes for each households income group in the Core and Periphery region. We observe that the total impact of SNAP for higher income households is larger than the amount of benefits received by them (reported in Table 4.7). For example, households in the Core with income over $100,000 receive 2% of SNAP benefits ($3,568,925), but they obtain 9.7% of the total Core economic impact of the program ($25,258,520). On the other hand, households in the Periphery with income under $25,000 receive 67% of SNAP assistance ($208,736,452), but they only obtain 52% of the Periphery economic impact ($219,404,993), including the direct transfer. This implies that the income increment above the original injection is

[36] Since we do not know the characteristic of those poor families sharing housing with wealthy families in higher income groups, we cannot move them to their real income group.

larger for higher income households, i.e. high-income household groups obtain a larger share of the indirect and induced income effect of SNAP in the economy.

Table 4.8: Own-region and cross-region SNAP total impact on income distribution for Portland Oregon Trade Area Core and Periphery, 2006

| Household Income Group | Unit | Core | | | Periphery | | |
|---|---|---|---|---|---|---|---|
| | | Core | Periphery | Total | Periphery | Core | Total |
| Less than $24,999 | $000 | 131,360 | 586 | 131,946 | 219,405 | 1,013 | 220,418 |
| | % | 50.3% | 9.5% | 49.3% | 52.1% | 5.6% | 50.2% |
| $25,000 to $49,999 | $000 | 56,327 | 1,585 | 57,912 | 101,315 | 3,476 | 104,791 |
| | % | 21.6% | 25.7% | 21.7% | 24.1% | 19.4% | 23.9% |
| $50,000 to $99,999 | $000 | 48,351 | 2,700 | 51,051 | 71,428 | 7,895 | 79,324 |
| | % | 18.5% | 43.7% | 19.1% | 17.0% | 44.0% | 18.1% |
| $100,000 or more | $000 | 25,259 | 1,309 | 26,568 | 28,963 | 5,545 | 34,508 |
| | % | 9.7% | 21.2% | 9.9% | 6.9% | 30.9% | 7.9% |
| Total | $000 | 261,296 | 6,180 | 267,476 | 421,111 | 17,929 | 439,040 |

It is easier to see the distribution of indirect and induced income economic impact[37] of SNAP in Table 4.9. The last row of this table shows the total income increment above the original SNAP transfer amount in each region. The rows above the total row indicate how this amount is distributed among household groups.

[37] In its most recent version, IMPLAN defines that all spending of labor income effects are induced effects so that what previously were considered direct (what was applied to the multiplies) indirect and induced effects if income transfers are now combined and reported as induced. In this essay, we consider, however, that household consumption expenditures are elements of final demand and can thus have a direct and indirect as well as an induced effect.

Table 4.9: Own-region and cross-region indirect and induced income impact of SNAP for Portland Oregon Trade Area Core and Periphery, 2006

| Household | Core | | | Periphery | | |
|---|---|---|---|---|---|---|
| | Core | Periphery | Total | Periphery | Core | Total |
| < $25 | 5.6% | 9.5% | 6.0% | 9.4% | 5.6% | 8.9% |
| $25 - $49 | 19.4% | 25.7% | 19.9% | 25.5% | 19.4% | 24.7% |
| $50 - $99 | 44.0% | 43.7% | 44.0% | 43.7% | 44.0% | 43.8% |
| >=$100 | 31.0% | 21.2% | 30.2% | 21.3% | 30.9% | 22.7% |
| Total ($000) | 70,072 | 6,180 | 76,252 | 113,510 | 17,929 | 131,439 |

We observe that high-income households obtain larger income benefits from the extra economic activity generated by SNAP than low-income households. The high-medium-income household group ($50,000 to $99,999) in both the Core and Periphery regions gains 44% of the own-region and cross-region extra income. The Highest household group ($100,000 or more) in the Core obtains a larger percentage of the extra income (31%) than the same group in the Periphery (21%). The low-medium-income households ($25,000 to $49,999) and the low-income households (less than $24,999) take approximately 26% and 9.5%, respectively, of own-region and cross-region extra income.

Table 4.10: Percentage of households by household income group for Portland Oregon Trade Area Core and Periphery

| Household | Core | Periphery |
|---|---|---|
| Less than $24,999 | 21.0% | 27.5% |
| $25,000 to $49,999 | 24.8% | 29.0% |
| $50,000 to $99,999 | 33.5% | 31.4% |
| $100,000 or more | 20.8% | 12.0% |
| Total | 762,640 | 805,482 |

Source: 2005-2007 American Community Survey (ACS) 3-Year Estimates

If we compare the gains in Table 4.9 with the relative shares of each household income group in the population (Table 4.10), we observe that extra income from SNAP gained by households increases along with their income, and it goes disproportionately to the higher income groups. This becomes clearer if we calculate total amount of extra income over the original SNAP injection gained per household in each household group (Table 4.11).

Table 4.11: Amount of dollars received per household from indirect and induced impact of SNAP for Portland Oregon Trade Area Core and Periphery, 2006

| Household | Core-Core | Periphery-Core | Total Core | Periphery-Periphery | Core-Periphery | Total Periphery |
|---|---|---|---|---|---|---|
| < $25 | 25 | 6 | 31 | 48 | 3 | 51 |
| $25 - $49 | 72 | 18 | 90 | 124 | 7 | 131 |
| $50 - $99 | 121 | 31 | 152 | 196 | 11 | 207 |
| >=$100 | 137 | 35 | 172 | 250 | 14 | 264 |

Table 4.11 presents the average amount of dollars received by households in each income group over the original injection of total SNAP payments into both Core and Periphery regions in 2006. Names in column-heads indicate the origin and destination of dollars. For example the column called "Periphery-Core" reports the average amount of dollars received by households in the Core from the indirect and induced economic effects of SNAP benefits distributed in the Periphery. As we mentioned, the richest households received larger economic benefits from the extra economic activity generated by SNAP. Households in the highest-income group in the Core and Periphery receive in average $172 and $264, respectively, while the poorest households obtain $31 in the Core and $51 in the Periphery.

**4.6 Conclusion**

In 2006, householders in the Portland Oregon trade area received $504,170,166 in benefits from the Supplemental Nutrition Assistance Program. Of this amount, $191,233,476 went to households in the Portland-metro Core and $312,946,690 went to households in the Periphery of the Portland Trade Area.

This study examined, among other things, the extent to which the urban Core and high-income classes benefit from food assistance to poor households in the hinterland. We find that food assistance programs spillover between regions and high-income households are not separated from its benefits. The Portland Core benefits more from a given level of income transfer to poor households in the Periphery than the Periphery benefits from the same level of income transfer to poor households in the Core. In addition, high-income households benefit more than low-income households from the indirect and induced economic impact of SNAP.

The amount of income gained by households over the original $504,170,166 injection of SNAP (that is the indirect and induced impact) increases by household group. The wealthiest households receive an average extra benefit of $172 and $264 per household in the Core and Periphery, respectively; while the poorest households obtained an extra income of $31 and $51 in the Core and Periphery, respectively.

Our results suggest social safety net programs benefit much more than their direct target population. It is the case that food safety net programs significantly affect not only the income and output of the beneficiary region, but also the economy of its trade area. In states like Oregon where state policy encourages SNAP participation and the coverage of the food safety net is very high, we may expect stronger economic benefits for all income groups. These programs increase the incomes of all families, not only of those that are food insecure.

Our conclusion should be taken considering the limitations and assumptions of this study. The method we used to calculate the impact of SNAP assumes that prices are not affected by SNAP transfer payments (no supply constraint), households consume goods always in the same proportion, industries face fixed commodity input structures (production functions do not change) and constant return to scale. These assumptions are reasonable if the economy is below capacity, for example in recession, and if the transfer of SNAP is small for the size of the economy and industrial inputs are tradable. In the case of our model, the Oregon economy was slightly below full capacity in 2006 with an unemployment rate of 5.4%. SNAP transfer payments in 2006 represented 0.11% and 0.23% of total purchases in the Core and Periphery, respectively.

We consider SNAP as a lump sum subsidy despite the fact that it does not change the maximum amount that households can spend on other goods because they cannot legally sell the benefits of SNAP. Our assumption is valid if the SNAP transfer payment is smaller than the maximum amount that households are willing to expend on food consumed at home. In this case, households can consume more food at home per month (in the amount of SNAP transfer), regardless of how much they are spending on other goods. This implies that SNAP causes a parallel shift outward of the budget line (i.e. the slope does not change) and the preferred bundle of goods is on the sloping part of the budget line.

According to the U.S. Bureau of Labor Statistics (2008), households with income below $20,000 expend between $1,800 and $2,476 in food at home. In addition, households with one parent and at least one child expend approximately $3,050 in food at home. This amount rises to $4,010 when there are at least 3 persons in the household (U.S. Bureau of Labor Statistics, 2008). In 2006, the average transfer of SNAP in Oregon was $173 per month ($2,076 per year) (U.S. Department of Agriculture, Food and Nutricion Service, 2010); and the average receipt household was headed by a female between 24 and 44 years old with children (Porter, 2010). Thus, it is very likely that SNAP acts as a lump sum subsidy to poor households. That is, it allows them to spend more on food at home without substantially changing the overall consumption pattern.

Our analysis here is not of sufficient complexity to allow a comprehensive evaluation of the cost and benefits of SNAP. Nevertheless, it does provide policy planners with objective measures on the potential direct and spillover spending and income impacts that SNAP might have in local economies and on the incomes of households at all income levels. The popular perception that public food assistance programs only benefit its recipients should be resisted. This analysis shows that high-income households and urban areas are not insulated from the benefits of food assistance programs for the rural poor.

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## 4.8 Appendix A: Procedure for Estimating Labor and Earnings

### 4.8.1 Labor Flows Estimation

We calculated labor flows using the information published by the US Census Bureau in the “United Stated Census 2000, County-To-County Worker Flow Files”. Specifically, we used the tables “Residence County to Workplace County Flows Sorted by Residence State and County” and “Residence County to Workplace County Flows Sorted by Workplace State and County” for Oregon and Washington.

Using data from the table “Residence County to Workplace County Flows Sorted by Residence State and County”, we added the number of commuters from each place of residence by place of work to obtain the labor flows inside the core and the periphery; between the core and the periphery; between the core and elsewhere; and between the periphery and elsewhere. For example, to estimate the number of workers that live and work in the core, we added for each county in the core the number of people living there that commute to any county in the core including itself. In the same way, to estimate the number of workers that live in the core and work in the periphery, we added for each county in the core the number of people living there that commute to work in any county in the periphery. Correspondingly, the flow of labor from the core to elsewhere was calculated adding the number of workers that live in each county in the core and commute to anywhere outside the core and the periphery. To estimate the number of workers that live in the periphery and commute to the core, the periphery and elsewhere we used the same procedure as that used to estimate the flows from the core.

To estimate the number of workers that live elsewhere and commute to the core or the periphery, we used data from the table "Residence County to Workplace County Flows Sorted by Workplace State and County". We added the number of commuters from outside the study area to each workplace county in the core or the periphery. For example, to estimate the number of workers that live elsewhere and work in the core, we sum up for each workplace county in the core the number of workers that reside outside the core and the periphery. In the same way, to calculate the labor flow from elsewhere to the periphery, we add for each workplace county in the periphery the number of workers that live outside the periphery and the core. The results of these calculations are shown in Table 4.12

Table 4.12: Labor flows between the urban Core and its trade region

| Place of Residence | Place of Work | | | |
|---|---|---|---|---|
| | Core | Periphery | Elsewhere | Total Labor by P.o.R. |
| Core | 866,761 | 18,575 | 7,839 | 893,175 |
| Periphery | 44,932 | 793,472 | 9,166 | 847,570 |
| Elsewhere | 6,151 | 5,949 | | |
| Total Labor by P.o.W. | 917,844 | 817,996 | | |

Source: US Census Bureau, Journey To Work and Place of Work (2001)

4.8.2Earnings Flows Estimation

We constructed earnings flows using data from the Bureau of Economic Analysis, Regional Economics Accounts, in "CA04 — Personal income and employment summary" for the year 2006.

From the table “CA04 —Personal income and employment summary” we obtained the earnings by place of work, the contributions for government social insurance, the adjustment for residence, and the net earnings by place of residence. Then, for each county in the study area, we calculated the net earnings by place of work subtracting the contributions for government social insurance to the earnings by place of work. Next, we found the total net earnings by place of work and the total net earnings by place of residence for the core and the periphery adding the values obtained for each county in each region. Thus, the total net earnings by place of work are $52,937,512 in the core and $35,575,563 in the periphery, and the total net earnings by place of residence are $51,750,992 in the core and $37,295,827 in the periphery.

We constructed earnings flows distributing proportionally the total earnings by place of work to the labor flows by place of work estimated on Table 4.12. For example, the total net earnings by place of work in the core is $52,937,512 and there are 866,761 workers that live and work in the core which correspond to 94% i.e. 866,761 / 917,844. Thus, the earnings for workers that live and work in the core is $49,991,252, i.e. $52,937,512 x 94%. Following the same procedure, we estimated the earnings of workers that work in the core and live in the periphery ($52,937,512 x 5%), work in the core and live elsewhere ($52,937,512 x 1%), work in the periphery and live in the core ($35,575,563 x 2%), work and live in the periphery ($35,575,563 x 97%), work in the periphery and work elsewhere ($35,575,563 x 1%).

In order to estimate the earnings flows of workers that work elsewhere and live in the core and the periphery we used the total earnings and total labor by place of residence. There are 7,839 and 9,166 workers from the core and the periphery that work elsewhere, respectively. Thus, the earnings for workers that work elsewhere and live in the core is $454,195 i.e. $51,750,992 x 0.88%; and that work elsewhere and in live in the periphery is $403,334 i.e. $37,295,827 x 1.08%

However, if we sum by place of residence and by place of work the flows obtained using this procedure, the result does not match the total net earnings by place of residence and by place of work that we originally obtained summing up the information of each county. Therefore, we used the RAS technique approach[38] to modify slightly each estimated flow to ensure that the sum of earnings flows by place of work and by place of residence match their respective totals obtained from the data set. Table 4.13 presents our results.

Table 4.13: Earnings flows between the urban Core and its trade Region

| Place of Residence | Place of Work | | | |
|---|---|---|---|---|
| | Core | Periphery | Elsewhere | Total Earnings by P.o.R. |
| Core | 50,287,477 | 888,001 | 575,514 | 51,750,992 |
| Periphery | 2,368,396 | 34,463,113 | 464,318 | 37,295,827 |
| Elsewhere | 281,640 | 224,448 | | |
| Total Earnings by P.o.W | 52,937,512 | 35,575,563 | | |

Source: Bureau of Economic Analysis, Regional Economic Accounts (2006)

[38] This technique is well described in Miller & Blair (1985) page 276.

## 4.9 Appendix B: Household Expenditure Impact Coefficients

Table 4.14. Expenditure impact coefficients in Metro Core to Metro Core sectors

| Sector | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Crops | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| Livestock | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Forest Product & Logging | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Commercial Fishing | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Landscaping & Ag. Services | 0.006 | 0.006 | 0.005 | 0.004 | 0.005 | 0.004 | 0.005 | 0.004 | 0.004 |
| Mining | 0.009 | 0.009 | 0.009 | 0.007 | 0.007 | 0.006 | 0.005 | 0.005 | 0.005 |
| Construction | 0.008 | 0.008 | 0.007 | 0.006 | 0.006 | 0.005 | 0.006 | 0.006 | 0.005 |
| Food Processing | 0.022 | 0.023 | 0.021 | 0.018 | 0.019 | 0.015 | 0.013 | 0.013 | 0.012 |
| Other Manufacturing | 0.040 | 0.039 | 0.037 | 0.031 | 0.034 | 0.029 | 0.030 | 0.029 | 0.027 |
| Wood Products | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Pulp & Paper Products | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Electronics & Instruments | 0.021 | 0.018 | 0.017 | 0.016 | 0.019 | 0.016 | 0.016 | 0.016 | 0.015 |
| Transportation | 0.036 | 0.034 | 0.032 | 0.027 | 0.029 | 0.026 | 0.028 | 0.027 | 0.026 |
| Communications | 0.029 | 0.028 | 0.026 | 0.023 | 0.025 | 0.022 | 0.023 | 0.022 | 0.021 |
| Utilities | 0.049 | 0.049 | 0.045 | 0.035 | 0.035 | 0.029 | 0.027 | 0.026 | 0.025 |
| Wholesale Trade | 0.073 | 0.072 | 0.067 | 0.057 | 0.064 | 0.054 | 0.052 | 0.050 | 0.048 |
| Retail Trade | 0.144 | 0.133 | 0.124 | 0.107 | 0.126 | 0.107 | 0.104 | 0.101 | 0.096 |
| Financial | 0.046 | 0.050 | 0.047 | 0.043 | 0.051 | 0.042 | 0.040 | 0.039 | 0.037 |
| Insurance & Real Estate | 0.116 | 0.110 | 0.103 | 0.086 | 0.091 | 0.071 | 0.071 | 0.068 | 0.065 |
| Eating, Drinking & Lodging | 0.050 | 0.053 | 0.049 | 0.045 | 0.055 | 0.049 | 0.051 | 0.049 | 0.047 |
| Other Services | 0.137 | 0.149 | 0.139 | 0.118 | 0.121 | 0.112 | 0.136 | 0.132 | 0.125 |
| Business Services | 0.041 | 0.040 | 0.038 | 0.032 | 0.035 | 0.030 | 0.032 | 0.031 | 0.029 |
| Health Services | 0.213 | 0.193 | 0.180 | 0.139 | 0.144 | 0.122 | 0.135 | 0.131 | 0.124 |
| Govt. Industry & Enterprise | 0.008 | 0.008 | 0.007 | 0.006 | 0.007 | 0.006 | 0.007 | 0.006 | 0.006 |
| Household Industry & Other | 0.110 | 0.107 | 0.100 | 0.082 | 0.112 | 0.109 | 0.123 | 0.119 | 0.112 |

Table 4.15. Expenditure impact coefficients in Metro Core to Periphery sectors

| Sector | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Crops | 0.001 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Livestock | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Forest Product & Logging | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Commercial Fishing | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Landscaping & Ag. Services | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mining | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Construction | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Food Processing | 0.006 | 0.007 | 0.006 | 0.005 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 |
| Other Manufacturing | 0.004 | 0.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 |
| Wood Products | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pulp & Paper Products | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Electronics & Instruments | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Transportation | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Communications | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 |
| Utilities | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Wholesale Trade | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Retail Trade | 0.008 | 0.007 | 0.007 | 0.006 | 0.007 | 0.006 | 0.006 | 0.005 | 0.005 |
| Financial | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Insurance & Real Estate | 0.006 | 0.006 | 0.006 | 0.005 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 |
| Eating, Drinking & Lodging | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| Other Services | 0.006 | 0.006 | 0.005 | 0.005 | 0.005 | 0.004 | 0.005 | 0.005 | 0.004 |
| Business Services | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 |
| Health Services | 0.004 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| Govt. Industry & Enterprise | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Household Industry & Other | 0.003 | 0.003 | 0.003 | 0.002 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 |

Table 4.16. Expenditure impact coefficients in Periphery to Periphery sectors

| Sector | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Crops | 0.005 | 0.005 | 0.005 | 0.004 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 |
| Livestock | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 |
| Forest Product & Logging | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Commercial Fishing | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Landscaping & Ag. Services | 0.007 | 0.007 | 0.006 | 0.005 | 0.006 | 0.005 | 0.006 | 0.006 | 0.006 |
| Mining | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Construction | 0.008 | 0.008 | 0.007 | 0.006 | 0.007 | 0.006 | 0.006 | 0.006 | 0.006 |
| Food Processing | 0.035 | 0.036 | 0.033 | 0.028 | 0.030 | 0.025 | 0.022 | 0.022 | 0.022 |
| Other Manufacturing | 0.036 | 0.036 | 0.033 | 0.029 | 0.033 | 0.029 | 0.029 | 0.029 | 0.028 |
| Wood Products | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Pulp & Paper Products | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Electronics & Instruments | 0.010 | 0.009 | 0.008 | 0.008 | 0.010 | 0.008 | 0.008 | 0.008 | 0.008 |
| Transportation | 0.035 | 0.033 | 0.031 | 0.027 | 0.030 | 0.027 | 0.029 | 0.029 | 0.028 |
| Communications | 0.024 | 0.024 | 0.023 | 0.020 | 0.023 | 0.020 | 0.021 | 0.021 | 0.020 |
| Utilities | 0.042 | 0.042 | 0.039 | 0.031 | 0.031 | 0.027 | 0.025 | 0.025 | 0.024 |
| Wholesale Trade | 0.040 | 0.040 | 0.037 | 0.033 | 0.037 | 0.032 | 0.030 | 0.030 | 0.030 |
| Retail Trade | 0.145 | 0.135 | 0.126 | 0.112 | 0.135 | 0.117 | 0.112 | 0.111 | 0.110 |
| Financial | 0.040 | 0.043 | 0.041 | 0.039 | 0.047 | 0.040 | 0.037 | 0.037 | 0.036 |
| Insurance & Real Estate | 0.104 | 0.099 | 0.093 | 0.080 | 0.086 | 0.070 | 0.068 | 0.068 | 0.067 |
| Eating, Drinking & Lodging | 0.055 | 0.058 | 0.055 | 0.051 | 0.065 | 0.059 | 0.060 | 0.059 | 0.058 |
| Other Services | 0.125 | 0.136 | 0.127 | 0.112 | 0.117 | 0.112 | 0.132 | 0.131 | 0.128 |
| Business Services | 0.037 | 0.036 | 0.034 | 0.030 | 0.033 | 0.029 | 0.030 | 0.030 | 0.029 |
| Health Services | 0.225 | 0.203 | 0.190 | 0.152 | 0.161 | 0.142 | 0.151 | 0.151 | 0.148 |
| Govt. Industry & Enterprise | 0.008 | 0.008 | 0.007 | 0.006 | 0.007 | 0.007 | 0.007 | 0.007 | 0.007 |
| Household Industry & Other | 0.114 | 0.111 | 0.104 | 0.088 | 0.122 | 0.122 | 0.134 | 0.133 | 0.129 |

Table 4.17. Expenditure impact coefficients in Periphery to Metro Core sectors

| Sector | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Crops | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Livestock | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Forest Product & Logging | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Commercial Fishing | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Landscaping & Ag. Services | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Mining | 0.005 | 0.005 | 0.005 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 |
| Construction | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Food Processing | 0.005 | 0.005 | 0.005 | 0.004 | 0.005 | 0.004 | 0.003 | 0.003 | 0.003 |
| Other Manufacturing | 0.007 | 0.006 | 0.006 | 0.005 | 0.006 | 0.005 | 0.005 | 0.005 | 0.005 |
| Wood Products | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Pulp & Paper Products | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Electronics & Instruments | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| Transportation | 0.006 | 0.006 | 0.006 | 0.005 | 0.006 | 0.005 | 0.005 | 0.005 | 0.005 |
| Communications | 0.004 | 0.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 |
| Utilities | 0.013 | 0.012 | 0.012 | 0.009 | 0.010 | 0.009 | 0.008 | 0.008 | 0.008 |
| Wholesale Trade | 0.039 | 0.038 | 0.036 | 0.031 | 0.036 | 0.031 | 0.029 | 0.029 | 0.029 |
| Retail Trade | 0.011 | 0.010 | 0.010 | 0.008 | 0.010 | 0.009 | 0.008 | 0.008 | 0.008 |
| Financial | 0.006 | 0.006 | 0.005 | 0.005 | 0.006 | 0.005 | 0.005 | 0.005 | 0.005 |
| Insurance & Real Estate | 0.020 | 0.019 | 0.018 | 0.016 | 0.017 | 0.014 | 0.014 | 0.014 | 0.014 |
| Eating, Drinking & Lodging | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 |
| Other Services | 0.025 | 0.026 | 0.025 | 0.022 | 0.023 | 0.021 | 0.024 | 0.023 | 0.023 |
| Business Services | 0.012 | 0.011 | 0.011 | 0.009 | 0.010 | 0.009 | 0.009 | 0.009 | 0.009 |
| Health Services | 0.009 | 0.009 | 0.008 | 0.007 | 0.008 | 0.007 | 0.007 | 0.007 | 0.007 |
| Govt. Industry & Enterprise | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Household Industry & Other | 0.006 | 0.006 | 0.005 | 0.004 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 |

### 4.10 Appendix C. Household Income Distribution Impact Coefficients

Table 4.18. Income distribution impact coefficients: Metro Core to Metro Core

| Household Group | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Less than 10,000 | 1.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| $10,000 to $14,999 | 0.005 | 1.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.003 | 0.004 | 0.004 |
| $15,000 to $24,999 | 0.016 | 0.015 | 1.014 | 0.012 | 0.013 | 0.012 | 0.012 | 0.013 | 0.014 |
| $25,000 to $34,999 | 0.027 | 0.026 | 0.024 | 1.020 | 0.022 | 0.019 | 0.021 | 0.021 | 0.023 |
| $35,000 to $49,999 | 0.053 | 0.050 | 0.046 | 0.039 | 1.043 | 0.037 | 0.040 | 0.041 | 0.044 |
| $50,000 to $74,999 | 0.108 | 0.102 | 0.095 | 0.079 | 0.088 | 1.077 | 0.083 | 0.083 | 0.090 |
| $75,000 to $99,999 | 0.074 | 0.070 | 0.065 | 0.054 | 0.060 | 0.052 | 1.057 | 0.057 | 0.062 |
| $100,000 to $149,999 | 0.074 | 0.071 | 0.065 | 0.055 | 0.061 | 0.053 | 0.057 | 1.058 | 0.063 |
| $150,000 or more | 0.053 | 0.051 | 0.047 | 0.039 | 0.043 | 0.038 | 0.041 | 0.041 | 1.045 |

Table 4.19. Income distribution impact coefficients: Metro Core to Periphery

| Household Group | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Less than 10,000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $10,000 to $14,999 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| $15,000 to $24,999 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| $25,000 to $34,999 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 |
| $35,000 to $49,999 | 0.006 | 0.006 | 0.005 | 0.004 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 |
| $50,000 to $74,999 | 0.010 | 0.010 | 0.009 | 0.008 | 0.009 | 0.007 | 0.008 | 0.007 | 0.007 |
| $75,000 to $99,999 | 0.005 | 0.005 | 0.005 | 0.004 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 |
| $100,000 to $149,999 | 0.004 | 0.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 |
| $150,000 or more | 0.003 | 0.003 | 0.003 | 0.002 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 |

Table 4.20. Income distribution impact coefficients: Periphery to Periphery

| Household Group | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Less than 10,000 | 1.004 | 0.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.004 | 0.004 | 0.005 |
| $10,000 to $14,999 | 0.008 | 1.008 | 0.007 | 0.006 | 0.007 | 0.007 | 0.007 | 0.007 | 0.009 |
| $15,000 to $24,999 | 0.026 | 0.024 | 1.023 | 0.020 | 0.022 | 0.020 | 0.022 | 0.023 | 0.027 |
| $25,000 to $34,999 | 0.038 | 0.036 | 0.033 | 1.029 | 0.033 | 0.030 | 0.032 | 0.034 | 0.040 |
| $35,000 to $49,999 | 0.066 | 0.063 | 0.059 | 0.051 | 1.058 | 0.052 | 0.056 | 0.060 | 0.071 |
| $50,000 to $74,999 | 0.115 | 0.109 | 0.102 | 0.088 | 0.101 | 1.091 | 0.098 | 0.105 | 0.124 |
| $75,000 to $99,999 | 0.062 | 0.059 | 0.055 | 0.048 | 0.054 | 0.049 | 1.053 | 0.057 | 0.067 |
| $100,000 to $149,999 | 0.050 | 0.048 | 0.045 | 0.039 | 0.044 | 0.040 | 0.043 | 1.046 | 0.055 |
| $150,000 or more | 0.036 | 0.034 | 0.032 | 0.028 | 0.032 | 0.029 | 0.031 | 0.033 | 1.039 |

Table 4.21. Income distribution impact coefficients: Periphery to Metro Core

| Household Group | Household Group ($000) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | <10 | 10-14 | 15-24 | 25-34 | 35-49 | 50-74 | 75-99 | 100-149 | >150 |
| Less than 10,000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $10,000 to $14,999 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| $15,000 to $24,999 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| $25,000 to $34,999 | 0.004 | 0.004 | 0.004 | 0.003 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 |
| $35,000 to $49,999 | 0.008 | 0.008 | 0.007 | 0.006 | 0.007 | 0.006 | 0.006 | 0.006 | 0.006 |
| $50,000 to $74,999 | 0.016 | 0.016 | 0.015 | 0.013 | 0.015 | 0.013 | 0.013 | 0.013 | 0.013 |
| $75,000 to $99,999 | 0.011 | 0.011 | 0.010 | 0.009 | 0.010 | 0.009 | 0.009 | 0.009 | 0.009 |
| $100,000 to $149,999 | 0.011 | 0.011 | 0.010 | 0.009 | 0.010 | 0.009 | 0.009 | 0.009 | 0.009 |
| $150,000 or more | 0.008 | 0.008 | 0.008 | 0.007 | 0.007 | 0.006 | 0.006 | 0.006 | 0.006 |

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