

Barrios, Erniel B.

Working Paper

Spatial effect in the efficient access of rural development

ADB I Discussion Paper, No. 65

Provided in Cooperation with:

Asian Development Bank Institute (ADBI), Tokyo

Suggested Citation: Barrios, Erniel B. (2007) : Spatial effect in the efficient access of rural development, ADB I Discussion Paper, No. 65, Asian Development Bank Institute (ADBI), Tokyo

This Version is available at:

<https://hdl.handle.net/10419/53538>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

ADB Institute Discussion Paper No. 65

Spatial Effect in the Efficient Access of Rural Development

Erniel B. Barrios

May 2007

Erniel Barrios was a visiting researcher at the Asian Development Bank Institute from July–December 2006. He is also a professor at the School of Statistics, University of the Philippines.

The views expressed in this paper are the views of the author and do not necessarily reflect the view or policies of ADBI nor Asian Development Bank. Names of countries or economies mentioned are chosen by the author, in the exercise of his academic freedom, and the Institute is in no way responsible for such usage.

ABSTRACT

The search for an effective policy direction to contribute to the alleviation of rural poverty requires understanding of various socio-economic dynamics affecting the household. The central issue in the economic dimension is inefficiency in production, which may contribute to the widening income gap among rural households. Spatial externalities are introduced into a stochastic frontier model in the analysis of rural households' efficiency in utilizing various factors of production including development interventions (infrastructure and capability-building activities) and other localized endowments. Output is measured in terms of income and perceptions on various aspects of rural development summarized into an index.

Provision of rural roads and other rural infrastructure should be bundled properly with support services and capacity building activities. This can enhance the demand for other infrastructure and services resulting in a dynamic evolution of essential elements in the pursuit of rural development. Bundles of intervention improve production efficiency of rural households at the different stages of production in-farm and/or off-farm.

Spatial indicators illustrate the role of geographical dynamics (physical, social and cultural factors) in rural development, justifying a site-specific, participatory approach in development intervention. Although site-specific interventions may be costly at first, they become more efficient in the long-run. Benefits from an intervention in one community are expected to produce ripple effects that reach its spatial neighbors.

Stakeholders' contribution in maintenance is feasible provided that there is a true sense of ownership of the infrastructure/project, usually evolving through a participatory approach. Public investment in infrastructure and user's fees can complement one another; continuous provision of new infrastructure and maintenance of existing infrastructure can add up to a sustainable track towards rural development. A socialized user's fee system can be used as a vehicle to prevent the potential widening of income disparity in rural areas. It is important however to carefully choose a suitable and acceptable basis for the socialized user's fee rates. An incorrect choice can be perceived as a disincentive for access or might stimulate distrust among the affluent segment of the rural society regarding the sincerity of the government in pushing rural development. An unsuitable basis for user's fee rates could thus eventually lead to more social problems instead of bridging inequality.

Keywords: *rural development, rural infrastructure, household efficiency, spatial autoregression, spatial stochastic frontier*

1 INTRODUCTION

Rural populations live in a simple environment, yet the structure and the dynamics of their day-to-day life are complex. Patterns of social processes vary across countries, and even across regions within a country; these patterns are highly sensitive to cultural differences. The study of rural societies has garnered interest in development economics as well as in many other disciplines. The panoramic view of developing economies is overshadowed by rural societies. Vulnerability, inequity, and deprivation are common issues confronting rural societies, prompting development assistance/interventions slanting in their direction.

Income vulnerability, one major issue confronting rural societies, exhibits strong interdependence with other thematic issues. In their own initiative to avoid exposure to income vulnerability, rural households tend to find ways to augment their livelihoods, which are mainly based on agriculture in a limited parcel of land. Their natural strategy for income augmentation often results to excessive, unsustainable use/harvesting of natural resources. Some examples are clearing of forest for additional agricultural land, logging, over-fishing (even using illegal tools/gear) in inland and coastal water, and intensive crop production resulting in massive environmental degradation. Some rural residents have opted to join the rural-urban labor migration that has been rampant in the rural Philippines for the last three decades. Initially, this process was motivated by conflict and social unrest. Later, and up to the present, poverty and the evolving economic landscape have also contributed to this migration.

The prominence of agriculture among rural communities naturally brings about linkages between rural and agricultural development. The role of agricultural development in fostering rural development cannot be ignored. The engine of agricultural development relies on facilitating production and efficient utilization of resources among the farming households. The study of agricultural development focuses on understanding how factors of production (technology, social and economic support services) are efficiently allocated to optimize output/outcome.

Facilitating non-farm livelihood is one commonly used strategy to complement agricultural development towards rural development. The outcome of this strategy is rural income diversification. Empirical evidence provides crucial inputs; see Barrett, et al. (2002), for instance, on the extraction of policy implications that can enable the diversification of rural income.

How is agricultural development stimulated? This question is best answered when each factor of production is analyzed in the context of production optimization/efficiency. The role of land ownership in agricultural production has long been used as a justification of agrarian reform programs in various countries. Farmers, the argument goes, will be free to choose a resource allocation scheme that will optimize production if they are not entangled in the bondage of the land, when there is no landlord who decides primarily despite lacking direct knowledge of the farming system. Landlords may decide how resources should be allocated only on the basis of their instincts to protect their interests, so their decisions may not necessarily yield optimum production. There is thus inefficiency in production when the farmer does not own the land. The farmer's lower stake means lower effort that will not necessarily involve highly-profitable crops may be provided (Bandiera, 2002). However, a farmer who owns the land may opt to plant high-value crops and exert proportional efforts to enhance productivity. Similar observations

were made by Larson and Plessmann (2002) that farming households that differ in their ability or willingness to take on risks are likely to make different decisions when allocating resources and effort among income-producing activities; these decisions have consequences for productivity. Diversification and technology choices do affect efficiency outcomes among farmers, although these effects are not dominant. In a similar context, but on a higher level of empowerment (organized community), Ranis et al. (2001) highlight the linkages between group behavior and economic performance.

Other points of view concerning land ownership differ with the above. Using a modern theory of agrarian organization, Conning and Robinson (2002) offered a reason why tenure improvement, despite its economic advantages, has been so little used in countries where agrarian reform is a salient political issue, explaining the relative failure of land reform in Latin America.

It is also possible that development policies are leading towards the opposite of what has been expected. Boothroyd and Nam (Eds., 2000) observed that in Vietnam, the appropriate balance in agricultural/industrial and rural/urban development occurred, but that industry has been deprived of the necessary endogenous factors for development. Streams of people have surged into towns and cities, crowding into slums, leaving behind a destitute, miserable countryside. Analyses by policymakers and leading scientific researchers have led to a conclusion that because of the small scale of agricultural cooperatives, conditions were not conducive to a re-division of labor in the direction of centralization and specialization that would promote enhanced production.

Development intervention can be broadly classified into four (possibly overlapping) categories: economic infrastructure (e.g., credit, production support); physical infrastructure (e.g., roads, irrigation); capacity building (e.g., training, information dissemination); and support services (e.g., marketing services, facilitation of access to basic social services). Physical and economic infrastructure has been emphasized from the start but it seems that the policies and other implementing guidelines may have not evolved completely to support development. Progress among developing countries, particularly the rural areas, has been slow. The role of infrastructure in development is emphasized in the literature. In most poverty reduction strategy programs (PRSP), financing demands usually focus on infrastructure like roads, potable water systems, and irrigation systems. Some studies that link infrastructure and development are discussed below.

Rural areas are characterized by isolation, lack or inadequate provision of basic amenities, inadequate health and social services, etc. Isolation needs to be resolved before it will be feasible for other issues to be resolved. Farm roads facilitate access to the major supply source and market destinations. Roads are expected to facilitate the reduction of costs for transporting farm inputs and bringing the produce to the supply chains. Although Glaeser and Kohlhase (2003) focused on peri-urban centers, they reported some 90% reduction in the cost of transporting goods through an efficient road system.

Although the economic importance of infrastructure is supported in the literature, there are also some negative externalities to the society. Dams, for example, are perceived to contribute towards sustainability of irrigation. They are also costly and controversial but Dulfo and Pande (2005) emphasized that there is less known about their impact. In an area where dams were constructed in India, production did not increase but poverty did. Among areas benefiting from irrigation, production increased, but those residing in the areas that become flooded due to the dam were vulnerable to substantial economic losses. Thus, dams can lead to widening inequality. It was argued

that as a whole, dam construction resulted in aggravating poverty because no safety nets were provided to the disadvantaged segment of the community.

The localization of infrastructure development policies was studied by Demurger et al. (2002) in China with the conclusion that there is geographic inequity of growth. There is a perception that coastal areas in China benefit from preferential policies, but this is actually because of deregulation policies that allow them to link to the international economy. Instead of re-imposing regulations, expanding deregulation to the inner provinces can help quicken growth. Infrastructure development to improve the accessibility of inner provinces is needed along with human capital development towards poverty alleviation.

Countries that use infrastructure inefficiently are effectively paying for growth at a much higher rate than those that use infrastructure more efficiently (Hulten, 1996). Capital stocks (infrastructure) that are not efficiently used would render marginal growth for additional capital formation. This usually happens when infrastructure identification lacks community participation, resulting in supply-demand mismatch. Furthermore, new investments (capital) need not indicate economic growth while efficient use of such translates into real growth. Hence, maintenance and sustainability are more important than putting up more new investments.

The effect of public infrastructure on Philippine agriculture has been established. Teruel and Kurodo (2005) used a trans-log cost function framework augmented with public infrastructure viewed as fixed input. Infrastructure substitutes labor and intermediate inputs. This supports the public capital hypothesis of complementation between public infrastructure and private capital input. The importance of farm roads in altering input demand and enhancing productivity is also established.

We will explore how rural households allocate and utilize factors to optimize production in order to mitigate their vulnerability due to dependence on agriculture, possibly leading them out of poverty. Production output will be measured in terms of income and rural households' perception of the presence of certain attributes of rural development aggregated into an index. Rural infrastructure, other development interventions and local/household endowments will constitute the exogenous determinants of production and efficiency in household production.

2 SOME MODELING STRATEGIES

The usefulness of an econometric model depends on the soundness of the assumptions underlying the mathematical equation. The plausibility of the model to depict reality is crucial in development studies aimed to understand the patterns and the engines that fuel the progress of an economic unit.

Lewis (1984) divided development theory into two categories: that relating to short-run allocation of resources and that relating to long-term growth. In the short-run, the main issues include price that does not equate to real social cost; an unregulated market that constraints productive capacity; and production and exchange not governed by the income maximization objective, but rather by other "non-economic" considerations. Decision making in development economics is not done on the sole basis of economics, but by integrating sociological perspectives as well (social cost, specifically). In long-term growth, two major issues exist: the search for an engine of growth, and the growth pattern. For the rural poor, land reform, infrastructure, production support, capacity building, etc. comprise a typical package serving as the growth engine. Lewis further

proposed that the real question is, given an intervention policy, how much change in development indicators do we expect? If so much land will be distributed for tenure improvement, how much increase in rural income is expected? In other words, it is not enough to say that infrastructure leads to income growth; more relevant information is the amount of contribution expected for a unit of infrastructure added.

To determine the impact of policy reforms in rural economies, the reaction of households to policy shocks was modeled by Taylor et al. (2005). The computable general equilibrium (CGE) model was used, and the resulting model accounts for the interaction among sectors, but is not able to assess household behavior as a consequence of the policy shock. The researchers proposed a new methodology that combines the advantages of both approaches (household and CGE models). Simulation was used to illustrate the role of the rural market constraints and the heterogeneity of the households in shaping household behavior.

2.1 STOCHASTIC FRONTIER MODEL

Traditional econometric modeling aims to explain the output indicator y in terms of determinants, say x . In the event that the predicted value \hat{y} is different from the actual value y , it is often explained in statistics as the amount due to other unaccounted determinants or to random errors that cannot be accounted for by x through the model.

Stochastic frontier analysis (SFA) or the “composed” error model was developed in the late 70’s to provide an alternative paradigm to the usually optimizing producer in the standard econometric literature. The stimulus is the observation that some stakeholders in an economy will not be successful enough in their optimization endeavors. In lieu of the optimization target (which cannot be achieved anyway), the aim may be adjusted to at least know how close they are to the optimum. An appropriate measurement of the distance of their actual production from the maximum potentials can push forward their allocative and productive efficiency. The measures of efficiency can then be linked to certain exogenous factors and anybody who is short of the optimum level will now be in the position to strategize towards attainment of that optimum in the future. The exogenous factors will provide guidance in the development of such strategies. SFA offers an alternative to the standard econometric assumption of equilibrium because it allows a certain degree of inefficiency. The SFA then led to a new error structure that is a composite of true error and those factors (presumably heterogeneous and unknown among producers) that contributed to the inefficiency. Fortunately, there is a growing area in statistical science called mixed models that readily supports the estimation and other statistical aspects of stochastic frontier analysis.

Kumbhakar and Lovell (2000) provided a comprehensive account of the developments in SFA. This account provides our major source for subsequent discussions. The cross-sectional production frontier model is given by

$$y_i = f(x_i; \beta) \exp(v_i) TE_i \quad \text{or} \quad TE_i = \frac{y_i}{f(x_i; \beta) \exp(v_i)},$$

where y_i is the single output of

producer i , x_i is the vector of inputs used in producing y_i , f is a parametric function, TE_i is the output-oriented technical efficiency of producer i , and v_i is a random error. $TE=1$ implies efficiency, while $TE<1$ indicates a shortfall (inefficiency) in an environment characterized by $\exp(v_i)$, possibly varying across producers. Let $TE_i = \exp(-u_i)$, then the production stochastic frontier model becomes $y_i = f(x_i; \beta) \exp(v_i) \exp(-u_i)$, the last two factors accounting for two error components.

For the parametric function f , the literature is dominated by those that assume the Cobb-Douglas family. Recently, however, Henderson and Simar (2005) considered a nonparametric specification of f . The nonparametric specification is desirable in cases where the modeler is not willing to risk any parametric functional form because of insufficient knowledge about the phenomenon being modeled. Even a Bayesian formulation of f was considered by Koop and Steel (2004). Contrary to the nonparametric argument, if some prior knowledge about the efficiency of producers being analyzed is available, the Bayesian strategy is the best way to incorporate such knowledge into the model.

The model is usually estimated via the maximum likelihood (MLE) procedure. The quantities v_i , u_i , and x_i are assumed to be independent and v_i is assumed to be normally distributed while u_i is often positive half normal to ensure that $TE \leq 1$. Other combinations of the distribution of v and u include normal-exponential, normal-truncated normal, and normal-gamma. Green (1990) reported that estimates of efficiency vary depending on the distributional assumption on v and u . The nature and relationship between v and u can be enhanced further into the model using mixed models.

Stochastic frontier models for panel data were also postulated. In the time-invariant technical efficiency assumption, the following models were considered: fixed-effects model, random-effects model, or even mixed model (for multiple output case). Kumbhakar and Lovell (2000) warned that the longer the panel, the less likely it becomes that technology remains constant, amounting to a serious violation of the assumption. The learning curve of producers is expected to improve over time. Therefore, any inefficiency realized in the distant past may have been resolved already and that inefficiency will arise from new sources.

The literature on time series data considered time-invariant or time-varying technical efficiency. The error assumptions also considered fixed and random effects. Heteroskedasticity in u and v was also considered, possibly leading to volatility assumption in technical efficiency.

To complement the production frontier, a cost frontier can also be specified so that instead of measuring how close actual production is to optimum production, the distance between lowest cost and realized cost is also compared. In both cases, efficiency is attained through appropriate allocation of resources (input).

The stochastic cost frontier model is given by $E_i \geq c(y_i, w_i; \beta) \exp(v_i)$, $E_i = \sum_n w_{ni} x_{ni}$ is the total cost incurred by producer i , $w_i = \{w_{1i}, w_{2i}, \dots, w_{Ni}\}$ is the vector of input prices for producer i , y_i is output of producer i , $x_i = \{x_{1i}, x_{2i}, \dots, x_{Ni}\}$ is the vector of inputs incurred by producer i to produce output y_i , β is a vector of technology coefficients, c is the cost function common to all producers, and $\exp(v_i)$ is the producer-specific cost. The cost efficiency (CE) is $CE_i = \frac{c(y_i, w_i; \beta) \exp(v_i)}{E_i}$.

One aim in SFA is to explain inefficiency/efficiency in terms of exogenous determinants. Kumbhakar and Lovell (2000) summarized the commonly used models to account for such.

1. $y_i = f(x_i, z_i; \beta) \exp(v_i) \exp(-u_i)$, the exogenous factor interacts along with the factors of production in the parametric function f .

2. Estimate TE_i first, then regress it on z_i (two-step estimation). The resulting model may be interpreted as the regression of technical efficiency on z , conditioning on the sampling distribution induced by the true error and the causes of inefficiency, $E(u_i/v_i - u_i) = g(z_i; \lambda) + \varepsilon_i$
3. Assuming a Cobb-Douglas production function, $\ln y_i = \ln f(x_i; \beta) + v_i - u_i$, $u_i = \gamma' z_i + \varepsilon_i \Rightarrow \ln y_i = \ln f(x_i; \beta) + v_i - (\gamma' z_i + \varepsilon_i)$ (Kumbhakar et al., 1991). The exogenous determinant is postulated outside the production function. This implies additivity of the effect of factors of production and exogenous factors to actual production.
4. $\ln y_i = \ln f(x_i; \beta) + v_i - u_i$, $u_i = g(z_i; \gamma) + \varepsilon_i$ (Reifschneider and Stevenson, 1991). This model is very much like that in (3).
5. $\ln y_i = \ln f(x_i; \beta) + v_i - [g(z_i; \gamma) + \varepsilon_i]$. The function g is allowed to include interaction of x_i and z_i (Huang and Liu, 1994).

The choice of the best way to analyze the effect of exogenous factors depends on the adequacy of the underlying assumption associated with the model. For example, if it is theoretically sound that the effect of the exogenous factors and the factors of production are additive, then (3) or (4) can be specified. The resulting estimates of production efficiency, however, are expected to vary according to the postulated model. Some simulation studies may help guide the researchers in the choice of an appropriate form of the way the exogenous factors are introduced into the model.

The use of SFA is not necessarily confined among establishments as producing units. Amos et al. (2004) used SFA in studying productivity and technical efficiency of small-scale farmers in Nigeria, providing empirical evidence of the common assumption that farmers engaged in mixed crops generally achieve higher technical efficiency than do those propagating only one crop at a time. Other demographic factors (exogenous to agricultural production) also affect technical efficiency in addition to cropping patterns.

2.2 SPATIAL CHARACTERISTICS OF DEVELOPMENT

Economic geography or spatial economics studies the location and reason for the choice of location or certain economic activities. The role of space in the dynamics of some phenomena has been acknowledged not just in economics but in many other disciplines as well. In economics, the distribution of economic activities in space is important in facilitating optimization of resource allocation, developing competitive cooperation, zoning, and even in the development of competition policies and many other concerns. In cases where such distribution changes, the impact on individuals and communities will be desirable to know because this knowledge will contribute to understanding overall changes to be expected in the growth patterns of the economy in general. This is contrary to the implicit assumption of neo-classical economics where activities are supposed to be evenly distributed across space. Venables (2006) argued that the neo-classical assumption is not realistic because it boils down to "backyard capitalism" where production is intended primarily for local demand. Plausible explanations for location-dependence of economic activities include, among many, availability of raw materials, accessible natural resources, skill of the labor force, general policies resulting in zoning, socio-cultural aggregation, industrial clustering, cooperation, competition, and demand.

Little importance has been accorded to economic geography, but interest has grown dramatically in recent years (Fujita et al., 1999). This development was paralleled by development in statistics that readily offer modeling tools. Spatial models are available in

a longer time period, but in recent years, interest focused more on the space-time interaction of certain phenomena. Spatial economics, especially the issues of economic clustering and integration, will provide an avenue to better understand a more general pattern of economic growth.

Transportation cost has been an important determinant in clustering of economic activities leading to its spatial distribution. The fundamental premise is that geographical distance is a barrier to economic interaction, and time in transit is costly (Venables, 2006). Redding and Venables (2002) used a structural model of economic geography (estimated from cross-country data) and provided empirical evidence that the geography of access to markets and sources of supply explains cross-country variation in per capita income.

The effect of geography on the macroeconomy was analyzed by Gallup et al. (1998). The analysis looked at how location and climate affect (directly and indirectly) income and income growth through transportation cost, disease burdens, and agricultural productivity, among others. They also pointed out that even the choice of policies could also be geography-dependent. For example, if the production area is far from coastal areas, then large transportation cost is expected. As a policy response to this constraint, so that the same goods remain competitive, tariff liberalization can be considered.

A spatio-temporal model for some poverty indicators was postulated and estimated by Barrios and Landagan (2004). The result lends evidence that there is indeed a spatial clustering among the provinces in the Philippines with reference to the poverty indicators used. Provinces within a region exhibit a similar picture of the poverty situation. Thus, a strategy for alleviation may be adopted for a group of provinces rather than tailor-fitting it for individual provinces. The role of targeted intervention is emphasized over universal strategies. The interaction of socio-cultural scenarios would necessarily link and group together adjacent communities, explaining the spatial character of the poverty phenomenon.

3 THEORETICAL FRAMEWORK

The dynamics in a typical rural community are an irony between simplicity in rural life and the complexity of the economic system that is operating. The literature offers diverse theories and perspectives in trying to explain the rural economy. There seems to be a cycle over the years among these theories, postulated, reinvented, reformulated, refuted in some cases, and emerging again in recent literature. Lewis (1984) postulated that in the rural economy, growth is triggered by the initiation of trade. Farmers are producing not just for consumption but also for the demand in other communities. This is a valid assumption once productivity had surpassed the threshold for local needs. Otherwise, if the production level is still below the threshold, marginalization and subsequent exposure to vulnerability will dominate the rural production with growth hardly manifesting if not remaining impossible. Intensive intervention will be needed to push them initially to cross the threshold for growth. Growth will naturally push economic activities towards diversity at the community level and possibly (but not necessarily) specialization at the household level. In a growing rural economy, households cannot be competitive if they refuse to specialize. Given the limited technologies available to them (agriculture and non-agriculture), specialization will help maximize production in the light of economies of scale. As examples, working within a specific industry for microenterprise development (non-agriculture), raising specific crops requiring special farming systems (and technology) for agriculture, or even specialization of services offered in a diversifying economic environment, will continue to raise households'

competitive advantage in that area. Specialization will stimulate efficiency in rural production and possibly curtail certain factors of production (in the hope of attaining efficiency). Among the factors of production, labor is easily substituted through the choice of appropriate technology, resulting in displacement of many rural workers. This phenomenon was observed in the rural Philippines, which has continuously been experiencing rural-urban migration for the past three decades or so. A sizeable proportion of labor migration spills over to other countries. In the desire for market efficiency, specialization can actually lead towards inequality because of the unequal utility values placed on different production activities. As Lewis (1984) points out, market efficiency is not the solution towards equilibrium in an agrarian economy; the concept rather equates social cost with the real gains from trade to serve as an engine of growth. The solution proposed then is empowerment of rural communities. Empowerment can include, but is not limited to, the provision of infrastructure and capacity building. The framework that this study is based upon revolves around the complementation of infrastructure and capacity building in forging a path towards rural development.

The initial role of the government is neither regulation nor governance but empowerment of local communities, similar to the paradigm proposed by the World Bank in poverty alleviation. Empowerment is defined in this paradigm as *“the expansion of assets and capabilities of poor people to participate in, negotiate with, influence, control, and hold accountable institutions that affect their lives”* (Narayan, 2002). Focusing on empowerment in the framework, market efficiencies can be gradually attained since this will help in narrowing the information asymmetries among the stakeholders (the suppliers, the traders, the market/retailers, and the producers/farmers). The empowered stakeholders would like to gain access to pertinent information before they take specific decisions. Rural roads, other rural infrastructure, and capacity building activities will enable all the stakeholders to access relevant information of the supply-demand chains for rural/agricultural goods and services. The stakeholders can use such information in the efficient allocation of factors of production.

In the process, the government needs to facilitate the dynamics where the stakeholders interact towards attainment of efficiency. For certain interventions like credit, direct provision of say seed capital may be provided by the government or can be taken from some other forms of development assistance. This is also true for other infrastructure where the initial construction will need money that is beyond the capability of the stakeholders. It is important though to consider that rural infrastructure does not follow similar protocol as in mainstream public economics, where cost and maintenance have to be secured from the beneficiaries through the process of taxation. Many of the rural beneficiaries in developing countries fall short of the cut-off for taxable income brackets. However, direct provision should not be continuously done; the government and donors will have to veer away from direct provision and focus on facilitation to stimulate a participatory environment leading towards sustainability. It is important for the stakeholders to establish ownership. Hence, encouraging them to contribute (in cash or in kind) for maintenance to safeguard the sustainability plan should be part of the design of the intervention. The notion of user's fees is difficult to inculcate among the stakeholders especially because they have limited income and livelihood opportunities. A good advocacy strategy though will help rural stakeholders to eventually accept the concept of user's fees.

Models will be developed to explain the dynamics of the rural economy. The models will consider a household that would like to maximize its welfare function and will take into consideration spatial distribution. The spatial dimension will rationalize site-specific packaging of bundles of intervention. A stochastic frontier model, basically a production frontier, will also be developed with spatial dimensions. Note that the spatial dimension is

justified in terms of soil fertility and diversity of economic activities determined by topography, among others. This model will help explain how inequality among rural households can be traced to how efficient/inefficient they are in accessing the factors of production available to them.

The data that will be used in the empirical investigation will be discussed and presented along with the empirical modeling strategies.

3.1 THE ROLE OF RURAL ROADS

A rural road will be defined as an access route from the main road network to the rural communities and/or production areas. It is intended to provide an access path for individuals residing in rural communities and passage for light public vehicles carrying people and/or produce. Such roads allow transportation cost to be reduced because vehicles carrying farm loads are cheaper than the human carriers that are still used where there is no such road in many rural areas of the Philippines.

Farm roads are often constructed as dirt pavement, or are topped with gravel, with asphalt, or very seldom, with concrete (see Figure 4.1). Usually, only people and light vehicles pass through, but during harvest season, the local government or some community organization upgrades it so that haulers can reach as close as possible to the production areas. The roads in the main road network, called national roads in the Philippines, are usually constructed with concrete materials and are wider, thus accommodating heavy-duty haulers that will collect the produce and bring it to the main distribution depot (government or privately owned).



Figure 3.1 Typical Rural Road in the Philippines

The path of rural development from the improvement of accessibility in the rural communities will start from the known direct impact of rural roads. Roads are intended to mitigate an area's state of isolation that otherwise hinders the initiation of various facets of development. Improved access roads among the rural households will lead to increased accessibility and movement because of lower transportation cost, increasing economic activities. The literature documents a wide range of percentages of reduction in transportation cost as a result of establishing new rural roads or improving existing ones. Regardless of the amount of inputs invested, rural roads are expected to contribute to lowering transportation cost.

Improvement in road networks starts up a feedback system of input procurement and marketing of produce. Producers are expected to pay less for the inputs of production because of the improvement in accessibility, so they become more capable of procuring more inputs. The different suppliers of inputs will lose monopoly and be forced to become competitive since the farmers will now have alternative sources. Marketing will also not be limited among a few traders, resulting in a negotiable pricing system since transportation cost reduction will open the ceiling of price negotiations. This is of course based on the assumption that commodity financing (usually associated with price ceilings for goods and not so fair to the farmers) is no longer practiced or that there is a sustainable credit facility in place. Knowledge of marketing avenues and demand for various commodities (to be facilitated by the government) will encourage farmers to diversify crops, and later on, to specialize in high value crops only viable in the production area (efficiency). Thus, increased production and increased gross value coupled with lower input cost will benefit the farmers in terms of increased earnings.

Improved accessibility will also facilitate provision of basic social services like education and health. Even if such services are not brought right into the community, it will be easier for the households to access those from the town centers or in another community. Social services should result in enhancement of human capital and along with other capacity building interventions, should contribute to empowering the rural community.

Rural roads will also generate multiplier effects. Foremost, they serve as catalysts for greater public investment into infrastructure and capacity building. Given that an improved access road will facilitate the construction of a health center (and visits of health professionals), a warehouse for agricultural commodities, and even the conducting of training and other capacity building activities. Provision of other physical infrastructure will be feasible because materials can be easily transported. Then for those manned by personnel from outside the community, or for capacity building where resource persons come from outside, traveling into the community will be viable now, reducing the lost time normally spent traveling to the site.

Because of the improved mobility of the households, they will be exposed to outside communities and may observe prototype development that will serve as a stimulus for their desire to realize similar development in their locality. It will then foster a good motivating factor for them to participate in the process of identification of strategies that can lead towards development. This is the start of community building that will later on evolve into a sustainability backbone.

With the growing demand for infrastructure, demand for support services will also increase, requiring more participation on the part of the household in planning and in sourcing for infrastructure and support services. This will encourage the local government to contribute as well, so sustainability will become clearer. All of this will lead to increased production. Because of the growing demand for infrastructure, there is now a viable input sourcing at reasonable cost (due to reduction in transportation cost). Better post-production handling will result in lower post-production losses, yielding a good profit margin for the farmers.

For the non-agricultural household, the direct impact of roads will be in terms of facilitating the emergence of new investments and new enterprises. Eventually, more diverse choices of livelihood will become available to them, an important manifestation of rural development.

The complementation between increased production among farming households and the non-farming households engaged in microenterprise development are early leads towards rural development. In rural areas where employment opportunities should extend beyond the traditional agriculture basis, the empowered households—a stronger community that participates in intervention programs—will benefit not only the individual households, but the entire community, leading towards sustainability.

3.2 DATA SOURCES

A client satisfaction survey was commissioned by the World Bank in 2005 (NEDA-WB-ASEM, 2005) to develop a perception-based survey that will facilitate the verification of the effect of the outputs of the rural sector agencies (Department of Agriculture, Department of Agrarian Reform, and Department of Environment and Natural Resources) on rural development in the Philippines. A rural development and living condition scale (see Appendices 1 and 2) was developed and pilot-tested several times (see NEDA-WB-ASEM, 2005 and NEDA-WB, 2003). It was concluded that the scale can approximate the constructs of rural development. The survey was implemented in purposively selected *barangays* (villages) where households were then randomly selected. In the purposive selection of the *barangays*, prototype interventions of the departments were considered, along with an appropriate control group (no known intervention from the government in recent years). For the government interventions, the strata were defined in terms of whether the project is locally funded or with foreign funding for each of the three major departments working within the rural sector (agriculture, agrarian reform, and environment and natural resources). The delineation between local and foreign funding serves as a proximate indicator of the intensity of resources used in implementing the project, where resources from local sources are usually lesser than those coming from foreign sources. The *barangays* in the control group were also allocated according to expected income level (low, medium, high income), by topography (upland, coastal areas), and to include the KALAHI-CIDSS sites (a government project using an integrated strategy of facilitating rather than direct provisions, and a participatory approach rather than imposition of appropriate interventions). More than 6,000 households were included in the database. Only rural *barangays* were included.

The Family Income and Expenditures Survey (FIES), conducted every three years by the Philippine National Statistics Office (PNSO), will also provide data analyzed in this paper. It is a probability sample of about 20,000 households with rural-urban areas of the provinces as domains (until 2000). In 2003, the domain was raised to the regions. In return, more detailed information was collected. The units of analysis are also the households, but in contrast to the information from the Client Satisfaction Survey, long-term outcomes are collected. Transportation cost is used as a proxy indicator of road system improvement.

3.3 BACKFITTING ESTIMATION

In a model with several variables including a good number that are dichotomous (dummy) variables, estimation using least squares may be affected because the design-matrix can become ill-conditioned. Estimates may yield reverse signs, so sensitivity analysis on each independent variable may not be feasible. Forecasting/prediction though may still be viable even when the least squares method is used in the presence of ill-conditioning in the design matrix.

To resolve the potential problem caused by ill-conditioning in the design matrix, the backfitting algorithm can be used in the estimation. The algorithm assumes that the postulated model is additive, a generalization of the linear regression model. The model

is expressed as a sum of basic functions that can be linear, non-linear, or non-parametric. The additive model is given by

$$y = \alpha + \sum_{j=1}^r f_j(x_j) + \varepsilon . \text{ The function } f \text{ can be of the form } f_j(x_j) = \beta_j x_j , \varepsilon \text{ are}$$

independent of the x 's, $E(\varepsilon) = 0$ and $var(\varepsilon) = \sigma^2$. The backfitting algorithm described by Hastie and Tibshirani (1990) enables additive model-fitting using any regression-type estimation mechanism, given by:

(i) Initialize: $\alpha = \text{ave}(y_i)$, $f_j = f_j^0$, $j = 1, 2, \dots, r$

(ii) Cycle: $j = 1, 2, \dots, r$

$$\hat{f}_j = S_j \left[\left(y - \sum_{k \neq j} f_k \right) / x_j \right]$$

(iii) Continue (ii) until the individual functions do not change where S_j denotes a smoothing of the response y against the predictor x_j .

Smoothing may reduce to ordinary least square for simple regressions (one-at-a-time) if the functions are linear.

3.4 EFFICIENCY IN HOUSEHOLD PRODUCTION

Stochastic frontier analysis (SFA) will be used in analyzing efficiency of household production both from farm and non-farm sources. The model will be used in explaining inequality among rural households. It is postulated that inequality among rural households will depend on how efficient they are in utilizing infrastructure facilities towards increasing their income and other benefits in general. This is also affected by the combination of infrastructure and other interventions available and is needed in their production activities. Bundles yield more effect than simply adding the individual effect of each intervention.

It is further assumed that efficiency is also affected by spatial dependence in production/income-generation because of soil fertility that is site-specific, diversity of economic activities influenced by topography, homogeneity of agents of transportation, the source and availability of inputs, and markets in adjacent communities.

Technical efficiency will be computed for farming and non-farming activities of the household. The production function will consider income and the rural development index as the dependent variable.

3.4.1 Specification and Estimation of Production Frontier (Model 1)

Consider a cross-sectional production frontier model $y_i = f(x_i; \beta) \exp(v_i) TE_i$ or $TE_i = \frac{y_i}{f(x_i; \beta) \exp(v_i)}$. $[y_i]$ is the actual production and $[f(x_i; \beta) \exp(v_i)]$ is the theoretical production function. x_i is a vector of production inputs needed to produce y_i while v_i is a random error. Note that the distribution of v_i and the form of the function f will dictate an efficient estimation procedure for the parameters. Assuming that the

theoretical production function is correct, the ratio between actual and theoretical production level yields a reasonable account of technical efficiency (TE).

The function f should satisfy the following conditions provided by Kumbhakar and Lovell (2000) summarized in Section 2 above. Let $TE_i = \exp(-u_i)$, then the production stochastic frontier model becomes $y_i = f(x_i; \beta) \exp(v_i) \exp(-u_i)$, yielding two error components v_i and u_i . The negative sign for u_i will ensure that $TE \leq 1$. $TE=1$ implies efficiency, while $TE < 1$ indicates a shortfall (inefficiency) in a stochastic environment characterized by $\exp(v_i)$, varying across households. The variable u_i will be linked to some factors that are postulated to influence production efficiency of rural households. Reifschneider and Stevenson (1991) proposed $\ln y_i = \ln f(x_i; \beta) + v_i - u_i$ and $u_i = g(z_i; \gamma) + \varepsilon_i$. We will imbed a spatial autoregression model or SAR (Pace and Barry, 1997) with a general linear mixed model. Thus, the postulated technical efficiency model is $u = w\varphi + z\phi + \delta D[u - w\varphi - z\phi] + \varepsilon$,

$$\text{where } u = (u_1, \dots, u_n)' , \quad w = \begin{bmatrix} w_{11} & \dots & w_{1a} \\ \dots & \dots & \dots \\ w_{n1} & \dots & w_{na} \end{bmatrix} , \quad z = \begin{bmatrix} z_{11} & \dots & z_{1b} \\ \dots & \dots & \dots \\ z_{n1} & \dots & z_{nb} \end{bmatrix} \quad \varphi = (\varphi_1, \dots, \varphi_a)' ,$$

$\phi = (\phi_1, \dots, \phi_a)'$, δ is a spatial parameter, $D = [(d_{ij})]$, the spatial weight matrix where $d_{ij} = \begin{cases} 1, & \text{if unit } i \text{ and unit } j \text{ are spatially related} \\ 0, & \text{otherwise} \end{cases}$. Two households will be considered spatially

related if they belong to the same barangay/village. w_i is a vector of fixed factors, z_i is a vector of random factors, and $\varepsilon' = (\varepsilon_1, \dots, \varepsilon_n)$ is pure error. If the observations are arranged so that households coming from the same barangay are next to each other, then the matrix D is block diagonal. The joint distribution of $z' = (z_{11}, z_{12}, \dots, z_{1n}, \dots, z_{i1}, \dots, z_{ij}, \dots, z_{in}, \dots, z_{k1}, \dots, z_{kn})$ and $\varepsilon' = (\varepsilon_1, \dots, \varepsilon_n)$ is assumed to be normal with mean $E \begin{bmatrix} \varepsilon \\ z \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$ and variance $V \begin{bmatrix} \varepsilon \\ z \end{bmatrix} = \begin{bmatrix} \Sigma & 0 \\ 0 & \Gamma \end{bmatrix} = \Omega$, where Σ and Γ are not necessarily diagonal. We are assuming a general dependence structure among the elements of z' and ε' , but independence of elements of z' from elements of ε' is imposed.

Thus, the production frontier equations can be summarized into $y_i = f(x_i; \beta) \exp(v_i) \exp(-u_i)$ or

$$\ln y_i = \ln f(x_i; \beta) + v_i - u_i \quad (3.1)$$

$$u = w\varphi + z\phi + \delta D[u - w\varphi - z\phi] + \varepsilon , \quad (3.2)$$

where $v_i \sim N(0, \sigma^2)$ and $\varepsilon', z' \sim N(0, \Omega)$. The function f may take the Cobb-Douglas form or a more general exponential or a non-linear function. Since dummy variables will be used in addition to factors of production that are zero for some households, an exponential function f will be used. The location of an exponential function can be adjusted so that the six properties above are satisfied.

Estimation will be done using a modified backfitting algorithm (Landagan and Barrios, 2007), taking advantage of the additive nature of (3.1) and (3.2). The estimation algorithm follows:

1. Depending on the link function f , ignore u_i in (3.1) and estimate β using maximum likelihood estimation (MLE) or least squares estimation (LSE).
2. Compute the residuals from (3.1), $\hat{u}_i = \ln f(x_i; \hat{\beta}) - \ln y_i$. This now contains information on φ, ϕ and δ .
3. Estimate φ and ϕ from (3.2), setting aside the spatial effect, using the initial estimates of technical efficiency (\hat{u}_i). A maximum likelihood estimator for a mixed model can be used.
4. Compute residual technical efficiency $\hat{u} = \hat{u} - w\hat{\phi} - z\hat{\phi}$. This contains information on δ .
5. Estimate δ from $\hat{u} = \delta D\hat{u} + \varepsilon$, which is a regression through the origin with a single covariate ($D\hat{u}$).
6. Use the estimates derived from (5) in revising the estimates of technical efficiency (\hat{u}_i^*) from (3.2).
7. Estimate the overall constant term of (3.1) using a non-negative filter (e.g., logistic function), and deduct this from the revised estimate from (6).

The algorithm is expected to converge after (7), (see Landagan and Barrios, 2007 for details).

3.4.2 Specification and Estimation of Production Frontier (Model 2)

In the second model, spatial dependence is postulated on the production function instead of appearing in the efficiency equation.

$$\ln y_i = \ln f(x_i; \beta) + \delta D[\ln y_i - \ln f(x_i; \beta)] + v_i - u_i \quad (3.3)$$

A similar argument on spatial dependency can be made whether it is in the production function or in the technical efficiency equation. Estimation can be done using a similar algorithm to that in Model 1 above.

The advantage of simultaneous estimation of parameters through maximum likelihood estimation using a distribution of non-negative values for v (e.g., half-normal, logistic) is that it always produces estimates of technical efficiency ≤ 1 . An alternative is to filter u using a function in a non-negative domain, similar to (7) in the algorithm above. Thus, instead of fitting a linear regression of the first residual from (3.3) above, filtering is done, e.g.,

$$u = \frac{1}{1 + \exp(-w\varphi)} + \varepsilon. \quad (3.4)$$

A similar algorithm can be used with (3.4) above, in lieu of the linear regression of u on the determinants of efficiency. A no constant specification of (3.4) would ensure that \hat{u} will always be positive, so that the estimate of technical efficiency will be between 0 and 1.

3.4.3 Specification of Variables

The response variables are total income and the rural development index (standardized so that values will range from 0 to 100). The total income coincides with farm income if the household derives all income from farming, non-farm income if it earns income from non-farm sources, and the aggregate of farm and non-farm income if it derives income from both sources.

The survey design imposes constraints in the choice of inputs of production (farming) among the households. Some proximate indicators were considered in lieu of real production inputs so that the production function becomes comprehensive. This will provide a rationale to the estimates of technical efficiency. The following inputs of production will be considered: area cultivated, access to irrigation, access and utilization of credit (as proximate indicators of procurement of farm inputs or capital availability for non-farm activities, a requirement for the development of small scale industries), whether single or multiple crops are planted (proximate indicator of farming system), health indicator of household members (as proximate indicator of human capital), number of household members with work (non-farm), and tenure of work. Two dummy variables will

also be included: $S_1 = \begin{cases} 1, & \text{if household derives income from farming activities} \\ 0, & \text{otherwise} \end{cases}$ and

$S_2 = \begin{cases} 1, & \text{if household derives income from non-farming activities} \\ 0, & \text{otherwise} \end{cases}$. If the household derived income

from both farming and non-farming sources, then $S_1=S_2=1$. The interaction between S_1 and farming inputs, and S_2 with non-farming inputs, will be included to ensure that causation between output and production inputs are appropriate.

For the efficiency equation, the determinants are classified as fixed or random effects. Fixed effect determinants will register similar results regardless of the household being observed. On the other hand, random effect determinants are those whose effects are governed by a sampling distribution, i.e., one household may react differently from another household. The fixed-effect factors are household demographic characteristics (including dependency ratio), land tenure, female-male headed household, education of household members, and the spatial effect. The weight matrix for the spatial effect will be computed for the barangay (village) and will not differentiate households within the same barangay. The spatial indicator will account for socio-geographic characteristics that will affect production and income, soil fertility, and other site-specific unknown agronomic factors. For non-farming activities, the spatial effect will explain the kind of economic activities viable in the area and other site-specific unknown economic and cultural conditions.

Among the random factors to be included are availability of needed infrastructure or other intervention activities, bundles of such, whether the bundles include roads, membership in organization (as measure of participation), and whether they commit to contribute for maintenance. Since these factors are measured in terms of perception among the households, it is expected that the dichotomous responses will yield varying effects among the households.

4 SPATIAL EFFECT AND EFFICIENCY IN HOUSEHOLD PRODUCTION

Household analysis based on perceptions can provide almost instantaneous feedback on various activities geared towards rural development. Causation is better seen using perceptions instead of income measures that may take a considerable lag time before effects are manifested. Although income manifestation is a long-term outcome, it should also be carefully factored into the analysis as a validation tool and other information it ought to contribute.

Spatial dependence measures are used and explicitly incorporated into the models to generate further evidence on the generation of multiplier effects beyond the direct beneficiaries of various interventions. This will also account for the possible intervention leakage (when non-intended beneficiaries receive the intervention) and the justification of targeted rather than universal intervention for development.

The results of estimation of the spatial autoregression and spatial stochastic frontier models are given in Appendices 3-13.

4.1 EFFICIENCY OF HOUSEHOLD PRODUCTION (INCOME)

In the assessment of household efficiency, the household utility function is indexed both by income and the rural development index. While a production frontier is also fitted in the estimation of technical efficiency, the results are similar to the models presented in Barrios (2007), so only the determinants of efficiency are discussed in this section.

Starting with income as an indicator of household production, some demographics, participation indicators, availability and needs for some development interventions, bundles of interventions, and spatial dependency turned out to significantly contribute to the efficiency of a household's income generation.

Female-headed households are more efficient in income-generation, explained by the way they allocate the limited factors of production. The savings rate among female-headed households is higher, an indication of how they conserve current earnings for possible future use, not excluding investment for future income-generation. They are also efficient if there are few members below 16 years old: the lower dependency rate indicates more members eligible to join the labor force. More members 6–16 years old attending school is also an indicator of household efficiency. Education as part of human capital in rural areas is confirmed here. The nuclear family types are more efficient. Even if the large family size common among extended family types generates more income, these households are not necessarily efficient. Setting aside family structure, large households in general are more efficient. Considering the fact that agricultural sources still dominate the income of rural households, the efficiency of large households can be taken as possible evidence of rural labor migration. There is already a labor shortage in some areas (confirmed in some case studies) and in labor-intensive agricultural production, it is advantageous if one can easily tap family labor, which is abundant among large households.

The continuous provision of services from rural infrastructure indeed stimulates household efficiency. The households who indicated willingness to contribute to the maintenance of water systems and post-harvest facilities are more efficient in income-generation. The water system will have welfare implication affecting the human capital, so a properly maintained system can be expected to contribute towards household

members in efficiently generating income. The post-harvest facilities, on the other hand, will ensure that the produce will be efficiently converted into household income.

There are a few stand-alone development interventions, mostly infrastructure that contributed to households' efficiency in income generation. The more efficient households were those who perceived availability and believe that roads, bridges and haulers are needed. Note that these are the elements that will facilitate access to and from production areas, thus linking them to the suppliers of inputs as well as the market for their produce. Households who perceived need and believe that credit is available also manifested efficiency. Among trainings, availability and perceived need for training on the use of farm machineries, and care and management of the environment contributed to efficiency. The use of farm machineries can lead to efficiency, especially considering that there are already signs of rural labor shortages as a result of rural-urban migration. Training on care and management of the environment is an important facility for sustainable agriculture.

Perceived availability and need for bundles of training on farm production improvement becomes an efficiency driver for household income generation if it goes with rural roads. These trainings include pest management, planting technologies, use of farm machineries, harvesting methods and use of equipments, use of hybrid varieties, multiple cropping, and crop selection. Individually, the training does not affect efficiency. A training curriculum then among agricultural extension workers would necessitate bundles, rather than small trainings that will have minimal impact. The key for these trainings to yield efficiency in production is the enhancement of accessibility to various agents in the household income generation chain through rural roads.

On the non-agriculture side, availability and perceived needs for training on microenterprise development, in-farm livelihood, with credit for microenterprise development, at the least can contribute to household efficiency in income generation. This bundle, however, along with rural roads, can yield more efficient household income generation. The roads here will have a similar role to that in farm production: accessibility of the outputs of the microenterprise will be linked towards various agents in the production process. Trainings will provide the skill, credit for the capital, and road for input procurement and the marketing of the outputs.

The spatial dimension in the production frontier was introduced as a sparse autoregressive term. Households coming from the same barangay (small village) are treated as neighbors. There is indeed evidence of spatial convergence of efficiency in household production. Neighbors within the barangay exhibit homogeneous efficiency in income generation. This is easily explained by the homogeneity in various factors of production (including soil productivity) and the kind of development intervention or support services they have access to. The implication is that programs that are geared towards enriching households' production efficiency should be site-specific. Many development projects would include social preparation that will accomplish both the advocacy function and the identification of appropriate modalities for a target site.

Accessibility infrastructure has a prominent role in the efficiency of the households in income generation. It should be bundled with other interventions for better benefits, i.e., more efficient income generation.

4.2 EFFICIENCY OF HOUSEHOLD PRODUCTION (RDI)

A similar production frontier was fitted but instead of income, the rural development index (RDI) was used as the indication of production. In the production frontier with income, contribution for the maintenance of various infrastructure projects turned out to

affect household efficiency. With RDI, only the contribution for maintenance of the water system is significant. Membership in various organizations (generic farmer's organization, community organization, and credit organization), however, also contributes towards household efficiency in welfare maximization, i.e., perceiving that there is rural development. By interacting with other members of the organization, the household may already imbibe the prospect of development, an important precursor of the manifestation of real rural development. The path towards rural development becomes clear once the stakeholders have a positive view towards rural development.

Efficiency in income generation is affected more by bundles than by single interventions. Perception on rural development, however, is affected by single interventions in addition to the bundles. Availability and perceived need for key physical infrastructure like roads, bridges and irrigation can improve the way households view the presence of rural development. The role of accessibility and other physical infrastructure in household efficiency in perceiving rural development confirms the actual manifestation (income) of rural development discussed in the previous section.

Availability and perceived need for trainings on planting technologies, use of hybrid seeds, and care and management of the environment will at least leave an impression on the empowerment of the stakeholders, resulting in the households efficiently perceiving that there is rural development. This is enhanced further by development of cooperatives, training of off-farm livelihood, and credit. In addition, support for marketing linkages completes the list of individual interventions that can influence how efficiently the households would perceive the presence of rural development.

Among the bundles of intervention that prominently influence households' efficiency of perceiving rural development, training on livelihood and microenterprise development with appropriate credit, with or without road projects, is more important. An effort that will illustrate to the rural stakeholders that the means to expand income sources are available can persuade them to believe that there is indeed rural development. To reiterate a point, non-farm income sources can help alleviate the income vulnerability of rural households. Thus, skills training, credit and roads that provide means of accessing other income sources will motivate the households to believe that there is rural development. These elements will eventually result in actual manifestation of income increases as discussed in the previous section.

In the same way as the households' efficiency in income generation converges spatially (at village level), this is also true for rural development perception. The perception of contentment in a household in the community spreads to other members of the community. This will facilitate the participatory identification of appropriate development interventions in a site since a community level consensus can be generated, as guaranteed by this spatial convergence of their perception on rural development in general.

Bundled interventions and rural roads also encourage households to optimize their utility function efficiently. They are more efficient in raising their rural development index score if roads, trainings, and other support services are bundled and made available to them.

4.3 OTHER SPATIAL EFFECTS IN HOUSEHOLD DYNAMICS

Spatial distance is represented in the model by averaging the rural development index score among all households in the same region. It is then assigned for all households in the region. A linear and a quadratic term for this indicator were included in the model; both are significant. This indicates that there is indeed regional convergence

in the rural development index among the households. There is a chance that the perception on rural development of one household can be spread to other households in the same community. This result supports the idea of concentrating the interventions in a few sites rather than spreading it in as many sites as possible. Convergence in perceptions can facilitate the multiplier effect that is expected in limiting the interventions in a few sites. Not only will this strategy generate larger multiplier effects, but is also cost-effective.

Using average farm income among households in the same region as a proximate indicator of spatial distance, regional convergence of farm income is confirmed ($p < 0.000$). Farm incomes of households coming from the same region tend to be similar. This can be explained by a variety of reasons, including soil fertility being homogeneous among neighboring areas, uniformity of farming systems among neighboring communities, and similarity in farming cultural practices in a community neighborhood. The regional convergence will have important consequences for the type and nature of policies and interventions in agriculture that are intended to upgrade farm income. A universal policy, though less costly, will not be optimal in terms of income generation among farmers. Culture-specific practices and farming systems should also be taken into consideration in the formulation of strategies in agriculture to at least maximize the potential benefits among farmers, specifically in income generation.

The average non-farm income among households in the same region and in the same strata (project sites) is used as the indicator of spatial distance. There is a regional convergence of non-farm income ($p < 0.000$) as well as in the specific strata or intervention sites of the government ($p < 0.000$). Regional variation of non-farm livelihood opportunities will explain the regional convergence, while the project menu (of the government intervention sites) and the constraints in resource availability (the control sites) can help explain convergence of non-farm income across strata. The present strategies used by the Departments of Agriculture, Agrarian Reform, and Environment and Natural Resources have varying effects on non-farm income. The programs of these departments are also specialized according to the mandate of the department. In the hope to deliver their mandate, interventions are sometimes provided in a stand-alone fashion. For a more comprehensive strategy towards the pursuit of rural development, these departments can consider combining their strategies and should carefully plan the paradigm shift from direct provision to facilitation of access to certain development interventions to ensure efficiency, effectiveness, and eventually sustainability.

4.4 SPATIAL EFFECTS IN LONG-TERM OUTCOMES

Income is the only indicator of rural development from the Family Income and Expenditures Survey (FIES). The breakdown of farm income and non-farm income will be analyzed separately. Income growth may manifest in the mid- to long-term, but spatial autoregression will help account for the possible lagged effect of the determinants of income. Furthermore, we have filtered households from rural areas only for the analysis.

There is no direct measurement of intensity of accessibility infrastructure because nationwide data is not available at the household or even at the community level. Some measures of expenditures on certain economic activities will be used as proximate indicators. Although reduction in transport cost is not as instantaneous as the provision of rural roads, the fact that we are also using income as indicator of rural development justifies the causative models.

Non-Agriculture Income

The demographic determinants of non-farm income with positive effects include age of the household head ($p < 0.000$); whether the head is married ($p < 0.000$); and whether

the head's education is elementary ($p < 0.000$), high school ($p < 0.000$), or college ($p < 0.000$). There is a premium for age in non-farm income generation since this is usually associated with accumulated experience/skills and rank. Being married could mean that there is a spouse who can also contribute to the household non-farm income. Furthermore, any level of education is an investment in non-farm income; the higher the level of education, the higher the expected income returns.

An agricultural household (income is generated mostly from agriculture) has non-agriculture income that is 53% lower than the non-agriculture household (income derived mostly from non-agriculture sources). Even among households in rural areas alone, the vulnerability of the farmers is very clear. Male-headed households also generate lower non-farm income. This coincides with an earlier analysis on the efficiency of female-headed household in income generation. Nuclear families that usually have smaller sizes and those with more members below 15 years old also have lower non-farm income since there are few members eligible for non-farm employment. Furthermore, the nuclear families have more employed individuals and an employed spouse generating more non-farm income.

Income generated by professional workers is the highest, followed by operators (usually skilled), laborers (usually unskilled), and those in agriculture; animal husbandry and forestry still generate the lowest income from outside the farm. Although there is a gradual diversification of occupation, the goal of alleviating the vulnerability of rural communities is not yet attained since the indicator of employment in a private enterprise is not significant, while employment in a private household is significant. There is not enough income generated from the private enterprises because there are only a few of them operating in rural areas. The rural enterprises have not evolved yet as planned from being micro to medium (or even small) scale.

Higher expenditures on petroleum, telephone, electricity and water are all functions of accessibility of an area. Isolation of a community can raise all these expenditures. All these indicators yield significant, negative coefficients in the regression of non-farm income. Furthermore, expenditure on manufacturing activities also yields a negative regression coefficient. Manufacturing requires transportation of raw materials and finished products. Hence, cost of production is closely associated with transportation cost. Improved accessibility infrastructure can indeed generate more non-farm income among the rural households.

The spatial autoregressive parameter is also significant ($p < 0.000$), indicating that non-farm income is significantly affected by the homogeneity of inputs of non-farm production in an area. One simple way of facilitating homogeneity of access to such inputs is the improvement of access and mobility among the stakeholders. If there is a provision for ample mobility among stakeholders in a rural community, non-farm income generation becomes feasible.

Agriculture Income

In as much as agricultural production requires male workers, male-headed households have the advantage of generating more income from agriculture. As strong workers have an advantage in land cultivation, younger people also have natural advantages in agriculture. Education, however, unlike in non-farm income where it has a positive contribution, it is not necessarily needed to cultivate the land. Furthermore, while the younger members of the household (<15 years old) cannot get jobs outside the farm yet, and hence have negative contributions to non-farm income, they can be (and in fact are) used as agriculture labor, doing light jobs like planting, weeding, and harvesting. Thus, they contribute positively to agricultural income generation.

Higher expenditures on electricity, water and land transportation are all proximate indicators of availability of access infrastructure. Expenditures on the wholesale and retail trade are usually dominated by transportation cost, since the activity requires movement of goods from the producers to the consumers. Cost in the operation of a transport business easily increases when the road system is of poor quality. These indicators also generate negative coefficients in the regression of agriculture income, indicating that accessibility infrastructure affects both the farm and non-farm income levels of rural households. Absence of an accessibility network isolates a place or a community, reducing their productive potential from both farm and non-farm sources.

5 CONCLUSIONS AND RECOMMENDATIONS

Microeconomic models were developed with households as unit of analysis. To assess the impact of infrastructure and other development interventions, both the actual income manifestation and perceptions were analyzed. For income, total household income and breakdown by source (farm, off-farm, non-farm) were considered. For perceptions, a scale item that directly inquires whether or not the households believe that there is rural development was considered. Furthermore, an index based on the scale was also considered.

Availability of roads and bridges are indicated by lower transportation cost, lower cost of utilities, and in a mid- to long-term range by diversification of employment opportunities. Electricity and water lines are installed in rural areas along paved road systems. Service cost is expected to be lower if the road system is favorable.

Given roads, investments in microenterprises will move towards rural communities because it will be cost-effective to locate production facilities in areas where the raw materials originate. This will result later in employment/occupation diversification. Change of occupation from farming to non-farming will benefit non-farm income but will be a loss to farm income. However, total income will be expected to post a positive net growth.

The importance of spatial indicators in the different models for various indicators illustrates the role of geographical dynamics in rural development. Various physical, social, and cultural factors play a pivotal role in the rural development dynamics. This also justifies the necessity for development intervention to be site-specific, participatory in approach, and not the universal targeting type. Although site-specific interventions may not be cheaper initially, in the long-run, a site-specific targeting approach may be more efficient. Development in one small community can easily spread to the spatial "neighbors" of the community. Because of the spatial dependence among communities, benefits from an intervention in one community are expected to produce a ripple effect reaching its spatial neighbors.

Provision of rural roads should be the core of rural infrastructure. This provision should be bundled properly with support services and capacity building activities like training to enhance demand for other infrastructure and services, thus resulting in a highly dynamic movement of various elements essential for rural development. Bundles of intervention further improve production efficiency of the rural stakeholders since this will facilitate activities at the different stages of production at or outside the farm.

The gap in rural development strategies can be isolated from the fact that there are fewer employment opportunities from private establishments. It is important to encourage or provide incentives to private establishments to establish operations in rural areas. This

incentive should primarily consist of accessibility development to reduce transportation cost. Private investments in rural areas can help mitigate the vulnerability of rural households when they become independent from the limitations inherent in agricultural production. Rural-urban labor migration may also be relieved. This will also serve as the catalyst in the development of sustainable microenterprises. Private establishments with a sound social responsibility program can also contribute to mitigating inequality.

REFERENCES

- Amos, T., Chikwendu, D., and Nmadu, J., 2004, Productivity, Technical Efficiency, and Cropping Patterns in the Savanna Zone of Nigeria, *Food, Agriculture and Environment*, 2(2): 173–176.
- Bandiera, O., (2002), Land Distribution, Incentives and the Choice of Production Techniques in Nicaragua, *Center for Economic Policy Research (CEPR) Discussion Paper No. 3141*
- Barrett, C.B., Reardon, T.A., Webb, P., Nonfarm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implications, 2002, *Food Policy*, 26(4): 315–331.
- Barrios, E., (2007), Access to Rural Development: Household Perceptions on Rural Development, *Asian Development Bank Institute Discussion Paper No. 61, Tokyo, Japan*.
- Barrios, E. and Landagan, O., 2004, Geographic Distribution of the Poor: Is Poverty Contaminating?, proceedings of the 9th National Convention of Statistics, Manila.
- Boothroyd P. and Nam, P.X., Eds., 2000, Socioeconomic Renovation in Viet Nam: The Origin, Evolution and Impact of Doi Moi, Singapore: IDRC/ISEAS.
- Conning, J.H. and Robinson, J.A., 2002, Land Reform and the Political Organization of Agriculture, *CEPR Discussion Paper No. 3204*.
- Demurger, S., Sachs, J., Woo, W., Bao, S., Chang, G., and Mellinger, A., 2002, Geography, Economic Policy, and Regional Development in China, *NBER Working Paper No. 8897*, National Bureau of Economic Research.
- Dulfo, E. and Pande, R., 2005, Dams, *NBER Working Paper No. 11711*, National Bureau of Economic Research.
- Fujita, M., Krugman, P., and Venables, A., 1999, *The Spatial Economy: Cities, Regions, and International Trade*, MIT Press.
- Gallup, J., Sachs, J., and Mellinger, A., 1998, Geography and Economic Development, *NBER Working Paper No. 6849*, National Bureau of Economic Research..
- Glaeser, E. and Kohlhase, J., 2003, Cities, Regions and Declines of Transportation Cost, *NBER Working Paper No. 9886*, National Bureau of Economic Research.
- Green, W., 1990, A Gamma-Distributed Stochastic Frontier Model, *Journal of Econometrics*, 46(1): 141–164.
- Hastie, T.J., and Tibshirani, R.J., 1990, *Generalized Additive Model*, St. Edmundsbury Press.
- Henderson, D. and Simar, L., 2005, A Fully Nonparametric Stochastic Frontier Model for Panel Data, paper presented during the 9th *European Workshop on Efficiency and Productivity Analysis*, Brussels, Belgium.

- Holtz-Eakin, D. and Lovely, M., 1995, Scale Economics, Returns to Variety, and the Productivity of Public Infrastructure, *NBER Working Paper No. 5295*, National Bureau of Economic Research.
- Huang, C. and Liu, J., 1994, Estimation of a Non-Neutral Stochastic Frontier Production Function, *Journal of Productivity Analysis*, 5(2): 171–180.
- Hulten, C., 1996, Infrastructure Capital and Economic Growth: How Well You Use It Might Be More Important than How Much You Have, *NBER Working Paper No. 5847*, National Bureau of Economic Research.
- Koop, G. and Steel, M., 2004, Bayesian Analysis of Stochastic Frontier Models, *ESE Discussion Paper No. 19*, Edinburgh School of Economics, University of Edinburgh.
- Kumbhakar, S. and Lovell, C., 2000, *Stochastic Frontier Analysis*, Cambridge University Press.
- Kumbhakar, S., Ghosh, S., and McGuckin, J., 1991, A Generalized Production Frontier Approach for Estimating Determinants of Inefficiency in US Dairy Farms, *Journal of Business and Economic Statistics*, 9(3): 279-286.
- Larson, D.F., Plessmann, F., 2002, Do Farmers Choose to Be Inefficient? Evidence from Bicol, Philippines, *WB Working Paper 2787*, World Bank.
- Landagan, O. and Barrios, E., 2007, An Estimation Procedure for a Spatial-Temporal Model, *Statistics and Probability Letters*, 77(4): 401-406.
- Lewis, W.A., 1984, The State of Development Theory, *The American Economic Review*, 74(1): 1–10.
- Narayan, D. (Ed.), 2002, *Empowerment and Poverty Reduction: A Sourcebook*, International Bank for Reconstruction and Development, World Bank.
- NEDA-WB, 2003, The Dynamics of Rural Development: Implications of the Intervention of the National Government, under the NEDA-WB TA on Capacity Building on Rural Development and Natural Resource Management: Planned Performance Monitoring and Indicator System, Pasig City, Philippines.
- NEDA-WB-ASEM, 2005, The Contributions of the Government to the Rural Sector, under *NEDA-WB-ASEM TA on Poverty Monitoring and Analysis*, Pasig City, Philippines.
- Pace, R. and Barry, R. (1997), Sparse Spatial Autoregressions, *Statistics and Probability Letters*, 33: 291–297.
- Ranis, G., Burmeister, L., Wang, M., 2001, Group Behavior and Development: A Comparison of Farmers' Organization in South Korea and Taiwan, *Yale Economic Growth Center Discussion Paper No. 828*.
- Redding, S., and Venables, A., 2002, Economic Geography and International Inequality, *Globalization Programme*, Center for Economic Performance, London School of Economics.

- Reifschneider, D. and Stevenson, R., 1991, Systematic Departures from the Frontier: A Framework for the Analysis of Firm Inefficiency, *International Economic Review*, 32(3): 715–723.
- Taylor, J.E., Dyer, G., and Yunez-Naude, A., 2005, Disaggregated Rural Economy-wide Models for Policy Analysis, *World Development*, 33(10): 1671–1688.
- Teruel, R. and Kuroda, Y., 2005, Public Infrastructure and Productivity Growth in Philippine Agriculture, 1974–2000, *Journal of Asian Economics*, 16: 555–576.
- Venables, A., 2006, Economic Geography: Spatial Interactions in the World Economy, in Weingast, B. and Wittman, D., Eds., *The Oxford Handbook of Political Economy*, Oxford University Press, In-Press (2006).

APPENDICES

APPENDIX 1: SELF ASSESSMENT OF LIVING CONDITIONS

The following is the scale used in collecting perceptions on living conditions in rural areas:

Some issues relevant to your community are listed below. We would like to ask your opinion, idea and some recommendations concerning these issues. For each item below, please indicate your agreement/disagreement whenever applicable. Note that NOT APPLICABLE option is included in case the issue is irrelevant to you. Please tell me what number best represents your assessment as I read each statement. **(USE SHOWCARD). READ THE STATEMENT ONLY, DO NOT READ THE ANSWERS, HAND DOWN THE SHOWCARD TO THE RESPONDENT WHILE READING THE STATEMENTS.**

0 – Not Applicable 1 – Disagree 5 – Agree (1,2 levels of disagreement, 4,5 levels of agreement, 3 about to agree/disagree)
(The showcard will contain 5 varying faces indicating extent of agreement/disagreement to the statement.)

1 Housing unit is comfortable for the family	5	4	3	2	1	0
2 Toilet is hygienic	5	4	3	2	1	0
3 Cost of electricity is reasonable	5	4	3	2	1	0
4 Water source is accessible	5	4	3	2	1	0
5 Water is safe for drinking	5	4	3	2	1	0
6 Water cost is reasonable	5	4	3	2	1	0
7 School is more accessible now	5	4	3	2	1	0
8 There is an improved quality of education	5	4	3	2	1	0
9 Income is more regular	5	4	3	2	1	0
10 Income is sufficient for household needs	5	4	3	2	1	0
11 There are enough jobs available now	5	4	3	2	1	0
12 There is enough training on possible livelihood	5	4	3	2	1	0
13 There is enough training on new farming practices	5	4	3	2	1	0
14 There is enough food for the family	5	4	3	2	1	0
15 It is now easy to take a public transportation	5	4	3	2	1	0
16 There is general feeling of satisfaction in the community.	5	4	3	2	1	0
17 I am contented with the way our needs are met.	5	4	3	2	1	0
18 Our living conditions now are much better than 5 years ago	5	4	3	2	1	0

APPENDIX 2: SELF ASSESSMENT OF RURAL DEVELOPMENT STATUS

The following is the scale used in collecting perceptions on rural development status in rural areas:

Please indicate your agreement on the following issues on rural development and poverty.

0 – Not Applicable 1 – Disagree 5 – Agree (1,2 levels of disagreement, 4,5 levels of agreement, 3 about to agree/disagree)

(The showcard will contain 5 varying faces indicating extent of agreement/disagreement to the statement.)

1. The poverty reduction strategy of the government is effective.	5	4	3	2	1	0
2. There is rural development	5	4	3	2	1	0
3. There are enough programs by local government on agriculture.	5	4	3	2	1	0
4. There are enough employment opportunities.	5	4	3	2	1	0
5. There is equitable access to productive resources.	5	4	3	2	1	0
6. Harvesting of resources is sustainable.	5	4	3	2	1	0
7. There are enough agricultural trainings.	5	4	3	2	1	0
8. The rural sector participates in the discussion on development issues.	5	4	3	2	1	0
9. Government's effort on agricultural research is important.	5	4	3	2	1	0
10. There is enough employment/livelihood in the area.	5	4	3	2	1	0
11. Agrarian reform is properly implemented.	5	4	3	2	1	0
12. The state of environment may cause calamities.	5	4	3	2	1	0
13. Ecological integrity can be maintained while there is development.	5	4	3	2	1	0

APPENDIX 3: SPATIAL ADDITIVE MODEL FOR RDI RESULTS

Source	SS	df	MS	Number of obs =	5326
Model	202663.971	7	28951.9959	F(7, 5318) =	73.54
Residual	2093701.13	5318	393.700852	Prob > F =	0.0000
				R-squared =	0.0883
				Adj R-squared =	0.0871
Total	2296365.1	5325	431.242273	Root MSE =	19.842

rdi	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
farminc	2.42e-06	9.96e-07	2.43	0.015	4.67e-07 4.37e-06
roadmain	2.000226	.6927994	2.89	0.004	.6420547 3.358396
wrrdi	-2.797715	1.700229	-1.65	0.100	-6.13086 .535431
wsrdi	-2.97547	1.713636	-1.74	0.083	-6.334899 .3839588
wl	.0667817	.0310345	2.15	0.031	.0059414 .1276219
irrmmain	1.388528	.6975741	1.99	0.047	.0209971 2.75606
phmain	2.94377	.7279947	4.04	0.000	1.516602 4.370938
_cons	167.5357	93.84975	1.79	0.074	-16.44831 351.5197

Source	SS	df	MS	Number of obs =	5326
Model	13415.3942	6	2235.89904	F(6, 5319) =	5.72
Residual	2080285.74	5319	391.10467	Prob > F =	0.0000
				R-squared =	0.0064
				Adj R-squared =	0.0053
Total	2093701.14	5325	393.183312	Root MSE =	19.776

rdi1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
sch6_12	.0172174	.0064104	2.69	0.007	.0046504 .0297844
sch17_21	.0136378	.0077343	1.76	0.078	-.0015247 .0288003
depend12	-.0260411	.0123641	-2.11	0.035	-.0502797 -.0018024
notmigr	1.301375	.5771753	2.25	0.024	.1698751 2.432876
intmigr	1.470534	.7743534	1.90	0.058	-.0475162 2.988584
workover21	.0184567	.0061059	3.02	0.003	.0064867 .0304268
_cons	-3.138566	.8995905	-3.49	0.000	-4.902132 -1.375

Source	SS	df	MS	Number of obs =	5326
Model	14360.3731	3	4786.79104	F(3, 5322) =	12.33
Residual	2065925.37	5322	388.185901	Prob > F =	0.0000
				R-squared =	0.0069
				Adj R-squared =	0.0063
Total	2080285.74	5325	390.663988	Root MSE =	19.702

rdi2	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
roof	1.424448	.5586398	2.55	0.011	.3292848 2.519611
govthosp	-1.554159	.6968348	-2.23	0.026	-2.92024 -.188077
toilet	2.997115	.7023592	4.27	0.000	1.620203 4.374027
_cons	-2.911548	.6505384	-4.48	0.000	-4.18687 -1.636226

Source	SS	df	MS	Number of obs =	4392
Model	7015.12691	2	3507.56346	F(2, 4389) =	9.06
Residual	1700094.22	4389	387.353434	Prob > F =	0.0001
				R-squared =	0.0041
				Adj R-squared =	0.0037
Total	1707109.35	4391	388.774618	Root MSE =	19.681

rdi3	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
comorg	2.549524	.7632132	3.34	0.001	1.053241 4.045807
irrigorg	5.539626	2.119422	2.61	0.009	1.38449 9.694763
_cons	-.7497969	.3317722	-2.26	0.024	-1.400238 -.099356

Source	SS	df	MS	Number of obs =	5326
Model	1632.23049	1	1632.23049	F(1, 5324) =	4.22
Residual	2058096.02	5324	386.5695	Prob > F =	0.0399
				R-squared =	0.0008
				Adj R-squared =	0.0006
Total	2059728.25	5325	386.803427	Root MSE =	19.661

rdi4	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
agri	.0490255	.0238586	2.05	0.040	.0022529	.0957982
_cons	.0049955	.2834337	0.02	0.986	-.5506506	.5606415

Source	SS	df	MS	Number of obs = 5326		
Model	12233.1112	4	3058.2778	F(4, 5321) =	7.95	
Residual	2045862.95	5321	384.488433	Prob > F =	0.0000	
				R-squared =	0.0059	
				Adj R-squared =	0.0052	
Total	2058096.06	5325	386.496914	Root MSE =	19.608	

rdi5	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
tenant	3.37592	.7869787	4.29	0.000	1.833119	4.918721
own	1.254455	.6166544	2.03	0.042	.04556	2.463351
amortizing	8.36614	3.164095	2.64	0.008	2.163217	14.56906
upland	.4630886	.2330683	1.99	0.047	.0061791	.919998
_cons	-1.1546	.3795538	-3.04	0.002	-1.898681	-.4105192

Source	SS	df	MS	Number of obs = 5326		
Model	29315.1102	7	4187.87289	F(7, 5318) =	11.04	
Residual	2016547.81	5318	379.192893	Prob > F =	0.0000	
				R-squared =	0.0143	
				Adj R-squared =	0.0130	
Total	2045862.92	5325	384.199609	Root MSE =	19.473	

rdi6	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
creditrepay	2.752348	.6181064	4.45	0.000	1.540606	3.96409
mccoopac	2.33913	.9137023	2.56	0.010	.5478985	4.130361
mcgbankav	2.256361	.9822183	2.30	0.022	.3308107	4.181912
phfacil	5.193719	2.741423	1.89	0.058	-.1805951	10.56803
mcgfiav	9.061952	1.892495	4.79	0.000	5.351885	12.77202
mcgfiac	-13.05389	3.302386	-3.95	0.000	-19.52792	-6.579856
prodloan	-2.47991	1.151964	-2.15	0.031	-4.738232	-.2215878
_cons	-2.587589	.5515059	-4.69	0.000	-3.668766	-1.506411

Source	SS	df	MS	Number of obs = 5283		
Model	52592.8721	33	1593.7234	F(33, 5249) =	4.30	
Residual	1943795.47	5249	370.317292	Prob > F =	0.0000	
				R-squared =	0.0263	
				Adj R-squared =	0.0202	
Total	1996388.34	5282	377.960685	Root MSE =	19.244	

rdi7	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
areaadj	1.713528	.4512627	3.80	0.000	.8288658	2.598191
i21	.0832391	.0452058	1.84	0.066	-.005383	.1718613
ageadj	-.0482329	.0271912	-1.77	0.076	-.1015389	.0050732
ageadj2	.0022403	.0011392	1.97	0.049	6.93e-06	.0044737
i2_fpi1	-2.480024	1.353856	-1.83	0.067	-5.134145	.1740961
i126	2.25432	.7517844	3.00	0.003	.7805097	3.72813
i123	1.648263	.8724714	1.89	0.059	-.0621438	3.35867
i212	-.0877862	.0502697	-1.75	0.081	-.1863356	.0107633
i3_fpi4	11.1933	4.348552	2.57	0.010	2.668333	19.71827
i3_fpi6	-8.495248	4.7443	-1.79	0.073	-17.79605	.8055538
i2_ph3	4.967488	2.161574	2.30	0.022	.7299047	9.205072
i132	-1.623938	.456063	-3.56	0.000	-2.518011	-.729865
br6	4.117373	1.859797	2.21	0.027	.4713968	7.763349
i121	-1.172574	.4888251	-2.40	0.016	-2.130875	-.2142737
i125	-1.77297	.627896	-2.82	0.005	-3.003907	-.5420328
i2_tft3	-7.709473	2.273298	-3.39	0.001	-12.16608	-3.252865
i2_tft4	4.960242	2.72763	1.82	0.069	-.3870474	10.30753
b3	-4.440714	1.413989	-3.14	0.002	-7.212721	-1.668707
i112	-1.159336	.4563647	-2.54	0.011	-2.054001	-.2646719
i2_tft7	4.839006	2.299451	2.10	0.035	.3311265	9.346886
i116	.8387854	.4968378	1.69	0.091	-.1352233	1.812794
i131	1.115049	.6457493	1.73	0.084	-.150888	2.380986
i221	.2124763	.0612028	3.47	0.001	.0924934	.3324592


```

i114 | -1.909885   .563299   -3.39   0.001   -3.014186   -.805585
i229 |  .0881832   .0525178   1.68   0.093   -0.0147736   .191114
  b4 |  2.553285   1.443797   1.77   0.077   -0.2771583   5.383729
i3_ocb1 | -6.879749   3.507305   -1.96   0.050   -13.75552   -0.0039725
  i23 | -0.0907933   .0456153   -1.99   0.047   -0.1802182   -0.0013683
  i231 | -0.1922895   .072802   -2.64   0.008   -0.3350116   -0.0495673
  b5 | -3.328982   1.953244   -1.70   0.088   -7.158152   .5001878
i3_ph4 | -7.398437   3.688918   -2.01   0.045   -14.63025   -0.166624
  i115 |  1.338683   .5179082   2.58   0.010   .3233676   2.353999
i3_lti1 |  8.596055   3.306   2.60   0.009   2.114919   15.07719
  _cons | -0.2279601   .3660384   -0.62   0.533   -0.9455476   .4896273
-----

```

```

. predict rdierr, resid
(43 missing values generated)

```

```

. gen aperdiadd=abs(rdierr)
(43 missing values generated)

```

```

. sum aperdiadd, detail

```

```

-----
aperdiadd
-----
Percentiles   Smallest
1%            .1808723     .0005737
5%            1.048358    .0033927
10%           2.009198    .0047022   Obs           5283
25%           4.900703    .0058451   Sum of Wgt.   5283

50%           10.17546
                    Largest
75%           18.64712    69.82649
90%           30.07888    69.87405   Mean          14.01554
95%           45.30962    70.77287   Std. Dev.     13.09699
99%           60.13055    71.48418   Variance      171.5311
                    Skewness      1.732325
                    Kurtosis      6.048047

```

APPENDIX 4: SPATIAL ADDITIVE MODEL FOR FARM INCOME RESULTS

Source	SS	df	MS	Number of obs = 5326		
Model	12691.2383	7	1813.03404	F(7, 5318) = 79.41		
Residual	121423.157	5318	22.8324853	Prob > F = 0.0000		
				R-squared = 0.0946		
				Adj R-squared = 0.0934		
				Root MSE = 4.7783		
lfarminc	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
wrfarm	9.31e-06	1.84e-06	5.06	0.000	5.70e-06	.0000129
farmerorg	2.056803	.2461888	8.35	0.000	1.574172	2.539434
cooporg	.48237	.1997994	2.41	0.016	.0906812	.8740588
irrmain	1.034425	.1653308	6.26	0.000	.7103091	1.358541
phmain	1.677004	.1644165	10.20	0.000	1.35468	1.999328
irrigorg	2.365613	.4935181	4.79	0.000	1.398115	3.333111
creditorg	1.319596	.346657	3.81	0.000	.6400066	1.999186
_cons	2.424669	.1451744	16.70	0.000	2.140068	2.70927

Source	SS	df	MS	Number of obs = 5326		
Model	1266.2845	4	316.571125	F(4, 5321) = 14.02		
Residual	120156.872	5321	22.5816336	Prob > F = 0.0000		
				R-squared = 0.0104		
				Adj R-squared = 0.0097		
				Root MSE = 4.752		

lfl	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
hs	-.5451271	.1478216	-3.69	0.000	-.834918	-.2553363
college	-.5863684	.1721378	-3.41	0.001	-.9238291	-.2489076
nuclearfam	.2562293	.1466451	1.75	0.081	-.0312552	.5437138
workover21	-.008552	.001453	-5.89	0.000	-.0114005	-.0057035
_cons	.4886389	.154825	3.16	0.002	.1851185	.7921593

Source	SS	df	MS	Number of obs = 5326		
Model	37580.7445	18	2087.81914	F(18, 5307) = 134.18		
Residual	82576.1278	5307	15.5598507	Prob > F = 0.0000		
				R-squared = 0.3128		
				Adj R-squared = 0.3104		
				Root MSE = 3.9446		

lf2	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
rice	1.362836	.1575751	8.65	0.000	1.053924	1.671748
corn	1.154734	.2185612	5.28	0.000	.7262646	1.583204
coconut	3.523113	.2038196	17.29	0.000	3.123542	3.922683
amortizing	1.170141	.6485395	1.80	0.071	-.1012633	2.441545
industrial	2.885491	.4324953	6.67	0.000	2.037623	3.73336
livestock	3.064782	.233366	13.13	0.000	2.607289	3.522276
inherited-y	1.787529	.4960865	3.60	0.000	.8149959	2.760063
cash	.9379582	.1906504	4.92	0.000	.5642051	1.311711
tenant	2.344184	.2062378	11.37	0.000	1.939873	2.748494
riceint	.0004329	.0002395	1.81	0.071	-.0000366	.0009024
cornint	.2391876	.0737612	3.24	0.001	.0945852	.3837899
lowirrarea	.3770942	.0712243	5.29	0.000	.2374652	.5167232
lownonarea	.0538082	.0242698	2.22	0.027	.0062294	.101387
upland	.1664961	.0491404	3.39	0.001	.0701607	.2628315
pasture	.4875872	.2911907	1.67	0.094	-.0832663	1.058441
own	2.453647	.1752489	14.00	0.000	2.110087	2.797207
leased	3.536133	.4005222	8.83	0.000	2.750945	4.321321
mortgage	2.919444	.575653	5.07	0.000	1.790928	4.04796
_cons	-2.806318	.0814157	-34.47	0.000	-2.965926	-2.646709

Source	SS	df	MS	Number of obs = 5326		
Model	660.590634	6	110.098439	F(6, 5319) = 7.15		
Residual	81915.5366	5319	15.4005521	Prob > F = 0.0000		
				R-squared = 0.0080		
				Adj R-squared = 0.0069		
				Root MSE = 3.9244		

lf3	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
prodloan	.5357472	.2328978	2.30	0.021	.0791721	.9923223

mccoopac	-.3937065	.1883841	-2.09	0.037	-.7630167	-.0243964
homefin	-.6443944	.1765078	-3.65	0.000	-.990422	-.2983668
phfacil	1.179652	.5528514	2.13	0.033	.0958368	2.263468
mcgfiav	.9106685	.3005929	3.03	0.002	.3213831	1.499954
farmimp	.4428051	.1989939	2.23	0.026	.0526955	.8329147
_cons	-.0031789	.0636142	-0.05	0.960	-.1278887	.121531

Source	SS	df	MS	Number of obs	=	5283
Model	1779.66068	20	88.9830342	F(20, 5262)	=	5.88
Residual	79610.9188	5262	15.129403	Prob > F	=	0.0000
				R-squared	=	0.0219
				Adj R-squared	=	0.0181
				Root MSE	=	3.8897
Total	81390.5795	5282	15.4090457			

lf4	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
areaadj	-.0543301	.0226059	-2.40	0.016	-.0986471	-.0100131
i130	.1953823	.0948572	2.06	0.039	.0094227	.3813418
ageadj	-.0119675	.0038423	-3.11	0.002	-.0195	-.0044351
i12	.1758237	.0673658	2.61	0.009	.0437588	.3078887
i2_fpi1	.7372256	.2831242	2.60	0.009	.1821847	1.292266
i2_fpi3	-.8468514	.3510844	-2.41	0.016	-1.535123	-.1585804
br2	-.3028512	.1766985	-1.71	0.087	-.6492537	.0435513
i120	-.3116621	.1312695	-2.37	0.018	-.5690047	-.0543194
i114	.3781926	.1053129	3.59	0.000	.1717357	.5846495
i133	-.3281229	.1082097	-3.03	0.002	-.5402589	-.115987
i2_ph3	1.098663	.4328236	2.54	0.011	.2501494	1.947177
i3_ocb1	1.086488	.6203349	1.75	0.080	-.1296253	2.302602
i121	.3528756	.108392	3.26	0.001	.1403824	.5653688
i3_tft6	-1.738982	.5671848	-3.07	0.002	-2.850899	-.6270641
i118	.1508653	.0838389	1.80	0.072	-.0134936	.3152243
i126	-.2781655	.1271717	-2.19	0.029	-.5274747	-.0288562
i134	.2514829	.1084677	2.32	0.020	.0388411	.4641246
i112	-.2621128	.0789337	-3.32	0.001	-.4168557	-.1073699
i17	.4126705	.1100435	3.75	0.000	.1969395	.6284015
i2_ocb2	-.7440646	.3764408	-1.98	0.048	-1.482045	-.0060845
_cons	.0645903	.0582138	1.11	0.267	-.0495329	.1787134

apefarmadd

Percentiles	Smallest	Obs	Sum of Wgt.
1%	.723089		
5%	3.245842		
10%	6.197344	2416	
25%	15.58593		2416
50%	29.43713	Mean	33.19672
		Std. Dev.	22.82155
75%	46.29243	Largest	
90%	65.1321	107.6966	
95%	77.36747	107.734	Variance
99%	97.09464	107.9066	520.8233
		108.409	Skewness
			.8068743
			Kurtosis
			3.235003

. drop apefarmadd
.gen apefarmadd=(100*exp(abs(lferr)))/farminc
(2910 missing values generated)

. sum apefarmadd, detail

apefarmadd

Percentiles	Smallest	Obs	Sum of Wgt.
1%	.0012586		
5%	.0040729		
10%	.0084841	2416	
25%	.027488		2416
50%	.104981	Mean	3.324435
		Std. Dev.	16.35675
75%	.5589297	Largest	
90%	3.351768	199.1093	
95%	11.67186	226.3076	Variance
99%	72.14625	235.6032	267.5432
		242.6177	Skewness
			8.86184
			Kurtosis
			97.42754

APPENDIX 5: SPATIAL ADDITIVE MODEL FOR NONFARM INCOME RESULTS

Source	SS	df	MS	Number of obs = 3808		
Model	207.852799	3	69.2842662	F(3, 3804)	=	78.90
Residual	3340.5148	3804	.878158464	Prob > F	=	0.0000
				R-squared	=	0.0586
				Adj R-squared	=	0.0578
Total	3548.3676	3807	.932063987	Root MSE	=	.9371

lnonfarminc	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
wrnonfarm	7.31e-06	5.60e-07	13.06	0.000	6.21e-06	8.41e-06
wsonfarm	6.34e-06	8.32e-07	7.62	0.000	4.71e-06	7.97e-06
cooporg	.0835438	.0472579	1.77	0.077	-.0091093	.176197
_cons	9.633375	.109615	87.88	0.000	9.418465	9.848285

Source	SS	df	MS	Number of obs = 3808		
Model	471.550391	11	42.8682173	F(11, 3796)	=	56.72
Residual	2868.96442	3796	.755786202	Prob > F	=	0.0000
				R-squared	=	0.1412
				Adj R-squared	=	0.1387
Total	3340.51481	3807	.87746646	Root MSE	=	.86936

lnf1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
college	.339692	.0344922	9.85	0.000	.272067	.4073171
nuclearfam	-.102876	.0317016	-3.25	0.001	-.1650299	-.0407222
hhsz	.0512437	.0056758	9.03	0.000	.0401158	.0623715
work17_21	.0017759	.00061	2.91	0.004	.0005799	.0029719
workover21	.000656	.0003184	2.06	0.039	.0000317	.0012803
empfff	-.1348592	.0334835	-4.03	0.000	-.2005066	-.0692118
empent	-.1058995	.0376904	-2.81	0.005	-.179795	-.032004
empofw	1.028642	.4364424	2.36	0.018	.1729582	1.884327
prof	.0052847	.001277	4.14	0.000	.002781	.0077883
admin	-.0201065	.0019484	-10.32	0.000	-.0239266	-.0162865
fulltime	.0106979	.0007561	14.15	0.000	.0092154	.0121803
_cons	-.4669879	.0548333	-8.52	0.000	-.5744934	-.3594824

Source	SS	df	MS	Number of obs = 3808		
Model	28.6081527	6	4.76802544	F(6, 3801)	=	6.38
Residual	2840.35628	3801	.747265529	Prob > F	=	0.0000
				R-squared	=	0.0100
				Adj R-squared	=	0.0084
Total	2868.96443	3807	.753602424	Root MSE	=	.86445

lnf2	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
mccoopav	.0954696	.0317418	3.01	0.003	.033237	.1577022
farmimp	-.2285592	.0606443	-3.77	0.000	-.3474578	-.1096606
mcgbankav	.0829429	.0461735	1.80	0.073	-.0075844	.1734702
creditrepay	.0748795	.0324781	2.31	0.021	.0112032	.1385557
prodloan	-.1231131	.0655043	-1.88	0.060	-.2515401	.0053139
consloan	.1549011	.0933371	1.66	0.097	-.0280944	.3378966
_cons	-.0764853	.0302456	-2.53	0.011	-.1357844	-.0171862

Source	SS	df	MS	Number of obs = 3784		
Model	15.1649468	7	2.16642098	F(7, 3776)	=	2.91
Residual	2807.14422	3776	.743417432	Prob > F	=	0.0048
				R-squared	=	0.0054
				Adj R-squared	=	0.0035
Total	2822.30917	3783	.746050534	Root MSE	=	.86222

lnf3	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
i216	-.0086378	.004786	-1.80	0.071	-.0180211	.0007456
br4	-.1371217	.0731037	-1.88	0.061	-.2804483	.006205
i2_fpi1	.1635975	.0682911	2.40	0.017	.0297064	.2974885
b3	.1327432	.0633864	2.09	0.036	.0084683	.2570181
i3_tft5	.2734171	.1553872	1.76	0.079	-.031234	.5780681
i3_mc1	-.2658072	.1485077	-1.79	0.074	-.5569702	.0253558
i217	.0119813	.0047043	2.55	0.011	.002758	.0212046
_cons	-.0058404	.0145752	-0.40	0.689	-.0344165	.0227357

```

apenfarmadd
-----
Percentiles      Smallest
1%      .0833014      .0001686
5%      .4210005      .0027407
10%     .8500838      .0032561      Obs          3784
25%     2.129962      .0069774      Sum of Wgt.  3784

50%     4.569485
75%     8.057197      Largest
90%     12.84925      44.97093
95%     16.50062      46.9798      Variance     32.24533
99%     27.6897       47.38177      Skewness     2.308739
                                         Kurtosis     11.45339

```

```

. drop apenfarmadd

. gen apenfarmadd=(100*exp(abs(lnferr)))/nonfarminc
(24 missing values generated)

. sum apenfarmadd, detail

```

```

apenfarmadd
-----
Percentiles      Smallest
1%      .0005403      .0003016
5%      .0007652      .0003576
10%     .0009316      .0003649      Obs          3784
25%     .0013556      .0003704      Sum of Wgt.  3784

50%     .0020768
75%     .003983       Largest
90%     .0131855      1.46245
95%     .0303114      2.31804      Variance     .0089473
99%     .2339839      2.385149      Skewness     18.41596
                                         Kurtosis     425.3251

```

**APPENDIX 6: PRODUCTION FRONTIER MODEL (MODEL 1)
FOR TOTAL INCOME RESULTS**

Source	SS	df	MS	Number of obs =	5326
Model	593983.7	26	22845.5269	F(26, 5300) =	3131.98
Residual	38659.7121	5300	7.29428531	Prob > F =	0.0000
				R-squared =	0.9389
				Adj R-squared =	0.9386
Total	632643.412	5326	118.783968	Root MSE =	2.7008

ltotalinc	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
area	.0605294	.0165883	3.65	0.000	.0280094 .0930494
lowirrarea	.0701429	.050762	1.38	0.167	-.0293715 .1696572
fulltime	.0254436	.002201	11.56	0.000	.0211288 .0297584
upland	.0036723	.0361175	0.10	0.919	-.0671328 .0744775
pasture	.352242	.1999019	1.76	0.078	-.039648 .744132
industrial	1.344755	.2952606	4.55	0.000	.7659229 1.923588
riceint	.4475129	.0782143	5.72	0.000	.2941807 .6008452
mccoopac	.7117961	.1281763	5.55	0.000	.4605178 .9630743
mcgbankav	.9002543	.1268626	7.10	0.000	.6515514 1.148957
cornint	.5070422	.0666039	7.61	0.000	.3764712 .6376132
farm	1.714419	.1323264	12.96	0.000	1.455005 1.973833
mcgfiac	1.017187	.3808696	2.67	0.008	.2705257 1.763848
nonfarm	5.577375	.0842737	66.18	0.000	5.412164 5.742586
creditrepay	2.454605	.0783181	31.34	0.000	2.301069 2.608141
farmimp	.0174135	.1431171	0.12	0.903	-.2631548 .2979819
banana	-.2133564	.1670462	-1.28	0.202	-.5408356 .1141229
workover2l	.0096377	.0008445	11.41	0.000	.0079821 .0112933
phfacil	1.470329	.3882252	3.79	0.000	.7092479 2.23141
comfin	.314071	.1566782	2.00	0.045	.0069172 .6212247
livestock	-.1411877	.1632525	-0.86	0.387	-.4612298 .1788543
empfff	2.081867	.1285742	16.19	0.000	1.829809 2.333926
empent	1.88566	.1057361	17.83	0.000	1.678373 2.092946
rice	.3245987	.1533733	2.12	0.034	.0239239 .6252734
cash	.4651375	.1284085	3.62	0.000	.2134039 .716871
coconut	.8165834	.1371015	5.96	0.000	.547808 1.085359
work17_2l	.0024425	.0016819	1.45	0.146	-.0008547 .0057397

. predict u, resid

```

Random-effects ML regression                Number of obs   =   5326
Group variable (i): ID                    Number of groups =   5317

Random effects u_i ~ Gaussian              Obs per group:  min =    1
                                           avg  =   1.0
                                           max  =    2

LR chi2(18) = 159.38
Log likelihood = -12616.179                Prob > chi2     =   0.0000

```

uhat1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
comorg	.3258437	.0926302	3.52	0.000	.1442918 .5073957
farmerorg	.504598	.1340074	3.77	0.000	.2419484 .7672476
creditorg	.3526925	.1881558	1.87	0.061	-.016086 .721471
irrmain	.2204825	.0967211	2.28	0.023	.0309125 .4100525
phmain	-.1695554	.0967892	-1.75	0.080	-.3592587 .0201479
roadmain	.274929	.1022203	2.69	0.007	.0745809 .475277
watermain	-.2069049	.0995874	-2.08	0.038	-.4020926 -.0117173
il_fpi1	.3835193	.0799758	4.80	0.000	.2267697 .540269
il_ph4	-.2735824	.1298783	-2.11	0.035	-.5281392 -.0190256
il_ph5	.3769297	.0883879	4.26	0.000	.2036925 .5501669
il_ph6	-.1552989	.088676	-1.75	0.080	-.3291008 .018503

il_mc1	.4830169	.1154152	4.19	0.000	.2568073	.7092265
il_ms2	-.0982851	.1273144	-0.77	0.440	-.3478167	.1512466
il_ltil	.2820723	.1175838	2.40	0.016	.0516122	.5125324
il_os3	-.082044	.1090454	-0.75	0.452	-.2957691	.1316811
bd5	-1.045845	.3493395	-2.99	0.003	-1.730538	-.361152
bdr3	-.2026367	.1650174	-1.23	0.219	-.5260649	.1207915
bdr6	.8097695	.3946969	2.05	0.040	.0361777	1.583361
_cons	-1.115835	.0700681	-15.93	0.000	-1.253166	-.9785043

/sigma_u	0	1.926709	0.00	1.000	-3.77628	3.77628
/sigma_e	2.585327	.025049	103.21	0.000	2.536232	2.634422

rho	0	.	.	.	.	.

Likelihood-ratio test of sigma_u=0: chibar2(01)= 0.00 Prob>=chibar2 = 1.000

. predict uhat2, e

Source	SS	df	MS	Number of obs =	5326
Model	.071863601	2	.0359318	F(2, 5324) =	3.28
Residual	58.2696595	5324	.010944714	Prob > F =	0.0376
				R-squared =	0.0012
				Adj R-squared =	0.0009
				Root MSE =	.10462

uhat2	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
femaleheaded	.0090221	.0036961	2.44	0.015	.0017762 .016268
hhsz	-.0000449	.0002568	-0.17	0.861	-.0005483 .0004586

. predict ehat3

. regress uhat3 d, noconstant

Source	SS	df	MS	Number of obs =	5326
Model	17.9336004	1	17.9336004	F(1, 5325) =	2.68
Residual	35578.1195	5325	6.68133699	Prob > F =	0.1014
				R-squared =	0.0005
				Adj R-squared =	0.0003
				Root MSE =	2.5848

uhat3	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
d	.0006577	.0004014	1.64	0.101	-.0001293 .0014446

Generalized linear models
Optimization : ML: Newton-Raphson
Deviance = 1096.52038
Pearson = 1096.52038
Variance function: V(u) = 1
Link function : g(u) = ln(u/(1-u))
Standard errors : OIM
Log likelihood = -3348.505344
BIC = -44593.87408
No. of obs = 5326
Residual df = 5325
Scale parameter = .2059193
(1/df) Deviance = .2059193
(1/df) Pearson = .2059193
[Gaussian]
[Logit]
AIC = 1.257794

lfinalteto~c	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
_cons	.2485158	.0252578	9.84	0.000	.1990113 .2980202

. gen ffte=exp(lfinaltetotalinc+.2485158)
.gen a=log(ffte)
.glm a, l(logit)

a	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
_cons	1.452136	.0404559	35.89	0.000	1.372844	1.531428

. gen b=exp(a-1.4521)						
Variable	Obs	Mean	Std. Dev.	Min	Max	
b	5326	.5788204	.2452161	.0927958	3.011428	

APPENDIX 7: PRODUCTION FRONTIER MODEL (MODEL 1) FOR RDI RESULTS

Source	SS	df	MS	Number of obs =	5002
Model	72554.3678	20	3627.71839	F(20, 4982) =	1969.28
Residual	9177.63536	4982	1.84215884	Prob > F =	0.0000
				R-squared =	0.8877
				Adj R-squared =	0.8873
Total	81732.0031	5002	16.3398647	Root MSE =	1.3573

lrldi	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
cash	.285406	.0663884	4.30	0.000	.1552555 .4155565
lowirrarea	-.0455163	.0249923	-1.82	0.069	-.0945122 .0034796
corn	.299971	.0584794	5.13	0.000	.1853257 .4146163
upland	.028341	.0167654	1.69	0.091	-.0045266 .0612086
highvalue	.3187988	.1737627	1.83	0.067	-.0218527 .6594502
il_fpi3	.6076598	.0433786	14.01	0.000	.5226186 .6927009
homefin	.6057857	.0624081	9.71	0.000	.4834384 .7281331
rice	.1329359	.0515288	2.58	0.010	.0319167 .2339551
mcgbankav	.5094715	.0651348	7.82	0.000	.3817787 .6371644
banana	.3860973	.0853127	4.53	0.000	.2188468 .5533478
industrial	.5331771	.1520985	3.51	0.000	.2349971 .8313571
workover2l	.0073799	.0004248	17.37	0.000	.0065472 .0082126
live	.4231314	.0937061	4.52	0.000	.2394262 .6068366
creditrepay	1.742027	.0377881	46.10	0.000	1.667945 1.816108
farmimp	.0736015	.0733389	1.00	0.316	-.0701749 .2173779
prodloan	.0985224	.0862323	1.14	0.253	-.0705309 .2675757
farm	1.572874	.0447268	35.17	0.000	1.48519 1.660558
phfacil	.5824764	.2035183	2.86	0.004	.1834909 .9814619
permanent	.0878108	.1416556	0.62	0.535	-.1898965 .3655181
fulltime	.0299464	.0010038	29.83	0.000	.0279784 .0319144

. predict u, resid

```

Random-effects ML regression                Number of obs   =       5002
Group variable (i): ID                    Number of groups =       4995

Random effects u_i ~ Gaussian              Obs per group:  min =         1
                                           avg =         1.0
                                           max =         2

LR chi2(14)                               =       99.55
Log likelihood = -2296.2373                Prob > chi2     =       0.0000

```

comorg	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
farmerorg	-.0229624	.0208189	-1.10	0.270	-.0637668 .0178419
creditorg	-.0048264	.0291862	-0.17	0.869	-.0620304 .0523776
watermain	.0256753	.0114305	2.25	0.025	.0032719 .0480786
il_fpi1	.0316677	.0122089	2.59	0.009	.0077387 .0555967
il_fpi3	-.0363805	.0127919	-2.84	0.004	-.0614521 -.0113088
il_ph5	.0338524	.0131409	2.58	0.010	.0080967 .0596082
il_ph6	.0048062	.0135485	0.35	0.723	-.0217483 .0313607
il_tl2	.055383	.0154761	3.58	0.000	.0250504 .0857156
il_ms2	-.0384982	.0191267	-2.01	0.044	-.0759859 -.0010105
il_och1	.0273024	.0129664	2.11	0.035	.0018886 .0527161
bd4	.0276628	.0325462	0.85	0.395	-.0361266 .0914521
bd5	-.0018906	.0569713	-0.03	0.974	-.1135523 .1097712
bdr3	.0089672	.0247878	0.36	0.718	-.039616 .0575503
bdr6	.0679065	.0595668	1.14	0.254	-.0488424 .1846554
_cons	.1292147	.0100087	12.91	0.000	.1095981 .1488313
/sigma_u	0	.1336917	0.00	1.000	-.262031 .262031

```

/sigma_e | .3829409 .0038286 100.02 0.000 .375437 .3904448
-----+-----
rho | 0 . . .
-----+-----

```

Likelihood-ratio test of sigma_u=0: chibar2(01)= 0.00 Prob>=chibar2 = 1.000

. predict uhat2, e

Source	SS	df	MS	Number of obs =	5002
Model	.011721079	4	.00293027	F(4, 4998) =	7.01
Residual	2.08856862	4998	.000417881	Prob > F =	0.0000
				R-squared =	0.0056
				Adj R-squared =	0.0048
Total	2.1002897	5002	.00041989	Root MSE =	.02044

uhat2	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
islam	.0079576	.0020205	3.94	0.000	.0039965 .0119186
single	.0024523	.0010038	2.44	0.015	.0004845 .0044202
sales	-.0000584	.0000309	-1.89	0.058	-.0001189 2.08e-06
tenant	-.0014335	.0007337	-1.95	0.051	-.002872 4.96e-06

. predict ehat3

. regress uhat3 d, noconstant

Source	SS	df	MS	Number of obs =	5002
Model	1547.45437	1	1547.45437	F(1, 5001) =	899.38
Residual	8604.59165	5001	1.72057421	Prob > F =	0.0000
				R-squared =	0.1524
				Adj R-squared =	0.1523
Total	10152.046	5002	2.02959736	Root MSE =	1.3117

uhat3	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
d	.0004549	.0000152	29.99	0.000	.0004251 .0004846

. gen lfinalterdi=log(finalterdi)

```

Generalized linear models          No. of obs      =      5002
Optimization      : ML: Newton-Raphson  Residual df    =      5001
Scale parameter   = .0494573
Deviance          = 247.3357966          (1/df) Deviance = .0494573
Pearson           = 247.3357966          (1/df) Pearson  = .0494573

Variance function: V(u) = 1          [Gaussian]
Link function     : g(u) = ln(u/(1-u)) [Logit]
Standard errors  : OIM
Log likelihood    = 422.5917973          AIC              = -.1685693
BIC               = -42349.14735

```

lfinalterdi	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
_cons	-.7042495	.0142028	-49.59	0.000	-.7320865 -.6764124

. gen ffte=exp(lfinalterdi-.7042495)

Variable	Obs	Mean	Std. Dev.	Min	Max
ffte	5002	.7045425	.1427215	.3471777	.9351272

APPENDIX 8: PRODUCTION FRONTIER MODEL (MODEL 2) FOR INCOME RESULTS

Source	SS	df	MS	Number of obs =	5326
Model	596709.769	34	17550.2873	F(34, 5292) =	2584.66
Residual	35933.6435	5292	6.79018206	Prob > F =	0.0000
				R-squared =	0.9432
				Adj R-squared =	0.9428
Total	632643.412	5326	118.783968	Root MSE =	2.6058

ltotalinc	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
area	.0573434	.0144001	3.98	0.000	.0291134	.0855735
pasture	.2724178	.1928181	1.41	0.158	-.1055851	.6504207
il_fpi3	.6022401	.0803514	7.50	0.000	.4447182	.7597621
mccoopav	.67189	.083117	8.08	0.000	.5089464	.8348337
mcgbankav	.5413176	.1244969	4.35	0.000	.2972523	.7853829
mcgfiac	.7693056	.3717522	2.07	0.039	.0405181	1.498093
creditgov	1.032905	.0999866	10.33	0.000	.8368905	1.22892
creditrepay	1.603965	.1040977	15.41	0.000	1.399891	1.80804
prodloan	.2633697	.156125	1.69	0.092	-.0426997	.5694392
farmequip	.7109045	.4102669	1.73	0.083	-.0933878	1.515197
phfacil	1.586861	.3729696	4.25	0.000	.8556874	2.318036
comfin	.3763184	.1509731	2.49	0.013	.0803489	.6722879
consloan	.7416051	.2396307	3.09	0.002	.2718302	1.21138
homefin	.6483972	.117121	5.54	0.000	.4187918	.8780025
corn	.7818903	.1145975	6.82	0.000	.5572319	1.006549
coconut	.7392534	.1321736	5.59	0.000	.4801387	.9983681
industrial	1.168788	.2863117	4.08	0.000	.6074994	1.730077
cash	.3692052	.1262547	2.92	0.003	.121694	.6167164
banana	-.431082	.1624925	-2.65	0.008	-.7496342	-.1125297
riceint	.4156937	.0513985	8.09	0.000	.3149314	.516456
work6_12	.005843	.0038121	1.53	0.125	-.0016303	.0133162
work17_21	.0025226	.0016306	1.55	0.122	-.0006741	.0057193
workover21	.0084803	.0008157	10.40	0.000	.0068812	.0100795
fulltime	.0206289	.0023327	8.84	0.000	.0160558	.025202
farm	1.462155	.1299373	11.25	0.000	1.207424	1.716886
nonfarm	5.276055	.0856196	61.62	0.000	5.108205	5.443905
empfff	1.97632	.1241209	15.92	0.000	1.732992	2.219648
empent	1.772595	.1031134	17.19	0.000	1.57045	1.974739
prof	.0176714	.0035563	4.97	0.000	.0106995	.0246433
service	.0149379	.0030297	4.93	0.000	.0089984	.0208775
agri	-.0148921	.0033789	-4.41	0.000	-.0215161	-.008268
own	.4103475	.1111938	3.69	0.000	.1923617	.6283333
leased	.4239898	.2640287	1.61	0.108	-.0936153	.9415948
tenant	.4355807	.1315043	3.31	0.001	.177778	.6933834

. predict u1, resid

. regress u1 d, noconstant

Source	SS	df	MS	Number of obs =	5326
Model	1225.0223	1	1225.0223	F(1, 5325) =	187.94
Residual	34708.6212	5325	6.51805094	Prob > F =	0.0000
				R-squared =	0.0341
				Adj R-squared =	0.0339
Total	35933.6436	5326	6.74683506	Root MSE =	2.553

u1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
d	.0004222	.0000308	13.71	0.000	.0003618	.0004826

. predict u2, resid

```

Generalized linear models
Optimization      : ML: Newton-Raphson
Deviance          = 33704.22144
Pearson           = 33704.22144
No. of obs       = 5326
Residual df      = 5309
Scale parameter  = 6.348507
(1/df) Deviance = 6.348507
(1/df) Pearson  = 6.348507

Variance function: V(u) = 1
Link function     : g(u) = ln(u/(1-u))
Standard errors   : OIM
[Gaussian]
[Logit]

Log likelihood    = -12470.56183
BIC               = -11848.88732
AIC               = 4.689283

```

u2	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
femaleheaded	-11.41005	6.826552	-1.67	0.095	-24.78984 1.969746
ink	12.96357	8.315626	1.56	0.119	-3.334757 29.2619
dependl6	1.222137	.6217165	1.97	0.049	.0035947 2.440679
nuclearfam	-141.8734	71.14385	-1.99	0.046	-281.3128 -2.434054
sch6_l2	-.3960306	.2040984	-1.94	0.052	-.796056 .0039948
schl3_l6	-1.517638	.7559284	-2.01	0.045	-2.99923 -.0360455
il_ph5	-253.21	127.9089	-1.98	0.048	-503.9068 -2.513145
il_ph6	42.44212	21.73064	1.95	0.051	-.149163 85.03339
il_tft4	-227.868	115.258	-1.98	0.048	-453.7695 -1.966484
il_tl3	38.74271	20.68604	1.87	0.061	-1.80117 79.2866
il_ocb2	4.633387	3.301879	1.40	0.161	-1.838176 11.10495
il_ti2	-6.989196	4.352563	-1.61	0.108	-15.52006 1.541671
il_ti7	40.78323	20.69941	1.97	0.049	.2131343 81.35332
bd5	44.69259	24.32985	1.84	0.066	-2.993049 92.37823
bdr2	-90.61268	45.84645	-1.98	0.048	-180.4701 -.7552879
bdr3	318.7326	160.6427	1.98	0.047	3.878677 633.5865
_cons	108.1582	54.0603	2.00	0.045	2.201934 214.1144

```

. predict p3
(option mu assumed; predicted mean u2)

```

Variable	Obs	Mean	Std. Dev.	Min	Max
tetotalinc	5326	1.370173	.697646	1	2.718282

```

.

```

Variable	Obs	Mean	Std. Dev.	Min	Max
p3	5326	.2175341	.4074387	0	1

```

. sum tetotalinc

```

Variable	Obs	Mean	Std. Dev.	Min	Max
tetotalinc	5326	.8611859	.2586368	.3678795	1

APPENDIX 9: PRODUCTION FRONTIER MODEL (MODEL 2) FOR RDI RESULTS

Source	SS	df	MS	Number of obs =	5326
Model	52356.62	23	2276.37478	F(23, 5303) =	196.52
Residual	61425.5237	5303	11.583165	Prob > F =	0.0000
				R-squared =	0.4601
				Adj R-squared =	0.4578
Total	113782.144	5326	21.3635268	Root MSE =	3.4034

lrldi	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
il_fpi3	.3109322	.1042539	2.98	0.003	.1065516 .5153128
mcgbankav	.2943851	.1719954	1.71	0.087	-.0427967 .6315669
mcgfiav	.6196363	.331687	1.87	0.062	-.0306068 1.269879
mcgfiac	-1.987411	.5785247	-3.44	0.001	-3.121557 -.8532647
creditgov	.5381102	.130171	4.13	0.000	.2829215 .7932989
creditrepay	.6254965	.1354882	4.62	0.000	.3598839 .8911091
prodloan	-.6782187	.2022008	-3.35	0.001	-1.074616 -.2818219
consloan	.5811354	.3121752	1.86	0.063	-.0308564 1.193127
permanent	-.5214483	.340371	-1.53	0.126	-1.188715 .1458188
riceint	-.1313839	.0623407	-2.11	0.035	-.2535973 -.0091704
workover21	.0052556	.0010542	4.99	0.000	.003189 .0073222
fulltime	.0070556	.0028379	2.49	0.013	.0014922 .0126191
nonfarm	1.109664	.1072592	10.35	0.000	.899392 1.319936
empfff	.7105169	.1169772	6.07	0.000	.4811935 .9398402
empent	.5726917	.1336164	4.29	0.000	.3107487 .8346347
admin	.0130627	.007434	1.76	0.079	-.001511 .0276363
service	.0081836	.0038056	2.15	0.032	.0007232 .0156441
own	.6682702	.1279929	5.22	0.000	.4173515 .9191889
leased	.6234476	.340181	1.83	0.067	-.0434471 1.290342
mortgage	.9232939	.4937293	1.87	0.062	-.0446186 1.891206
tenant	1.061376	.1599086	6.64	0.000	.7478891 1.374862
inheriten-y	1.057923	.4245387	2.49	0.013	.2256522 1.890193
amortizing	.831036	.5578267	1.49	0.136	-.2625338 1.924606

. predict p1

Source	SS	df	MS	Number of obs =	5326
Model	132.860463	1	132.860463	F(1, 5325) =	11.54
Residual	61292.663	5325	11.5103593	Prob > F =	0.0007
				R-squared =	0.0022
				Adj R-squared =	0.0020
Total	61425.5235	5326	11.5331437	Root MSE =	3.3927

u1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
d	.0004526	.0001332	3.40	0.001	.0001914 .0007138

. predict u2, resid

Generalized linear models	No. of obs	=	5326
Optimization : ML: Newton-Raphson	Residual df	=	5305
	Scale parameter	=	11.48695
Deviance = 60938.26884	(1/df) Deviance	=	11.48695
Pearson = 60938.26884	(1/df) Pearson	=	11.48695
Variance function: V(u) = 1	[Gaussian]		
Link function : g(u) = ln(u/(1-u))	[Logit]		
Standard errors : OIM			
Log likelihood = -14047.69235	AIC	=	5.283024
BIC = 15419.4815			

u2	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
il_fpi1	-103.7355	121.3987	-0.85	0.393	-341.6725 134.2015
il_fpi6	49.02618	56.89279	0.86	0.389	-62.48164 160.534
il_lti1	13.86375	23.10037	0.60	0.548	-31.41215 59.13965
il_mc1	-227.584	261.9156	-0.87	0.385	-740.9292 285.7611
il_ms1	147.5004	170.9743	0.86	0.388	-187.6031 482.6039
il_ms2	15.67673	28.7194	0.55	0.585	-40.61227 71.96572
il_och2	14.58061	20.58066	0.71	0.479	-25.75675 54.91797
il_os1	59.07862	72.98629	0.81	0.418	-83.97188 202.1291
il_ph4	9.063902	17.20784	0.53	0.598	-24.66284 42.79065
il_ph5	-5.358641	9.34312	-0.57	0.566	-23.67082 12.95354
il_tft3	-135.0559	159.2869	-0.85	0.397	-447.2524 177.1406
il_tft4	177.3639	203.1055	0.87	0.383	-220.7157 575.4434
il_tft5	25.40797	39.28396	0.65	0.518	-51.58718 102.4031
il_tft6	-115.1525	137.1611	-0.84	0.401	-383.9833 153.6783
il_ti7	-44.99301	52.95184	-0.85	0.395	-148.7767 58.7907
il_tl3	69.61159	80.28455	0.87	0.386	-87.74324 226.9664
bd3	-44.29268	1218.404	-0.04	0.971	-2432.32 2343.735
bdr2	59.03838	81.54318	0.72	0.469	-100.7833 218.8601
bdr3	33.72659	50.50306	0.67	0.504	-65.2576 132.7108
bdr6	-92.88356	1224.729	-0.08	0.940	-2493.307 2307.54
_cons	-108.1061	123.9657	-0.87	0.383	-351.0744 134.8623

. predict p3

. sum terdi

Variable	Obs	Mean	Std. Dev.	Min	Max
terdi	5326	.9528485	.1643609	.3678795	1

.

**APPENDIX 10: PRODUCTION FRONTIER MODEL (HALF-NORMAL)
FOR TOTAL INCOME RESULTS**

Stoc. frontier normal/truncated-normal model Number of obs = 5326
 Wald chi2(26) = 162033.24
 Log likelihood = -608899.22 Prob > chi2 = 0.0000

totalinc	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
totalinc					
area	63628.29	4627.943	13.75	0.000	54557.68 72698.89
lowirrarea	1276494	14162.05	90.13	0.000	1248737 1304251
fulltime	46908.6	614.046	76.39	0.000	45705.09 48112.1
upland	146859.8	10076.34	14.57	0.000	127110.5 166609
pasture	506747.3	55770.18	9.09	0.000	397439.8 616054.8
industrial	905773.9	82374.1	11.00	0.000	744323.7 1067224
riceint	1041186	21820.86	47.72	0.000	998418.3 1083955
mccoopac	-135387.8	35759.6	-3.79	0.000	-205475.3 -65300.23
mcgbankav	449191.6	35393.1	12.69	0.000	379822.4 518560.8
cornint	202063.4	18581.66	10.87	0.000	165644.1 238482.8
farm	299836.9	36917.44	8.12	0.000	227480 372193.7
mcgfiac	423881.7	106257.9	3.99	0.000	215620 632143.4
nonfarm	2898507	23511.59	123.28	0.000	2852425 2944589
creditrepay	99569.44	21849.79	4.56	0.000	56744.64 142394.2
farmimp	66692.91	39927.9	1.67	0.095	-11564.34 144950.1
banana	-433439.8	46603.83	-9.30	0.000	-524781.6 -342098
workover21	-4058.362	235.605	-17.23	0.000	-4520.139 -3596.585
phfacil	5314634	108310.2	49.07	0.000	5102350 5526918
comfin	-716803.3	43711.3	-16.40	0.000	-802475.8 -631130.7
livestock	946833.9	45545.45	20.79	0.000	857566.5 1036101
empfff	-28023.54	35870.62	-0.78	0.435	-98328.66 42281.58
empent	-305930.2	29499.07	-10.37	0.000	-363747.3 -248113.1
rice	-1018055	42789.27	-23.79	0.000	-1101921 -934189.8
cash	-354924.5	35824.4	-9.91	0.000	-425139.1 -284710
coconut	574363.4	38249.63	15.02	0.000	499395.5 649331.3
work17_21	1062.214	469.2241	2.26	0.024	142.5517 1981.876
mu					
phmain	-.0530822	50.31414	-0.00	0.999	-98.66698 98.56081
il_ph4	-.0181091	127.844	-0.00	1.000	-250.5877 250.5514
il_ph5	.0316559	.	.	.	.
il_ph6	-.0299874	68.2365	-0.00	1.000	-133.7711 133.7111
il_mc1	-.0211947	.	.	.	.
il_ms2	.0919498	.	.	.	.
il_ltil	.0257011	.	.	.	.
il_os3	.0729574	.	.	.	.
bd5	-.0048892	.	.	.	.
bdr3	-.0346499	.	.	.	.
bdr6	-.0367729	.	.	.	.
femaleheaded	.0682635	.	.	.	.
hhsiz	-.0073009	4.169869	-0.00	0.999	-8.180094 8.165493
/lnsigma2	27.06494	.0013449	20124.60	0.000	27.0623 27.06757
/ilgtgamma	-30.45448	164.6212	-0.18	0.853	-353.1061 292.1971
sigma2	5.68e+11	7.64e+08			5.66e+11 5.69e+11
gamma	5.94e-14	9.78e-12			4.4e-154 1
sigma_u2	.033724	5.55169			-10.84739 10.91484
sigma_v2	5.68e+11	7.64e+08			5.66e+11 5.69e+11

Variable	Obs	Mean	Std. Dev.	Min	Max
tetotalinc	5326	.8668246	.02009	.7259138	.9369437

APPENDIX 11: PRODUCTION FRONTIER MODEL (HALF-NORMAL) FOR RDI RESULTS

Stoc. frontier normal/truncated-normal model Number of obs = 5006
 Wald chi2(21) = 22345.91
 Log likelihood = -22946.734 Prob > chi2 = 0.0000

rdi	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]

rdi					
cash	5.763345	1.154591	4.99	0.000	3.500389 8.026301
lowirrarea	-.0592454	.4304307	-0.14	0.891	-.902874 .7843833
corn	6.958514	1.005725	6.92	0.000	4.98733 8.929699
upland	.6536363	.2900032	2.25	0.024	.0852404 1.222032
highvalue	7.878869	2.995147	2.63	0.009	2.008488 13.74925
il_fpi3	11.08926	1.409837	7.87	0.000	8.32603 13.85249
homefin	9.488043	1.072172	8.85	0.000	7.386624 11.58946
rice	4.420164	.9039765	4.89	0.000	2.648403 6.191926
mcgbankav	8.505643	1.123379	7.57	0.000	6.303861 10.70742
banana	6.231354	1.463377	4.26	0.000	3.363189 9.09952
industrial	11.31061	2.625555	4.31	0.000	6.164612 16.4566
workover21	.1089153	.0073318	14.86	0.000	.0945452 .1232855
live	6.50314	1.610951	4.04	0.000	3.345734 9.660546
creditrepay	26.00054	.6711601	38.74	0.000	24.68509 27.31599
farmimp	3.92222	1.259747	3.11	0.002	1.453161 6.391278
prodloan	2.890311	1.482421	1.95	0.051	-.0151807 5.795803
farm	23.25332	.7767451	29.94	0.000	21.73092 24.77571
phfacil	17.84114	3.516259	5.07	0.000	10.9494 24.73288
permanent	4.096333	2.44747	1.67	0.094	-.7006202 8.893285
fulltime	.4716197	.0173172	27.23	0.000	.4376786 .5055608

mu					
comorg	-10.41729	8.392472	-1.24	0.215	-26.86624 6.031649
farmerorg	4.100987	.	.	.	.
creditor	-1.609262	16.62928	-0.10	0.923	-34.20205 30.98353
watermain	-22.91275	7.605384	-3.01	0.003	-37.81903 -8.006472
il_fpi1	-6.23268	13.66139	-0.46	0.648	-33.00851 20.54315
il_fpi3	4.50263	15.68513	0.29	0.774	-26.23966 35.24492
il_ph5	-7.302225	.	.	.	.
il_ph6	-10.4708	9.495631	-1.10	0.270	-29.08189 8.140296
il_tl2	-20.83305	11.60594	-1.80	0.073	-43.58028 1.914175
il_ms2	-2.640425	10.6917	-0.25	0.805	-23.59576 18.31491
il_ocb1	-6.651272	9.251208	-0.72	0.472	-24.78331 11.48076
bd4	-2.368892	27.23924	-0.09	0.931	-55.75683 51.01904
bd5	-33.14655	.	.	.	.
bdr3	5.049293	21.99942	0.23	0.818	-38.06877 48.16736
bdr6	47.70626	.	.	.	.
islam	-1.184846	12.67204	-0.09	0.926	-26.02159 23.65189
single	-21.96257	11.44684	-1.92	0.055	-44.39797 .472826
sales	-2.125233	1.706647	-1.25	0.213	-5.470199 1.219733
tenant	2.523827	.	.	.	.

/lnsigma2	6.378412	.0325874	195.73	0.000	6.314541 6.442282
/ilgtgamma	-2.381747	.2329708	-10.22	0.000	-2.838361 -1.925132

sigma2	588.9914	19.19369			552.5486 627.8377
gamma	.0845752	.0180371			.0552861 .1272903
sigma_u2	49.81408	11.89472			26.50085 73.12731
sigma_v2	539.1773	11.8454			515.9608 562.3939

. sum terdi					
Variable	Obs	Mean	Std. Dev.	Min	Max
terdi	5006	.3968948	.1633236	0	.8187075

**APPENDIX 12: SAR MODEL FOR NON-AGRICULTURE INCOME (USING FIES 2003)
RESULTS**

Source	SS	df	MS	Number of obs =
Model	43608.0533	47	927.830922	27783
Residual	11852.9128	27735	.427362998	F(47, 27735) = 2171.06
				Prob > F = 0.0000
				R-squared = 0.7863
				Adj R-squared = 0.7859
Total	55460.9661	27782	1.99629134	Root MSE = .65373

lnaginc	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
agrihh	-1.53018	.0102068	-149.92	0.000	-1.550186 -1.510174
malehead	-.0857743	.0180284	-4.76	0.000	-.1211108 -.0504378
hhage	.005431	.0003543	15.33	0.000	.0047365 .0061254
marriedhead	.0850989	.0176456	4.82	0.000	.0505128 .1196851
headelem	.278743	.0184082	15.14	0.000	.2426621 .314824
headhs	.4084108	.0197887	20.64	0.000	.3696239 .4471977
headunder	.5276068	.0240045	21.98	0.000	.4805568 .5746568
headcoll	.60926	.028348	21.49	0.000	.5536965 .6648235
mnrggov	.0065826	.0224266	0.29	0.769	-.0373746 .0505399
prof	.1611614	.0438911	3.67	0.000	.0751326 .2471901
techniaprof	-.0281913	.03855	-0.73	0.465	-.1037512 .0473685
clerk	.01833	.0415811	0.44	0.659	-.0631711 .0998311
service	.0504507	.0299037	1.69	0.092	-.0081621 .1090635
farmer	-.2626883	.0187186	-14.03	0.000	-.2993777 -.2259989
trade	.026351	.0245076	1.08	0.282	-.0216851 .074387
operator	.1148352	.0250806	4.58	0.000	.065676 .1639944
laborer	-.1660681	.0225895	-7.35	0.000	-.2103447 -.1217914
spocc	.1986786	.0571302	3.48	0.001	.0867006 .3106566
pvthh	.1123569	.0395229	2.84	0.004	.03489 .1898238
pvtest	.0264095	.0143165	1.84	0.065	-.0016516 .0544705
govt	.153146	.0223896	6.84	0.000	.1092613 .1970307
own	.0618325	.013282	4.66	0.000	.0357991 .0878659
workpayown	.0466034	.1006198	0.46	0.643	-.1506165 .2438232
worknopayown	.0896592	.0493983	1.82	0.070	-.0071638 .1864822
nuclear	-.0573938	.0109361	-5.25	0.000	-.0788291 -.0359585
pemplod	.0006539	.0002266	2.89	0.004	.0002098 .001098
plessi5	-.0009035	.0002336	-3.87	0.000	-.0013613 -.0004457
spousemp	.1459247	.0099997	14.59	0.000	.1263248 .1655247
FOOD	.0000148	2.78e-07	53.34	0.000	.0000143 .0000154
FDOUT	-2.17e-06	8.21e-07	-2.65	0.008	-3.78e-06 -5.65e-07
fuelightwa~r	.0000629	3.05e-06	20.64	0.000	.000057 .0000689
petrol	-.0001152	.000011	-10.46	0.000	-.0001368 -.0000937
elecexp	-.0000253	3.70e-06	-6.85	0.000	-.0000326 -.0000181
waterexp	-.0000478	5.21e-06	-9.18	0.000	-.0000581 -.0000376
landfare	.0000191	1.36e-06	14.04	0.000	.0000164 .0000217
airfare	8.35e-06	2.66e-06	3.14	0.002	3.13e-06 .0000136
waterfare	.0000157	3.39e-06	4.62	0.000	9.02e-06 .0000223
gasdiesel	3.13e-06	1.53e-06	2.05	0.041	1.34e-07 6.13e-06
tel	-9.92e-06	2.81e-06	-3.53	0.000	-.0000154 -4.41e-06
MEDIC	5.56e-06	5.20e-07	10.70	0.000	4.54e-06 6.58e-06
excrop	1.33e-06	2.18e-07	6.09	0.000	9.01e-07 1.76e-06
exlive	1.72e-06	3.93e-07	4.39	0.000	9.54e-07 2.49e-06
exfish	1.31e-06	2.80e-07	4.67	0.000	7.58e-07 1.86e-06
exforest	1.56e-06	1.01e-06	1.55	0.120	-4.09e-07 3.54e-06
exwholeret~l	9.67e-08	2.02e-08	4.78	0.000	5.70e-08 1.36e-07
exmanuf	-2.65e-07	8.19e-08	-3.23	0.001	-4.25e-07 -1.04e-07
extransp	8.55e-07	1.81e-07	4.73	0.000	5.01e-07 1.21e-06
_cons	9.6132	.0371565	258.72	0.000	9.540371 9.686028

. predict pnaginc

Source	SS	df	MS	Number of obs =
Model	1379.91794	1	1379.91794	27783
				F(1, 27782) = 3660.55
				Prob > F = 0.0000

Residual	|	10472.9948	27782	.376970515		R-squared	=	0.1164
-----+-----								
Total	|	11852.9128	27783	.426624654		Adj R-squared	=	0.1164
						Root MSE	=	.61398

e1	|	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
-----+-----							
d	|	.0281819	.0004658	60.50	0.000	.0272689	.0290949

. predict eh, resid

. sum lnaginmape

Variable	|	Obs	Mean	Std. Dev.	Min	Max
-----+-----						
lnaginmape	|	27783	4.824561	5.005045	.0000251	180.8987

.

**APPENDIX 13: SAR MODEL FOR AGRICULTURE INCOME (USING FIES 2003)
RESULTS**

Source	SS	df	MS	Number of obs =	25492
Model	25083.5963	46	545.295571	F(46, 25445) =	409.79
Residual	33859.0104	25445	1.33067441	Prob > F =	0.0000
				R-squared =	0.4256
				Adj R-squared =	0.4245
Total	58942.6067	25491	2.31229087	Root MSE =	1.1535

laginc	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
malehead	.2480851	.0342241	7.25	0.000	.181004 .3151663
hhage	-.0017967	.0006493	-2.77	0.006	-.0030693 -.0005241
marriedhead	.0402037	.0329344	1.22	0.222	-.0243496 .104757
headelem	-.0792299	.0327309	-2.42	0.016	-.1433844 -.0150754
headhs	-.331673	.03524	-9.41	0.000	-.4007453 -.2626006
headunder	-.5315983	.0440898	-12.06	0.000	-.6180168 -.4451797
headcoll	-.6295256	.0544892	-11.55	0.000	-.7363276 -.5227236
mnrggov	-.143542	.0437666	-3.28	0.001	-.2293271 -.0577569
prof	-.597688	.0913043	-6.55	0.000	-.7766497 -.4187263
techniaprof	-.5137368	.0768281	-6.69	0.000	-.6643242 -.3631493
clerk	-.734333	.0850501	-8.63	0.000	-.9010362 -.5676299
service	-.8044926	.0592729	-13.57	0.000	-.920671 -.6883143
farmer	1.201679	.0347842	34.55	0.000	1.1335 1.269858
trade	-.6552472	.0463711	-14.13	0.000	-.7461373 -.5643571
operator	-.887906	.0480297	-18.49	0.000	-.982047 -.793765
laborer	.5106462	.0429012	11.90	0.000	.4265574 .5947351
spocc	-.6577374	.1136766	-5.79	0.000	-.88055 -.4349247
pvthh	-.2292714	.0741008	-3.09	0.002	-.3745131 -.0840296
pvtest	.3284705	.0271103	12.12	0.000	.2753328 .3816082
govt	.032962	.0438431	0.75	0.452	-.0529731 .118897
own	.1284396	.0238506	5.39	0.000	.0816911 .1751882
workpayown	.3655942	.1820338	2.01	0.045	.0087975 .7223909
worknopayown	.0770633	.0928139	0.83	0.406	-.1048573 .2589839
nuclear	.0125636	.0202315	0.62	0.535	-.0270914 .0522185
pemployed	-.0001039	.0004202	-0.25	0.805	-.0009276 .0007197
pless15	.0018238	.0004306	4.24	0.000	.0009799 .0026678
spousemp	-.029122	.0183898	-1.58	0.113	-.0651671 .0069231
FOOD	.0000137	5.34e-07	25.62	0.000	.0000126 .0000147
FDOUT	-.0000241	1.68e-06	-14.34	0.000	-.0000274 -.0000208
fuelightwa-r	.0000989	5.59e-06	17.70	0.000	.000088 .0001099
petrol	.0001213	.0000212	5.73	0.000	.0000798 .0001627
elecexp	-.0001464	7.13e-06	-20.54	0.000	-.0001604 -.0001325
waterexp	-.0001917	.0000104	-18.38	0.000	-.0002121 -.0001712
landfare	-.0000293	2.84e-06	-10.29	0.000	-.0000349 -.0000237
airfare	-9.85e-06	5.26e-06	-1.87	0.061	-.0000202 4.54e-07
waterfare	-.0000146	7.75e-06	-1.88	0.060	-.0000298 5.98e-07
gasdiesel	3.30e-06	3.51e-06	0.94	0.346	-3.57e-06 .0000102
tel	.0000224	6.36e-06	3.52	0.000	9.96e-06 .0000349
MEDIC	1.36e-06	9.90e-07	1.37	0.171	-5.84e-07 3.30e-06
excrop	.0000126	3.87e-07	32.49	0.000	.0000118 .0000133
exlive	.0000109	7.35e-07	14.76	0.000	9.41e-06 .0000123
exfish	7.25e-06	4.96e-07	14.62	0.000	6.27e-06 8.22e-06
exforest	7.03e-06	1.78e-06	3.96	0.000	3.55e-06 .0000105
exwholeret~l	-4.20e-07	6.53e-08	-6.43	0.000	-5.48e-07 -2.92e-07
exmanuf	6.48e-08	1.59e-07	0.41	0.683	-2.46e-07 3.76e-07
extranosp	-9.31e-07	3.33e-07	-2.79	0.005	-1.58e-06 -2.78e-07
_cons	8.292025	.0676764	122.52	0.000	8.159375 8.424674

. predict paginc

Source	SS	df	MS	Number of obs =	25492
Model	3366.64946	1	3366.64946	F(1, 25491) =	2814.45
Residual	30492.3609	25491	1.19620105	Prob > F =	0.0000
				R-squared =	0.0994
				Adj R-squared =	0.0994

Total | 33859.0104 25492 1.32822103 Root MSE = 1.0937

e1	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
d	.0311404	.000587	53.05	0.000	.0299899 .032291

. predict eh, resid

Variable	Obs	Mean	Std. Dev.	Min	Max
lagincmape	25492	9.287714	13.89095	.0003315	344.8743