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by

ERNIEL B. BARRIOS

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School of Statistics
Ramon Magsaysay Avenue
U.P. Diliman, Quezon City
Telefax: 928-08-81
Email: updstat@yahoo.com

Efficient access of rural development among households

ERNIEL B. BARRIOS
Professor, School of Statistics
University of the Philippines Diliman

Abstract

The search for an effective policy direction to contribute in the alleviation of rural poverty requires understanding of various socio-economic dynamics affecting the household. Spatial externalities are introduced into the 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.

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

INTRODUCTION

Patterns of processes in rural societies 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 rural residents have opted to join the rural to 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.

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 per cent 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 polices 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 Kuroda (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.

LITERATURE REVIEW

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.

Stochastic Frontier Model

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 $y_i = f(x_i;\beta)\exp(v_i)TE_i$ or $TE_i = \dfrac{y_i}{f(x_i;\beta)\exp(v_i)}$, 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.

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.

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.

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.

MODELING STRATEGIES

The dynamics in a typical rural community is 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.

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. 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).

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.

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.

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, nonlinear, or nonparametric. The additive model is given by

y = $\alpha + \sum_{j=1}^{r} f_j(x_j) + \varepsilon$. The function f can be of the form $f_j(x_i) = \beta_j x_j$, ε 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: α = ave(y_i), $f_j = f_j^0$, $j = 1,2,\ldots,r$

(ii) Cycle: j = 1,2,...,r

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

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

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

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 production is also affected by spatial dependence 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.

Consider a cross-sectional production frontier model $y_i = f(x_i;\beta)\exp(v_i)TE_i$ or $TE_i = \dfrac{y_i}{f(x_i;\beta)\exp(v_i)}$. $[y_i]$ 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).

Spatial dependence is postulated to affect production in an autoregressive maaner as

$$\ln y_i = \ln f(x_i;\beta) + \delta D[\ln y_i - \ln f(x_i;\beta)] + v_i - u_i \qquad (1)$$

The efficiency equation is postulated as a logistic function in (2) to address the constraint that the technical efficiency is at most 1.

$$u = \frac{1}{1+\exp(-w\varphi)} + \varepsilon \,. \qquad (2)$$

δ is a spatial parameter, $D = \lfloor (d_{ij}) \rfloor$, the spatial weight matrix where

$d_{ij} = \begin{cases} 1, \text{if unit i and unit j are spatially related} \\ 0, \quad \text{otherwise} \end{cases}$. Two households will be considered spatially related if they belong to the same barangay or village. 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. w_i is a vector of fixed and random factors, ε is pure error.

Estimation will be done using a modified backfitting algorithm (Landagan and Barrios, 2007), taking advantage of the additive nature of (1) and (2). The estimation algorithm follows:

1. Depending on the link function f, ignore u_i and D in (1) and estimate β using maximum likelihood estimation (MLE) or least squares estimation (LSE).
2. Compute the residuals from (1), $\hat{u}_i = \ln f\left(x_i; \hat{\beta}\right) - \ln y_i$. This now contains information on φ and δ.
3. Compute D and estimate β and δ simultaneously, setting aside the efficiency determinants.
4. Compute residuals and regress it on w using (2) to estimate φ.
5. Iterate from 1.

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

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:

$$S_1 = \begin{cases} 1, \text{if household derive income from farming activities} \\ 0, \text{otherwise} \end{cases}$$

and $S_2 = \begin{cases} 1, \text{if household derive income from non-farming activities} \\ 0, \text{otherwise} \end{cases}$. 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 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.

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.

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 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.

Rural Development Index

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.

Other 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.

CONCLUDING NOTES

Microeconometric 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 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.

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