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THE SPATIAL DIVISION OF LABOR IN NEPAL

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Abstract

This paper examines how economic activity and market participation are distributed across space. Applying a non-parametric von Thünen model to Nepalese data, we uncover a strong spatial division of labor. Non-farm employment is heavily concentrated in and around cities while agricultural wage employment dominates villages located further away. Vegetable production takes place primarily in the vicinity of urban centers while paddy and other commercial crops are more important at intermediate distances. Isolated villages revert to self-subsistence. These findings are consistent with the von Thünen model of concentric specialization, except that they also show the importance of city size. Spatial division of labor is closely related to asset and human capital accumulation, especially at the local level. We discuss the policy implications for road construction and the placement of rural development projects.

1 Introduction

After decades of neglect, the economics profession has rekindled its interest in geographical phenomena. Much recent work has been devoted to agglomeration effects across regions and countries (e.g. Krugman 1991b, Fujita, Krugman and Venables 1999a, Ciccone and Hall 1996). Apart from research focusing on cities (e.g. Henderson 1974, Lampard 1968, Abdel-Rahman 1994, Rauch 1993, Fujita, Krugman and Mori 1999b, Arthur 1988, Glaeser, Kallal, Sheinkman and Shleifer 1992, Ellison and Glaeser 1997, Glaeser, Scheinkman and Shleifer 1995), most empirical work has remained at a fairly aggregate geographical level (e.g., Ciccone and Hall (1996), Radelet and Sachs (1998), Hummels (1995), Hall and Jones (1996) on countries; Desmet (1998) on European regions; Barro and Sala-I-Martin (1991) on U.S. states). Little attention has been devoted to more disaggregated geographical units that have a predominantly rural character, such

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as villages or counties (see, however, Ciccone and Hall (1996), Ciccone (1997), Fafchamps and Helms (1996), Desmet and Fafchamps (2000)). This is somewhat surprising given that much of traditional economic geography focuses on spatially disaggregated phenomena such as the distribution of cities over space and their relationship with surrounding rural areas (e.g. von Thunen 1966, Isard 1956, Christaller 1966, Losch 1954, Dicken and Lloyd 1990, Jacobs 1969).

There is also little recent work by economists on the spatial distribution of economic activity across space in rural and urban areas of the Third World, in spite of a long tradition of research on regional issues among development economists. This is not to say that there has been no work on spatial issues. The contrast between cities and countryside has long attracted the attention of development economists, to the point that this contrast has become a fundamental organizing concept of all development theory (e.g. Lewis 1954, Harris and Todaro 1970). There has also been a lot of work on work migration, non-farm production in rural areas (e.g., survey by Reardon (1997); for Nepal, see Seddon, Adhikari and Gurung (1999)), and on the spatial integration of agricultural markets (e.g. Takayama and Judge 1971, Ravallion 1986, Dercon 1995, Timmer 1986, Baulch 1997, Fafchamps and Gavian 1996). But this work remains fragmentary in the sense that it does not examine, in a comprehensive manner, how rural areas interact with each other and with cities as a function of their geographical proximity to cities.

The purpose of this paper is to begin filling this lacuna by examining how Nepalese households fit into the local economy as a function of their proximity to urban centers, in Nepal as well as India. Nepal is a particularly suitable place to study spatial specialization given the extreme diversity of the country in terms of accessibility and proximity to urban centers. At one end of the spectrum, Terai villages are but a stone throw away from densely populated Northern India, while Nepalese villages tucked in the Himalaya are among the most difficult to access anywhere on earth. As already argued by Jacoby (2000), Nepal is the perfect place to examine the effect of geographical isolation on economic activity.

Using household data from the Living Standard Measurement Survey (LSMS) of 1995/6, we investigate geographical patterns of agricultural production, agricultural sales and purchases, non-farm work, and labor migrations. Taken together, these different measures of economic activity and market participation provide a detailed picture of spatial specialization in a poor country. Our results largely confirm the von Thünen hypothesis of concentric circles of specialization around cities that vary according to transport costs (e.g. Henderson 1988, Dicken and Lloyd 1990, Abdel-Rahman 1988, Fujita 1988). To simplify, individuals living near markets and cities are more likely to engage in non-farm work rather than produce agricultural goods for sale. The switch from non-farm activity to agricultural production for nearby markets occurs only in more distant villages, with vegetables being produced close to cities and staple products produced further away. Minten and Kyle (1999) obtain a similar result in Zaire. Villages too far to export agricultural products tend to resort either to livestock production, self-subsistence, or to long-distance labor migrations. These results

confirm earlier work in Nepal by Jacoby (2000) and Seddon et al. (1999).

We also identify the width of each concentric circle using semi-parametric methods. To control for differences in road quality, travel time is used as a measure of distance instead of mileage. Non-farm work is shown to be limited to villages and suburbs less than two hours away from cities and, within wards, less than 30 minutes from the nearest market. Vegetable production is important in the 1-3 hours range, while the production of paddy for sale dominates the 3-5 hours range. Villages and households located more than 5 hours from a market or city derive cash income from livestock and, eventually, revert to self-subsistence.

To investigate the channels through which the spatial division of labor operates, we examine how distance to cities and markets is related to asset and human capital accumulation. We find that the two are closely related, so much so that most of the within ward effect of proximity to markets disappears once we control for household assets and education. We interpret this result as consistent with endogenous sorting within wards: individuals wanting to engage in, say, non-farm activities liquidate their land and livestock and to move closer to the market center. The same is not true across wards: while some of the effect of proximity operates through accumulation, strong spatial effects remain even after controlling for household characteristics. This means that two otherwise identically endowed households engage in different activities depending of their distance from nearby cities. In the absence of panel data, however, we cannot rule out the possibility that unobserved individual characteristics account for this discrepancy. This issue deserves more research.

It would be dangerous to draw strong policy conclusions from this work without properly controlling for self-selection in road placement and human settlement, something we intend to pursue in the future. Our results, however preliminary, nevertheless suggest that the effect of road construction on economic activity is likely to differ depending on how close to a town it brings a particular rural area. Roads that open previously unsettled land more than five hours away from urban centers are likely to favor the establishment of new, largely self-subsistent village communities. In other words, they extend the frontier. In contrast, roads that bring villages closer to nearby cities could enable them to produce vegetables and other agricultural products for urban consumption. Finally, roads that bring villages within commuting distance from cities are likely to induce villagers to switch to better paying urban jobs. By extension, our results suggest that the returns from investment in irrigation and other agricultural technologies are likely to be highest in villages located 2-5 hours away from urban centers, except for vegetables where proximity to cities is an advantage.

The paper is organized as follows. Concepts and theory are discussed in Section 1, together with the econometric approach. The data and its main characteristics are presented in section 2. We also describe how our various measures of geographical proximity are constructed. Section 3 tests the effect of distance to markets and cities. Section 4 seeks to identify some of the channels through which geography affects market participation. Conclusions and policy

implications are summarized at the end.

2 Theory and Concepts

German economist von Thünen was the first to hypothesize, as early as 1842, that economic activity need not be spread evenly across space even if land is undifferentiated between locations. His basic idea was that rural areas surrounding cities specialize in different agricultural products. He further argued that the product they specialize in depends on the cost of transporting output to the market. Locations close to the city specialize in high transportation cost goods, such as milk and vegetables, while locations further away specialize in less perishable, lower transport cost commodities such as cereals and pulses. Rural communities located too far from cities to trade with them must turn to self-subsistence in both agricultural and non-agricultural commodities Krugman (1991b), the latter being produced using small-scale, artisan technology. This theory is usually represented graphically as concentric circles of specialization, beyond which lies undifferentiated self-subsistence areas. Adding to this theory, Dore (1987) and Jacobs (1984) argue that peri-urban agriculture also benefits from spillover effects in technology and marketing, thereby suggesting something like concentric circles of technology usage as well. Another addition is the realization that isolated communities can interact with the global economy by sending workers away for extended periods of time, thereby triggering patterns of long-term work migrations to cities or plantations.

Von Thünen's theory was further refined by Losch (1954), Isard (1956) and Christaller (1966) who studied the relationship between cities of various sizes and between them and surrounding rural areas. They hypothesize the existence of hierarchies of cities performing different roles, each with its own rural hinterland (see Lee (1993) and Fafchamps and Helms (1996) for illustrations in Mexico and Guatemala). These refinements do not qualitatively affect the spatial specialization idea, although they may alter the shape it takes (e.g., honeycomb instead of circle). They also bring out the role that city size has on the width of concentric circles of rural specialization, larger cities requiring more vegetable and food products than small cities. More recently, it has also been shown that, with two or more immobile factors instead of one (e.g., land), more complex patterns can be generated that include incomplete or partial specialization (e.g. Fafchamps 1997, Venables and Limao 1999).

The recent economic geography literature has revisited many of these themes (e.g. Henderson 1988, Krugman 1991a, Fujita et al. 1999a). Much attention has also been devoted to the inner organization of cities themselves (e.g. Fujita 1988, Abdel-Rahman 1993, Abdel-Rahman 1994, Henderson 1974). In this respect, the literature has emphasized one important organizing principle, namely the tension between, on the one hand, agglomeration effects that incites firms to cluster, and, on the other, housing prices and commuting costs that raise workers' wages. This has, for instance, led to models of cities whereby activities that benefit from strong agglomeration effects, such as financial services,

take over city centers while workers live at the periphery where housing costs are lower. Depending on travel costs for consumers, shopping districts locate in city center or in residential areas (e.g. Abdel-Rahman 1988, Fujita 1988). In these models, the size of cities depends critically on their ability to attract workers. This in turn depends on the strength of agglomeration effects, which affects return to labor, and on commuting costs and housing prices, which affect wages. Further refinements, such as pollution, congestion, and the provision of intermediate goods can be added to generate different structures, e.g., industrial basins surrounded by residential towns some distance away (Desmet and Fafchamps 2000).

All these theoretical predictions can be summarized as follows. In its simplest form, the concentric circle theory predicts that what a community produces depends on distance from the nearest town. Villages located nearby town centers are expected to produce perishable products with a high transport cost, such as vegetables, while villages located further away are expected to produce low transport cost commodities such as cereals and pulses. A variant suggested by the urban economics literature has workers reside away from their work place. In this variant, villages and neighborhoods located close enough to cities count a number of commuters, that is, individuals who work in the city but return to the village (the suburb) at night. The income they bring to their place of residence in turn generates suburban jobs in consumer services and retail trade – what could be called the ‘shopping mall syndrome’.

Theories of hierarchies of cities predict more complex concentric zones whose width and spatial structure depend on their interaction with various cities of different sizes. In particular, they predict that larger cities have a larger hinterland, and that rural dwellers may buy and sell from different cities simultaneously. The presence of more than one immobile factor leads to incomplete specialization, whereby villages produce a multiplicity of goods at the same time. Finally, all theories predict that isolated locations must be self-sufficient in both agricultural and non-agricultural products, except for long-term work migrations.

These predictions can be empirically investigated as follows. Consider a vector of measures of economic specialization and market participation for individual households i . Let this vector be denoted $\{y_i^z\}$ for $z = 1, \dots, Z$, where y_i^1 is, say, vegetable production, y_i^2 is non-farm self-employment, y_i^3 is rice purchases, etc. Further suppose that we have information on the distance to the market center nearest to household i , denoted d_i . The von Thünen hypothesis, in its simplest form, predicts a relationship between y_i^z and d_i . As is clear from the economic geography literature, this relationship is expected to be non-linear, with unknown inflexion points. The relationship can be written:

$$y_i^z = f(d_i) + u_i \quad (1)$$

where u_i is an error term and $f(d_i)$ is an unknown smooth function of distance to the nearest market d_i . A similar approach is adopted by Chomitz and Gray (1996) in their analysis of land use in Belize. Estimating function $f(\cdot)$ non-parametrically provides a simple way of testing various hypotheses about the

effect of location on economic activity. In addition, inflexion points and zeros of the fitted $f(\cdot)$ function provide estimates of the width of various concentric circles, hence providing useful information for policy makers.

Equation (1) presents a number of drawbacks, however. First, it does not control for town size. Yet refinements of the von Thünen hypothesis predict that the width of concentric circles and the strength of the spatial division of labor depends critically on the magnitude of urban demand and thus on town size. Second, the equation fails to account for the possible effect of more distant cities and towns. As Isard (1956) has shown, the organization of economic activity over space reverts around a hierarchy of cities and partially overlapping concentric 'circles' (or rather, hexagons). Recent contributions also emphasize a possible overlap between the effect of multiple cities (Fujita et al. 1999b). A better test of the theory should thus allow for town size and the possible effect of multiple towns. Such a test can be constructed provided we have data on urban population residing at various distances h from household i . Let this information be denoted as $\{p_i(h)\}$. An alternative, more general test of spatial division of labor can then be constructed by estimating equations of the form:

$$y_i^z = f(d_i) + \int_0^H g(h)p_i(h)dh + u_i \quad (2)$$

The presence of two unknown functions in equation (??), the fact that function $g(\cdot)$ is multiplied by population $p_i(h)$, and the presence of censoring in the dependent variable make estimation by conventional non-parametric techniques very difficult. To turn the above equation into an estimable regression model, we choose instead to discretize both functions $f(\cdot)$ and $g(\cdot)$:

$$y_i^z = \sum_{j=1}^J \tau_j D_i^j + \sum_{h=1}^H \gamma_h P_i^h + u_i \quad (3)$$

where D_i^j is a dummy variable taking the value 1 if $j-1 < d_i \leq j$, and 0 otherwise. P_i^h is the urban population residing within, say, h and $h-1$ hours of travel from household i , i.e., $P_i^h = \int_{h-1}^h p_i(s)ds$. Parameter H is chosen large enough that proximity effects die out, that is, such that $g(H) \simeq 0$. Estimation efficiency can be improved by requiring that the estimated τ_j and γ_h parameters generate smooth approximations for functions $f(\cdot)$ and $g(\cdot)$. One such method is the so-called roughness penalty method suggested by Good and Gaskins (1971) and Silverman (1982). In the case of ordinary least squares, the estimator is obtained by minimizing:

$$\begin{aligned} & \sum_{i=1}^T [y_i^z - \sum_{j=1}^J \tau_j D_i^j - \sum_{h=1}^H \gamma_h P_i^h]^2 + \sum_{j=2}^{J-1} \lambda_\tau^2 [(\tau_{j+1} - \tau_j) - (\tau_j - \tau_{j-1})]^2 \\ & + \sum_{h=2}^{H-1} \lambda_\gamma^2 [(\gamma_{h+1} - \gamma_h) - (\gamma_h - \gamma_{h-1})]^2 \end{aligned} \quad (4)$$

where T is sample size and λ_τ and λ_γ are penalty parameters.¹ Standard errors are obtained by bootstrapping.²

In case y_i^z is censored so that OLS is inappropriate, the sum of squared residuals in equation (4) can be replaced with the required likelihood function. If the estimator is tobit, for instance, the objective function with roughness penalty correction is:

$$\begin{aligned} & \sum_{y_i^z=0} \log \Phi\left(\frac{-\sum_{j=1}^J \tau_j D_i^j - \sum_{h=1}^H \gamma_h P_i^h}{\sigma_u}\right) \\ & + \sum_{y_i^z>0} \log\left[\frac{1}{\sigma_u} \phi\left(\frac{y_i^z - \sum_{j=1}^J \tau_j D_i^j - \sum_{h=1}^H \gamma_h P_i^h}{\sigma_u}\right)\right] \\ & - \sum_{j=2}^{J-1} \lambda_\tau^2 [(\tau_{j+1} - \tau_j) - (\tau_j - \tau_{j-1})]^2 - \sum_{h=2}^{H-1} \lambda_\gamma^2 [(\gamma_{h+1} - \gamma_h) - (\gamma_h - \gamma_{h-1})]^2 \end{aligned} \quad (5)$$

where $\Phi(\cdot)$ and $\phi(\cdot)$ stand for the standard normal cumulative and probability distribution, respectively.³ The penalty parameters λ_τ and λ_γ must be adjusted accordingly. When the estimating function is a likelihood function (and provided some other conditions are satisfied), Silverman (1984) has shown that the roughness penalty approach yields a kernel estimator of $f(\cdot)$. The purpose of the rest of the paper is to estimate the above model using data on Nepal.

3 The Data

Home to the Everest, Nepal is located nearly entirely at the foot of the Himalaya mountains. It is composed of essentially four regions: the Himalayas themselves, which run along the entire Northern boundary of the country and are very sparsely populated; the central valley around Kathmandu; mountains

¹ These estimates of the τ 's and γ 's can easily be obtained using the regular OLS command by adding $J+H-4$ artificial observations at the end of the sample such that dependent variable and regressors are zero, except for $D_n^{n-T-1} = \lambda_\tau$, $D_n^{n-T} = -2\lambda_\tau$, and $D_n^{n-T+1} = \lambda_\tau$ for $n = T+1$ to $T+J-2$; and $P_n^{n-T-1} = \lambda_\gamma$, $P_n^{n-T} = -2\lambda_\gamma$, and $P_n^{n-T+1} = \lambda_\gamma$ for $n = T+J-1$ to $T+J+H-4$.

² We obtain standard errors by drawing 200 samples with replacement from the original sample. Artificial observations used to perform the roughness penalty correction are added to each bootstrap sample. Reported confidence intervals are the 5th and 95th percentiles of the bootstrap estimates. In practice, bootstrapped confidence intervals are virtually indistinguishable from the OLS or tobit reported estimates.

³ As in the case of OLS, approximate roughness penalty tobit estimates can be obtained by adding artificial observations and using the standard 'tobit' command. The only difference is that the value of the dependent variable in the artificial observations should be set to a small positive number – instead of zero. Experimentation indicates that the approximation error is small – i.e., it affects only the third or fourth decimal of the estimated coefficients.

(locally called 'hills' to contrast them with the Hymalayas) that run East-West parallel to the Hymalayas; and the plain of Terai that borders India to the South and has the best agricultural land (Government of Nepal 1995).

Nepal is largely rural, with 86% of its 21 million inhabitants living in villages or towns of less than 10,000 people. Kathmandu, the capital city and largest urban center, has a population of around half a million people.⁴ There are only 34 cities and towns of 10,000 inhabitants or more, most of which can be found either in the central valley or in Terai. Many cities can however be found across the Southern border in India, the largest of which – Lucknow and Putna – are but a few hours by truck from the border. Given the mountainous terrain, communications are generally more difficult within Nepal itself than between Terai and Indian cities. In fact, people living in the remote Northern part of Nepal must trek many hours by foot or bullock cart before reaching the nearest road. Nepal thus offers a perfect testing ground to examine the effect of isolation on spatial specialization and market participation.

The data we use comes from the Living Standard Measurement Survey (LSMS) of 1995/96. The survey covers some 3373 urban and rural households spread among 274 villages or 'wards' distributed over all regions of the country (Figure 1 – Map of Nepal with location of surveyed villages). 28 of these wards are located in Kathmandu alone. As with other LSMS surveys, data coverage is quite comprehensive. For our purpose, information is available on agricultural production, cropping patterns, self-employment in non-farm activities, wage employment by sector, sales and purchases of crops, and migrations. Unlike other LSMS surveys, the Nepal survey also contains detailed information about distance and travel time to markets and towns. Jacoby (2000) has used this information to show that land prices fall with distance from markets.

Table 1 summarizes the main characteristics of surveyed households. We see that households are mostly nuclear, with a large age gap between the household head and his spouse. They own a couple heads of livestock and cultivate one hectare of land on average, a third of which is irrigated. Educations levels are very low. Given that settlement is dispersed in much of Nepal, the location of individual households within the same ward varies a lot. The average household is located two hours away from the nearest market. The median is lower, at just above one hour. In the econometric analysis, the 20 distance dummies D_i^j are constructed by dividing the sample into five percent percentiles.

Table 2 summarizes the measures of economic activity and market participation that we were able to construct on the basis of the available data. We use seven categories of variables. Data on labor form the basis for our first set of specialization and market participation measures. The share of farm work in total employment is taken as rough measure of specialization in farming. Presumably non-farm work is highest either in isolated areas – where everything has to be produced locally – and at the proximity of urban centers – due to the joint effects of commuting and the shopping mall syndrome mentioned in Section 1. In isolated areas where the size of the market is small, we would expect

⁴421,000 inhabitants in 1991.

that most non-farm production takes the form of small enterprises – and hence of self-employment in non-farm activities. Where the market is larger, e.g., in urban centers, larger enterprises could take advantage of returns to scale, hence more emphasis on wage non-farm employment. By the same token, we expect administrative, clerical, and professional jobs to be concentrated in towns where large firms and government offices are concentrated.

Other patterns are also possible. For instance, it is conceivable that in isolated areas, most non-farm production takes place within the household itself and is not counted as work (e.g., food preparation, fuel and water collection, child care, personal services). In this case, non-farm work would not be recorded as such in self-subsistence regions (see Fafchamps and Helms (1996) for a similar observation in Guatemala). Prosperous agricultural areas may also foster the emergence of an active non-farm sector, especially in the production of non-tradables.

Table 2 shows the share of total household labor going to farm and non-farm work, both for self-employment and wage work. Self-employment in farming is the dominant form of employment, a reflection of the predominantly rural nature of the sample. Wage employment outside agriculture is the second most important category. Agricultural wage work and non-farm self-employment each represent about 12 percent of all labor. The breakdown of non-farm employment by sub-sector shows that trade and manufacturing (crafts) are the most important self-employment sectors. Production dominates in wage employment, together with various clerical, administrative, and professional jobs.

A measure of work-related short-term migrations is also given in the Table. It is constructed as the number of household members who work outside the survey ward. This is a reasonable approximation given that, to be counted as household member, a person must reside with the household. We expect migration to be most prevalent among households who reside at the vicinity of urban centers, although workers may also commute to neighboring agricultural employment areas.

Other measures of specialization focus on farming for which the survey contains a lot of information. Cultivated area and sale of livestock products capture the relative emphasis on agriculture or livestock. Crop choices are measured by cropping patterns, that is, by the share of land planted to different crops. Given the dependence of actual crop output on the weather, cropping patterns are a better measure of intended output than output itself. By definition, they are only available for farming households. Paddy, pulses, and vegetables are the main crops in the wet season. During the dry season, rice is typically replaced by other cereals because they are less dependent on water. Vegetables are the second most important crop, followed by pulses and oilseeds. Data on fertilizer use is meant to capture the relationship between location and technology adoption.

Market participation for agricultural products is presented in the second half of the table. We measure the extent to which surveyed households rely on the market to dispose of their excess agricultural output or to meet their food needs. We see that crop commercialization remains low and that most surveyed

households consume most if not all of their output. Sales are somewhat higher for crops other than paddy and cereals. The situation is reversed in terms of purchases: the average survey household purchases half of the rice and one third of cereals it consumes. The bottom of the table further confirms that the median Nepalese household has a large food deficit, particularly in rice and vegetables. Three quarters of them (two third of all farmers) spend more on rice than the value of their paddy output; two third of them (55% of all farmers) spend more on agricultural products than the value of their agricultural output. Marketed surplus is produced by a small group of farmers. Barrett and Dorosh (1996) describes a similar situation in Madagascar. The geographical location of this marketed surplus is of obvious interest to policy makers.

We complement these LSMS data with information about urban population in Nepal (34 towns and cities) and in bordering regions of India (30 towns within a 100 kilometer radius of Nepal). For our purpose, a town is defined as a settlement of more than 10,000 inhabitants (50,000 for India, which is much more densely populated). We first compute the distance between each surveyed ward and each of these towns. Distances are normally taken along existing roads, except when roads do not exist, in which case we calculate the shortest arc distance to the nearest road, and then the distance to various cities along the road.⁵ Distances are then converted into travel time using available information about trucking and walking speeds along various types of roads in Nepal.⁶ Off the road travel is assumed to take place by foot – a reasonable assumption for Nepal given the nature of the terrain.

Available information on distance to towns is summarized in Table 3. The average distance from surveyed wards to the nearest town is just under 4 hours, with large differences across wards. Around 30% of surveyed wards are located either within towns or very close to towns. Close to half the surveyed households live at most two hours travel away from a town or city; the median distance is 2 hours and 12 minutes. The other tail of the distribution is very long, reflecting the mountainous and isolated nature of much of Nepal. Twenty percent of surveyed wards are located more than 7 hours travel from the nearest town; ten percent are more than 10 hours away. One surveyed household in 30 is 15 to 30 hours travel away from the nearest town. This much variation should make it easier to identify the effect of distance on economic activity.

Combining information on distance to towns with data on population in these towns, we construct a measure of urban population at various time dis-

⁵This is a very time consuming process that requires a combination of various techniques. e.g., visual inspection of maps, statistical information on road grades, calculation of arc distances, comparisons across various measurements to identify shortest distances, etc. The assistance of Uwe Deichman and Jyotsna Puri (GIS lab, Department of Research of the World Bank) was essential to the success of this operation.

⁶Travel speeds are calculated for various terrains and types of road. Assumed travel times are as follows, in km/hour: These figures were obtained through discussion with various transportation experts and South Asia operations staff at the World Bank. Travel on highways and provincial roads is assumed to take place by truck; travel on secondary roads is assumed to be by cart.

tances from each ward.⁷ These measures, denoted P_i^h for $h = 1, \dots, H$ hours, only vary from ward to ward. They are organized as follows. Suppose that a ward i is 3 hours away from the nearest town, which has a population of 30,000. The next nearest town is 7 hours away and has a population of 100,000. In this case we have, for each household in the ward, $\{P_i^1; \dots; P_i^{10}\} = 0; 0; 30,000; 0; 0; 100,000; 0; 0, 0$. Table 4 summarizes our constructed P_i^h variables. The average surveyed ward has an urban population of 75,000 inhabitants located within an hour travel time. The median, however, is zero. Urban population first goes down with distance, reflecting the fact that some surveyed wards are urban or peri-urban. It then increases steadily, as more and more towns fall within a given travel time radius from the ward. Urban population figures beyond 10 hours of travel time become progressively dominated by Indian cities located more than 100 km from the Nepalese border. For this reason we confine our analysis of urban population effects to a 10 hour radius.

4 Econometric Results

We now turn to the econometric analysis. To keep the length of the paper manageable, we only present selected Figures and Tables. We begin with employment patterns. The dependent variable is the share of household labor going in non-farm and farm activities (self-employment or wage work); it is our measure of economic emphasis on non-farm and farm production. Given that dependent variables are shares, the estimator is a two-limit tobit with roughness penalty correction. We experiment with various values of the penalty parameter λ . Our best results (i.e., neither too smooth nor too rugged) are those presented. Qualitative results are not very sensitive to the value of the penalty parameter.

The shape of function $f(\cdot)$ is shown in Figure 2 for each employment variable; the shape of function $g(\cdot)$ is shown in Figure 3. The reader should keep in mind that distance to cities varies across wards only while distance to the nearest market varies across households within the same ward. Function $f(\cdot)$ thus controls for within ward distance variation. Figure 2 uses distance percentiles, not actual distance, on the x axis.⁸ The effect of actual distance is much steeper

⁷To keep things manageable, we adopt a simpler methodology for the Indian urban population residing more than 100 kilometers from the Nepalese border. We construct an approximation of this population as follows. We first compute an average urban population density for each 50km ring from the Nepalese border using actual Indian city population. This is done for rings up to 750 km from the Nepalese border. We then compute the shortest distance from each ward to the Southern Nepalese border with India. For each ward we compute an arc area within a given distance from this border. The fact that the Southern Nepal border is approximatively a straight line makes the arc approximation reasonable. After subtracting from this arc the area within the 200 kilometer region for which we computed town-by-town data, we obtain an arc area deep inside India. We then approximate the urban population residing in this arc with the average urban population density described above. This population is then added to the urban population calculated on the basis of ward-to-town calculations. In practice, the adjustment does not make any noticeable difference in urban population for distances below 10 hours of travel time. The above approximation thus plays little part in our results.

⁸Dummies used in estimation – and thus confidence intervals – are constructed using per-

than shown. With this caveat in mind, the resemblance in the shape of both functions is cunning. Non-farm employment is shown to decrease sharply with distance from market and urban centers. Within a ward, it tapers off within 30 minutes of walking time from the nearest market (Figure 2). Non-farm employment is thus located in or very near market centers. This finding is consistent with road construction evaluation reports that document the rapid increase in non-farm activities and the movement of villagers along a newly created road (e.g. Rapp 1994, NECMAC 1998, Bajracharya, Aryal, Sharma, Manandhar and Pyakuryal 1990). Results also show that non-farm employment is highest in urban wards and drops rapidly as one moves away from urban centers (Figure 3). Similar results obtain for non-farm wage employment, except that wage earners tend to live some distance from the market itself – probably to avoid congestion and pay lower rent. Self-employed non-farm workers, in contrast, reside near market centers where business is likely to be better.

Taken together, these results are consistent with the idea that non-farm production is concentrated in town and cities – hardly an original insight. These results are in line with the conclusions of the Government of Nepal (1999). They also indicate that city size matters: the larger the city, the stronger the effect on non-farm production, controlling for distance. The effect is particularly strong on non-farm wage employment, hence indicating a relationship between firm size and city/market size. Also of interest is the finding that non-farm employment remains significantly higher in peri-urban areas than in more strictly rural areas. The effect of town proximity extends for up to four hours of travel time away from the town itself – much further away than we would have initially expected. This suggests that the development of non-farm production in rural areas is intimately related to their proximity from large urban centers. At the other end of the spectrum, we also observe a slight increase in non-farm production in very isolated villages, a result that is consistent with Krugman’s (1991b) prediction that isolation protects non-farm production. Our contribution is to show that the effect is weak⁹ and requires drastic isolation to be noticeable. On balance, in Nepal, proximity to cities and market centers is a more effective way of increasing non-farm output than isolation.

Results regarding migration are less contrasted (Figure 4). The dependent variable is the share of household members who work outside their ward of residence. We find that work-related migrations are most prevalent in areas situated 1 to 5 hours away from urban centers, thereby suggesting that at least part of the non-farm employment encountered in peri-urban areas takes the form of commuting. The effect, however, is not highly significant. Within a ward, however, migrations are concentrated among those households further away from the nearest market. Taken together, these results suggest that temporary work migration is most prevalent among households located neither too far nor too close from city influences. These conclusions are similar to those reached by Seddon et al. (1999) in their work on Nepalese migration movements.

centile intervals.

⁹Possibly because demand for non-farm products is income elastic and isolated villages are poor.

Figures 2 and 3 also present results for self-employment and wage employment in agriculture. Again the dependent variable is the share of household labor in these two categories, and the estimator is tobit with roughness penalty correction. As anticipated, results indicate a very sharp increasing in the time households devote to farming as one moves away from markets and urban centers. But the pattern varies between self-employment and wage labor: self-employment in farming jumps up as soon as one gets out of the town while wage employment in agriculture rises more slowly, only to peak in areas 5 to 8 hours away from urban centers. This is consistent with the idea that, close to cities, household with little or no land can find profitable employment opportunities in the non-farm sector. In more rural wards, the dominant income generation activity for asset poor households is agricultural wage work. This interpretation is consistent with Jacoby's (2000) finding that wages fall slightly with distance from the nearest market.¹⁰ An immediate implication is that land inequality would have a stronger effect on income inequality and poverty in rural areas situated far from markets and cities. These areas are also those for which a proper understanding of agrarian institutions is essential to welfare analysis. When farm and non-farm wage work are combined, we see a sharp decrease in the share of wage work as one move away from urban centers. Capitalist modes of production, as Marxian economists would put it, are predominantly an urban phenomenon.

To investigate further the relationship between city size and non-farm work, we subdivide the $\{P_i^1; \dots; P_i^7\}$ into three subgroups: from 0 to 100,000; from 100,000 to 450,000; and above 450,000 and include them in the regression as three separate sets of regressors, each subject to roughness penalty correction. This approach is akin to a non-parametric decomposition of the relationship between city size and geographical specialization. Since results are difficult to visualize, we summarize them in writing. What transpires from the analysis is that, while the relationship between urban population and non-farm work is roughly similar across all city sizes, small towns have no effect on non-farm wage work; non-farm wage work is related to proximity with large cities only. Small towns, in contrast, create more non-farm self-employment. Another result of interest is that proximity to small towns, if anything, has a negative influence on work migrations.

Turning to farming in more detail, we see that cultivated area mirrors agricultural employment – it increases sharply with distance from markets and cities (Figures 5 and 6). Farmers operating within four hours of a large city have smaller farms than those located in more remote wards. The picture is slightly different for livestock production. The sale of livestock and livestock products initially rises with distance from market centers, albeit at a slightly slower pace than cultivated land. But it eventually tapers off for households located very far from a market center. This suggests that livestock production as a market-oriented activity is favored mainly by households residing between 1 to 4 hours from a market center.

¹⁰Jacoby, however, does not control for nearby urban population.

Next we investigate the von Thünen hypothesis, namely, that what farmers grow varies systematically with distance to towns and markets. For that purpose, the share of land planted to various categories of crops is used as dependent variable. Two cropping seasons are distinguished – the wet season when paddy is produced, and the dry season when the focus is on other cereals. Again, the estimator is tobit with roughness penalty correction. Note that the regressions are *conditional* on the household producing crops, an activity that, as we have seen, takes place outside towns and cities. Some of the results are presented graphically in Figures 7 and 8 for $f(\cdot)$ and $g(\cdot)$, respectively. Our strongest result is for vegetable production which, as predicted, is highest in the vicinity of cities and market centers, both during the dry and wet season. The effect is very significant and is still perceptible 3-4 hours away from (large) urban centers.

Land devoted to paddy initially increases with distance from towns and markets. This effects, however, tapers off in more remote areas. There, more emphasis is put on subsistence crops. Intense rice production ranges from 3 to 7 hours travel time from large cities. This is also the zone in which agricultural wage work is most prevalent. During the dry season, pulses, oilseeds, and other (minor) crops follow a pattern similar to that of paddy, albeit less pronounced. These results are in line with the concentric circles hypothesis. Perishable crops such as vegetables are produced near markets and cities. Less perishable commercial crops appear in areas further away from the city, but not so far that transport becomes problematic. In areas more than 8 hours away from cities, we observed a decreased emphasis on commercial crops and a switch from paddy to other cereals. These changes reflect the self-subsistence focus of isolated areas.

To confirm our results, we examine whether the commercialization of crops varies systematically with distance. To this effect, we regress the proportion of total agricultural output that is sold to the market (Figure 9).¹¹ By construction, the regression is limited to farming households. Results show crop commercialization initially increase with the distance between households on the one hand and cities and markets on the other. Jacoby (2000) obtains similar results. One possible explanation for this unexpected result is that households located near cities have less land and thus have less to sell. We revisit this issue in the next section. Commercialization is highest among households located two to three from cities and one to two hours from the nearest market. Beyond this distance, however, commercialization declines steadily, an indication that more distant villages produce staple food mostly for self-consumption. Crop sales essentially drop to zero for households residing 8 hours or more from a large town. In these villages, the share of output that is sold is essentially zero, an indication of the self-subsistence focus of agricultural production. The results nevertheless indicate that this focus on self-subsistence is circumscribed to extremely isolated wards, that is, wards more than 8 hours away from urban centers. In agreement with theory, proximity to market has a dramatic impact on the proportion of agricultural output that is sold. Agricultural commercial-

¹¹ Regressions for individual crops yield similar results.

ization is also closely related to technology adoption. Figure 8 also reports a sharp decrease in fertilizer use as one moves away from cities and market centers – presumably because of transportation costs.¹² Similar results are obtained by Jacoby (2000). But our estimation method suggests that the effect is not linear. Results indeed indicate that fertilizer use is highest among households located within 2 hours of a market center, after which usage drops sharply.¹³ This is also the zone within which crops are grown for the market. These conclusions are in close agreement with Jacoby’s (2000) findings that the value of land falls with distance from the market.

Next we turn to consumption. We first examine whether consumption patterns vary systematically with distance. We regress consumption shares in major food products on distance to markets and cities. Taken together, these products account for 86% of measured consumption. Results, summarized in Figure 10, show that vegetable consumption is highest in and around cities and markets. This pattern, which is consistent with the localization of vegetable production, suggests that vegetable consumption is essentially an urban phenomenon, with some spillover onto the neighboring countryside. Consumption of rice and other cereals rapidly rises with distance from cities, up to four/five hours of travel time, after which it declines. This indicates a decrease in the consumption of non-agricultural items. In the following section we investigate the extent to which this shift in consumption pattern reflects income elasticities. A different pattern is observed within wards: households located more than two hours away from the nearest market spend roughly 25% less on rice, the difference going to cereal consumption. This pattern is probably related to the need to process paddy into rice before consumption. Indeed, rice milling facilities are typically located in and around markets. Finally, we observe a progressive rise in the value of livestock food consumption among isolated communities, possibly because livestock production becomes more important with distance from markets.

Our next step is to investigate whether differences in consumption are related to crop monetization. We regress the share of cash purchases in total consumption for four agricultural products for which we have data: rice; other cereals; vegetables; and fruits; and all crop products together. Results are summarized in Figure 11. For all four crops, they indicate a systematic decline of the share of purchased consumption with distance: households residing in or near a town are more likely to purchase the food they consume. This hardly comes as a surprise, given that urban households are less likely to farm and thus to produce their own food.¹⁴ The effect is large in size both within wards and between wards and cities; it is very significant in all cases. Residents of wards located less than 3 hours away from a city are shown to rely massively on the market to fulfill their consumption needs. In contrast, households living more

¹² A similar regression conducted on fertilizer price indeed shows a sharp price increase with distance from cities. Households located within the same ward all pay the same price for fertilizer, but have to haul it over varying distances.

¹³ Virtually identical results obtain if one uses fertilizer per cultivated area.

¹⁴ The question is whether this is the only reason. We revisit this issue in the next section.

than four hours from a city do not at all rely on the market for their consumption of agricultural products. Taken together with earlier results about the sale of crop output, these results overwhelmingly confirm that crop commercialization – both in terms of sales and purchases – is linked to proximity to markets and urban centers.

Before we close this section, we examine how sale and consumption pattern combine to generate a spatial distribution of marketed surplus. Policy makers are indeed interested in what spatial conditions are most conducive to the production of food surpluses. We use two definitions of marketed surplus: first, as the ratio of crop production over consumption;¹⁵ second, as the difference between production and consumption. The first definition emphasizes the degree to which a household is in surplus or deficit, irrespective of the size of its output. The second definition emphasizes the size of the surplus that is put on the market. Results, presented in Figure 12, show that marketed surplus increases rapidly with distance from cities and markets. This is true both in terms of ratio and levels. Given that all households are included in the regression, this outcome largely reflects the fact that households located in and near cities and market centers spend less time producing food and more time producing non-farm products and services. Results in levels nevertheless serve as a reminder that the bulk of crop surplus is produced one hour or more from a market center. Given the nature of the terrain in Nepal, transporting crop surpluses to the market is a non-negligible task. It is therefore not surprising that the magnitude of marketed surplus drops among households located more than two hours from a market. Noticeable for all crops, this outcome stands in contrast with our previous result for livestock, which showed that the sale of livestock products only begins to drop among households located more than four hours from a market. Taken together, these results suggest that in the 2-4 hour range, livestock progressively supplants crops as the main cash generating activity for farmers.

To summarize, we have seen that non-farm activities are concentrated in and around cities and markets. By itself this is hardly a novel result. But we were able to show that the range of distance over which non-farm employment is stimulated by cities is much larger than what is often believed. Contrary to claims occasionally made, we find no evidence that cities eliminate non-farm employment in their hinterland – albeit they may eliminate certain activities.¹⁶ In terms of agriculture, we find several forces at work. The dominant force is that which affects commercialization. Our analysis demonstrates clearly that proximity to cities and markets has a strong positive effect on the sale and purchase of agricultural products. The commercialization of agriculture is thus predominantly a peri-urban phenomenon. This finding is consistent with the fact that non-farm production is also higher in peri-urban areas: villagers who do not farm rely on the market for consumption, and they can afford to rely on the market because traded quantities higher. Fertilizer purchases follow the same

¹⁵Because the resulting ratio has a highly skewed distribution, we use the $\log(1 + \text{ratio})$ instead as dependent variable.

¹⁶This issue is the object of future work.

pattern, suggesting that technology adoption is related to commercialization.

The effect of proximity is felt over a four hour radius around cities. Beyond this distance, crops are rarely sold and purchased. Livestock products, however, continue to be marketed well beyond this limit, suggesting a geographical pattern of specialization with crops close to cities and livestock further away. This is consistent with the fact that trade livestock products either transport themselves (live animals) or have a high value to weight ratio (e.g., ghee). Within the zone of influence of cities, agricultural specialization also varies with distance, with vegetables being produced closest to markets and paddy, pulses, and oilseeds produced further away. Concentric circles of specialization in Nepal thus seem to fit the von Thunen hypothesis. Our results also demonstrate the usefulness of the non-parametric approach: with few exceptions, the effect of distance is highly non-linear, with urban areas and isolated villages sometimes presenting similar features. The non-parametric approach also proved useful in identifying the spatial range of particular phenomena with a fair degree of precision. The results, however, are disappointing in some respects, particularly in identifying the channels through which geography affects activity. To this we now turn.

5 Controlling for Household Characteristics

The analysis presented so far examines how households interact with the market conditional on location only. Although it provides a valuable description of geographical patterns of specialization, it cannot isolate the causal effect of location on market participation. There are at least three reasons for this. First, people move to improve their lot. Someone who is gifted for farming is likely to migrate to an area where farming opportunities are plentiful and agricultural surplus can be sold to the market. The sorting of people across space thus tends to reinforce geographical advantage. Second, people accumulate human and physical capital in response to the returns to these assets. If returns to education are higher in cities, one would expect urban residents to invest more in schooling. Third, the localization of public services and infrastructures respond at least in part to cost-benefit considerations. Roads are thus more likely to be built in areas capable of producing an agricultural surplus. Inference based on equation (4) must therefore be interpreted in this light, i.e., as measuring the combined end-result of geographical forces, self-selection, and individual accumulation.

Although the reduced form approach offers the advantage of implicitly controlling for general equilibrium effects, it fails to identify the channels through which the spatial division of labor takes place. We have found that individuals living close to cities are more likely to be in the non-farm sector. The question arises of whether non-farm workers are found near cities because cities provide more non-farm work opportunities, or because educated workers live near cities and engage in non-farm work where the returns to education are higher (e.g. Fafchamps and Quisumbing 1999, Yang 1997). To investigate these processes, we extend the analysis along two separate steps. First, we examine whether

households characteristics vary systematically with location. To this effect, we apply equation (4) to households characteristics X_i such as human and physical capital. Second, we add these household characteristics X_i to equation (4) and reestimate market participation regressions; region and elevation dummies are also included to control for ecological and taste differences.¹⁷ The resulting regressions can be interpreted as measuring the residual effect of location conditional on household accumulation of human and physical capital. If, for instance, we find that the τ_j and γ_h coefficients are no longer significant in the non-farm regression once we control for education, we can conclude that the effect of location on non-farm work operates entirely through the spatial distribution of educated workers. If, on the other hand, location still matters even after we control for skills and assets, this indicates that two observationally equivalent households opt for different occupation based solely on the place of residence; location has an effect on market participation over and beyond its effect on individual accumulation.

The household characteristics that we use in the analysis are those measures of human and physical capital for which we have data – namely, household size and demographic composition, education and age, and productive assets (livestock, bullocks, farm equipment, and land of various quality). Land size controls for returns to scale and for the possibility that shadow factor costs vary systematically with land size and affect farm decisions (e.g. Feder 1980, Feder 1985). The age of household head controls for experience and life cycle effects. We also include inherited land as measure of parental wealth and prior exposure to farming. Results from our first set of regressions are summarized in Figures 12 and 13. We see that households residing close to cities are smaller, with relatively fewer children and more adult males. Schooling levels of male and female adults drops dramatically with distance from cities and markets, suggesting a possible relationship with non-farm work. As could be expected, livestock, land, and farming assets are all much lower in cities and around markets. Land suitable for irrigation is most prominent one to two hours away from markets – which is also the zone where paddy is produced.

We now investigate whether the geographical distribution of these characteristics accounts for some of the observed patterns. To this effect, we estimate regressions of the form:

$$y_i^z = X_i' \beta + \sum_{j=1}^J \tau_j D_i^j + \sum_{h=1}^H \gamma_h P_i^h + u_i \quad (6)$$

¹⁷ Variables included in X_i are: log of household size; share of adult males, adult females, and children (youths is the omitted category); log of years of schooling of adult males and adult females; log of owned land; share of *khet* (see below) and share of irrigated land; log of the value of farm equipment; log of the number of cattle; log of the value of livestock; log of inherited land; regional dummies (east, west, mid-west, and far-west, central region being the omitted category); and elevation dummies (hills and mountains, terai being the omitted category). Some regressions contain additional regressors (see *infra*). *Khet* land is a widely used local land classification that means 'suitable for rice production'. Most – but not all – irrigated land is *khet*.

using the roughness penalty correction as before. Controls are in general highly significant but since they do not represent the focus of this paper, they are not discussed here.

Our first set of results relate to non-farm work. Not shown here for the sake of brevity, they can be summarized as follows. The effect of distance from urban population is reduced by about 30% but the geographical pattern is essentially unchanged. In other words, proximity to cities has effects on non-farm work that are not fully captured by differences in human and physical capital. This is particularly true for wage work. Households with similar endowments but located in different places are thus expected to end up with different forms of employment. Within wards, however, the effect of distance is much less pronounced. This suggests that residential mobility and reallocation of productive resources within wards are by and large sufficient to match workers with location-specific occupations. In other words, households interested in trade or crafts appear to move to the market center and reduce their farming assets. This is in line with field observations made by Rapp (1994) and Bajracharya et al. (1990).

The sharpness of the above conclusion is, however, blurred by the possibility that unobserved household characteristics account for geographical patterns of specialization. Panel data would in principle enable us to control for time-invariant household unobservables, but such data do not presently exist. We therefore adopt an alternative, less demanding approach. To control for endogenous placement of households across wards, we split the sample into two groups: those in which the head of household was born in his ward of residence, and those who were born elsewhere. Individuals born elsewhere might have moved into their current ward in response to work opportunities. Consequently, they are most suspect of endogenous placement.¹⁸ Reestimating equation (6) with only locally born households yields results that are virtually indistinguishable from previous results. From this we tentatively conclude that endogenous placement along unobserved household characteristics is unlikely to account for observed geographical effects.

Next we turn to farming. To further control for farm size, we add a series of regressors measuring cultivated acreage and land quality. The idea is that households might opt for different cropping patterns or crop sales simply because they have farms of different size. Yet results concerning spatial cropping patterns, crop sales, and crop purchases are by and large unaffected. The only exception is that, once again, within ward variations are no longer significant in most cases. This is a general conclusion that holds for virtually all agricultural market participation indicators. This implies that farms of similar size and productive capacity but located in different wards end up with different cropping patterns and crop sales.

We also revisit crop consumption. Consumption shares and crop purchases are likely to be affected by income effects. To investigate whether the observed geographical pattern of consumption is due to income effects, we add

¹⁸Other households are also potentially subject to endogenous placement in the sense that they could have moved but chose not to. In practice, very few surveyed household heads were born outside the survey ward, so that endogenous placement bias is less of a concern.

total expenditures and expenditures squared to the set of X_i regressors in the consumption regressions. We also keep farming assets in the regression to control for the possibility that farmers consume different goods. We suspect that household income is higher in cities and near markets. As Figure 15 shows, this is only partly true: while total consumption expenditures fall dramatically for households living far from a market, proximity to cities has no significant or even systematic effect.

Consumption results indicate that income elasticity and farming effects account for part of the geographical differences in the cash purchases: controlling for expenditures and assets cuts the effect of proximity to cities by 40%. The effect nevertheless remains strong and significant: cities by themselves do favor reliance on the market for crop – and thus food – consumption. We also observe that the effect of urban proximity on consumption shares is markedly different with household controls: we now see that households located close to cities spend on average an extra 7% of their budget on rice. In contrast, consumption of cereals other than rice rapidly rises with distance from cities, up to four hours of travel time. This is in line with other studies that have brought to light the role of rice as an urban food, possibly because of ease of preparation (e.g. Savadogo and Brandt 1988, Nagy, Sanders and Ohm 1988). Another possible explanation is the need to process paddy into rice before consumption. Rice milling facilities are typically located in and around markets and cities, hence making rice consumption easier. Vegetable consumption, in contrast, no longer shows a significant relationship with distance: vegetable consumption is higher around cities essentially because incomes are higher.

6 Conclusion

Combining household level data with information on distance to markets and cities in Nepal and northern India, we have examined the spatial division of labor in Nepal. A semi-parametric model was used to avoid imposing too much structure on the shape of the relationship between spatial specialization and distance to markets and cities. Distance is measured in hours of travel time. Results indicate a strong spatial division of labor. Non-farm employment – our indicator of non-farm production – is heavily concentrated in markets and in and around cities. The effect is strong for cities of all sizes, but wage employment tends to be concentrated in large cities while small cities have more non-farm self-employment. Agricultural wage employment, in contrast, is concentrated in rural areas sufficiently close to cities that they can specialize in commercial crops but neither so close that non-farm employment takes over, nor so far that they revert to self-subsistence.

Crop choices also vary with distance to cities and with their size. Vegetable production in both seasons is concentrated at the vicinity of markets and urban centers while, paddy, pulses, oilseeds, and other commercial crops are more important at intermediate distances. Market participation varies with distance as well. Households near markets and cities buy most of the rice and agricultural

products they consume, even when we control for land and other farm assets. These households also sell a larger proportion of their crop production. An examination of the spatial distribution of marketed surplus indicates that food for urban consumption is mainly produced in an intermediate zone located 30 minutes to 2 hours away from the nearest market and 3 to 7 hours from large cities. Beyond this zone, households derive some cash income from the sale of livestock products, but this phenomenon itself tapers off beyond 8 hours of travel time from the nearest market.

Summarizing our results, proximity to markets and size of cities is strongly associated with different patterns of production among Nepali households. Cities themselves specialize in the production of non-farm products. They buy vegetables from immediately surrounding areas and cereals from villages located a little further away. Agricultural marketed surplus is produced in an intermediate zone where much agricultural wage work is also found. Ironically, this is not the zone where fertilizer consumption is highest. These results suggest that the agricultural marketed surplus could be increased by making fertilizer more widely available. Isolated households and villages essentially rely on self-subsistence, both in terms of non-farm production and food self-sufficiency. Broadly consistent with earlier findings by Jacoby (2000), all these findings are consistent with the von Thünen model of concentric specialization, except that our results also show the importance of city size. Less anticipated is our finding that villages located near cities also participate to non-farm production and that the proportion of agricultural wage work only rises slowly with distance from cities. These suggest that proximity to cities is not detrimental to non-farm production in nearby villages, contrary to what is sometimes assumed. This appears to be linked not so much to income effects but rather to more reliance on the market for the satisfaction of consumption needs.

These findings have important policy implications. First, they facilitate the assessment of the potential effect of road construction on production. In fact, since estimated coefficients are in terms of travel time, all that is needed to evaluate the effect of a road is the change in travel time. As is clear from our results, road incidence is expected to vary dramatically depending on the switch in travel time category that the road would induce. For instance, suppose a road were built to a village now 15 hours away from the nearest Nepalese city, bringing travel time down to 8 hours. In this case, the expected effect would be an increase in commercial agriculture and agricultural wage labor. In contrast, if a road were to bring travel time from 8 to 3 hours, we would expect a decrease in commercial crop production, more cereal production for sale, and more non-farm production. Finally, if a road were to bring a ward from 3 to 1 hour away from a city, we would expect non-farm production to increase dramatically, and farm output per household to drop, except for vegetables. Most households would rely on the market for all their consumption needs. These predictions are by and large consistent with the descriptive analysis of Bhandari, Banskota and Sharma (1999) and with traffic surveys conducted by road construction projects in Nepal (e.g. NECMAC 1998, Government of Nepal 1998, Rapp 1994, Bajracharya et al. 1990).

Second, the information provided by our estimates should help the placement of agricultural and rural development projects. For instance, a vegetable seed project would be expected to catch the interest of farmers in peri-urban areas, as observed by Mathema (2000) in his report on vegetable marketing in and around Kathmandu. Paddy or oilseed production with purchased inputs would probably raise interest in Nepalese villages up to four hours away from a medium size city, while livestock projects would raise interest in more distant villages and among more isolated households. Similarly, land reform and other efforts to tinker with agrarian structure would probably have the largest equity impact in the intermediate rural zone where agricultural wage work is prevalent. More research is needed to assess whether similar policy conclusions would apply to other countries.

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Table 1. Characteristics of Surveyed Households

	Unit	Mean	Std. dev.	Median	N. obs.
1. Household composition					
Household size, of which:	Number	5.6	2.8	5	3344
Adult males	Number	1.2	0.8	1	3344
Adult females	Number	1.3	0.8	1	3344
Teenagers	Number	1.9	1.6	2	3344
Children	Number	0.9	1.0	1	3344
Elderly	Number	0.2	0.5	0	3344
2. Human capital					
Age of household head	Years	44	15	43	3344
Age of spouse	Years	39	12	37	3344
Years of schooling of adult males	Years	0.9	1.5	0	3344
Years of schooling of adult females	Years	0.4	0.9	0	3344
3. Land					
Total operated area, of which:	Ha	0.8	1.7	0.4	2653
Irrigated land	Ha	0.3	0.8	0	2653
Total owned area	Ha	0.8	1.7	0.3	2653
4. Assets					
Cows and buffaloes	Number	2.6	3.1	2	3345
Farm equipment	Rupees	1549	20948	120	2220
5. Location					
Distance from hh to nearest market	Hours	2.2	3.4	1.1	3344
Distance from ward to nearest town	Hours	4.0	4.7	2.2	3344

Table 2. Production and Consumption

	Unit	Mean	Std. dev.	Median	N. obs.
1. Labor					
Share of total household employment in:					
Non-farm employment	Share	30.2%	37.6%	10.5%	3248
Non-farm self-employment	Share	12.1%	27.5%	0.0%	3248
Non-farm wage employment	Share	18.1%	30.3%	0.0%	3248
Farm employment	Share	69.8%	37.6%	89.5%	3248
Farm self-employment	Share	56.7%	38.1%	65.0%	3248
Farm wage employment	Share	13.1%	24.3%	0.0%	3248
Wage employment	Share	31.3%	34.6%	19.2%	3248
Self-employment	Share	68.7%	34.6%	80.8%	3248
Share of household members who work outside village	Share	4.2%	11.1%	0.0%	3337
2. Agriculture and livestock					
Operated area	Ha	0.81	1.67	0.37	3337
Value of annual livestock sales	Rupees	2937	7529	0	3337
Value of annual sale of livestock products	Rupees	1202	4207	0	3337
3. Cropping pattern (farmers only)					
Share of planted acreage in:					
Wet season:					
Paddy	Share	38.2%	35.0%	31.0%	2377
Other Cereals	Share	33.7%	30.9%	29.6%	2377
Pulses	Share	11.2%	15.7%	0.0%	2377
Vegetables	Share	9.6%	16.4%	0.0%	2377
Other crops	Share	7.3%	15.6%	0.0%	2377
Dry season:					
Cereals	Share	53.2%	34.4%	55.3%	2204
Pulses	Share	11.3%	19.1%	0.0%	2204
Oilseeds	Share	11.5%	18.7%	0.0%	2204
Vegetables	Share	16.8%	25.0%	4.2%	2204
Other crops	Share	7.2%	15.8%	0.0%	2204
4. Agricultural input use (farmers only)					
Fertilizer quantity	Kg	70	144	20	2329
Fertilizer per area	Kg/ha	125	440	33	2322
5. Sale of agricultural products (producers only)					
Sales of crop as % of value of crop output:					
Paddy	Share	9.3%	18.4%	0.0%	1989
Other cereals	Share	9.4%	19.5%	0.0%	2358
Other crops	Share	14.4%	25.0%	0.0%	2252
All crops combined	Share	12.5%	18.9%	0.0%	2505
6. Consumption of agricultural products					
Share in total consumption:					
Rice	Share	29.8%	10.5%	30.9%	3337
Other cereals	Share	47.3%	11.9%	47.5%	3337
Vegetables	Share	7.2%	5.6%	5.8%	3337
Fruits	Share	1.9%	3.5%	1.1%	3337
Share of cash purchases in consumption of:					
Rice	Share	52.4%	41.8%	51.7%	3326
Other cereals	Share	36.1%	41.1%	15.9%	3206
Vegetables	Share	43.1%	40.2%	31.4%	3317
Fruits	Share	58.3%	43.5%	75.6%	3058
All combined	Share	44.2%	36.4%	37.5%	3337
7. Marketed surplus					
Value of output minus value of consumption					
Paddy/rice	Rupees	-1683	13615	-2660	3337
Other cereals	Rupees	545	27248	-240	3337
Vegetables	Rupees	-1356	3032	-950	3337
Fruits	Rupees	-257	4626	-192	3337
All agricultural products combined	Rupees	-650	34704	-3538	3337

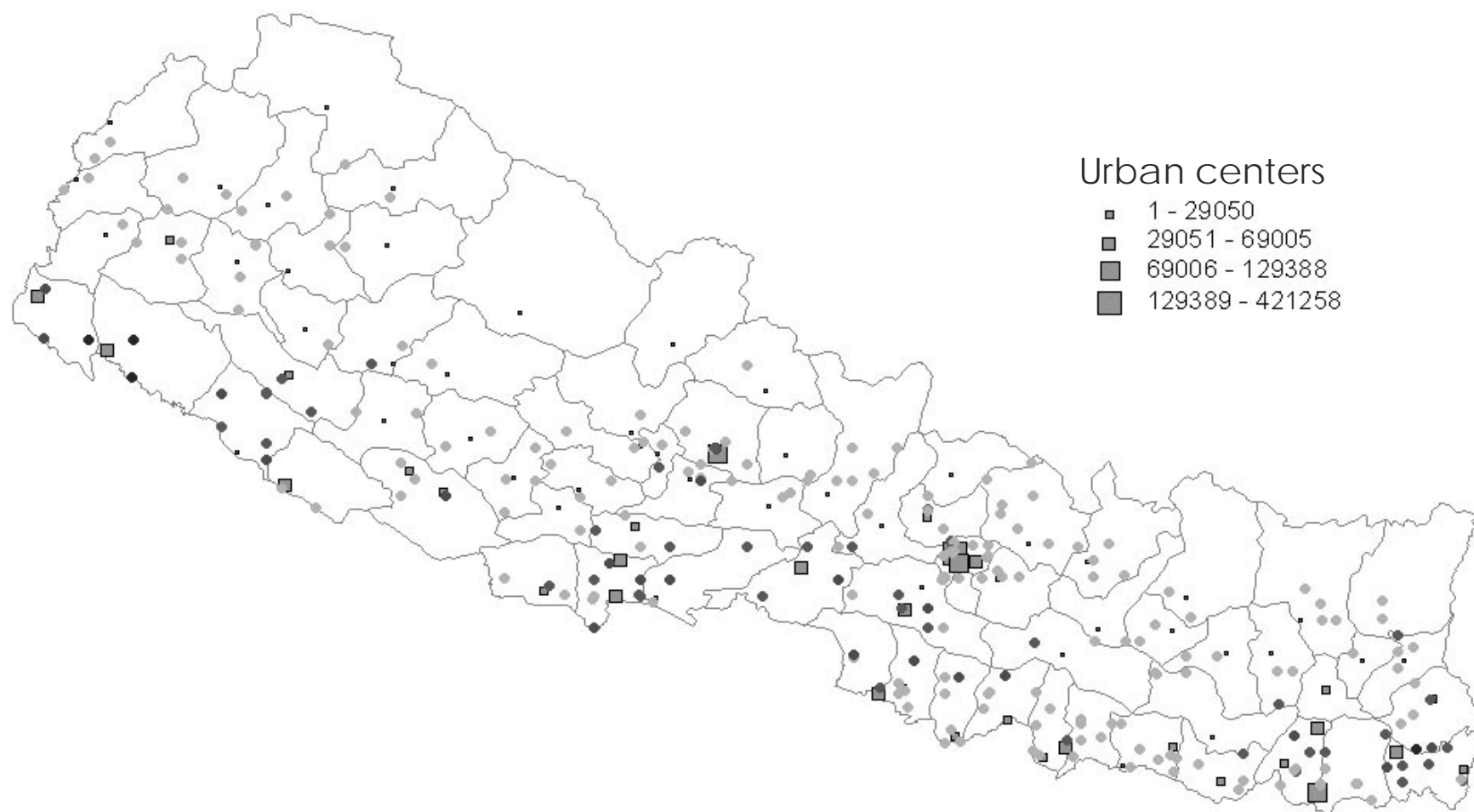
Table 3. Distance to the Nearest Town

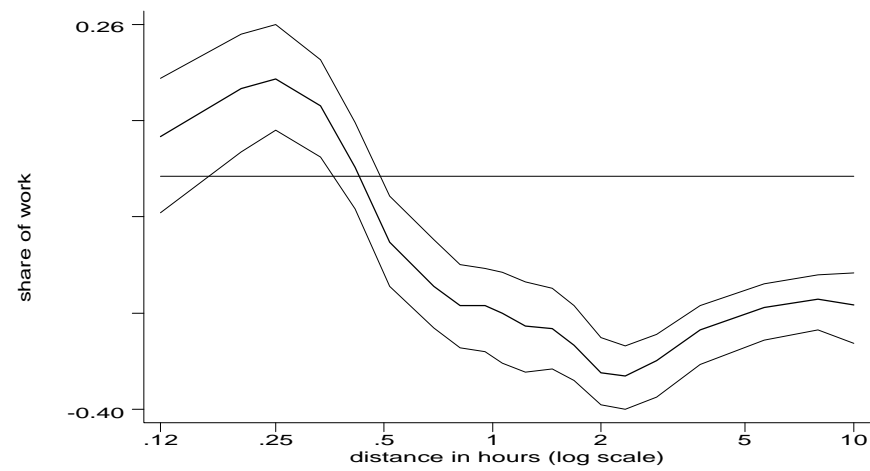
	Number of Wards	Percent	Number of Households	
7. Nearest City within				
0 -1 hour of travel time	80	29.2%	951	28.4%
1 - 2 hour of travel time	52	19.0%	634	19.0%
2 - 3 hour of travel time	40	14.6%	485	14.5%
3 - 4 hour of travel time	16	5.8%	199	6.0%
4 - 5 hour of travel time	10	3.6%	117	3.5%
5 - 6 hour of travel time	12	4.4%	152	4.5%
6- 7 hour of travel time	9	3.3%	108	3.2%
7 - 8 hour of travel time	6	2.2%	72	2.2%
8 - 9 hour of travel time	9	3.3%	115	3.4%
9 - 10 hour of travel time	7	2.6%	84	2.5%
10 - 11 hour of travel time	6	2.2%	75	2.2%
11 - 12 hour of travel time	6	2.2%	80	2.4%
12 - 13 hour of travel time	7	2.6%	98	2.9%
13 - 14 hour of travel time	1	0.4%	12	0.4%
14 - 15 hour of travel time	4	1.5%	49	1.5%
15 - 30 hour of travel time	9	3.3%	113	3.4%
	274		3344	

Table 4. Proximity to Urban Population

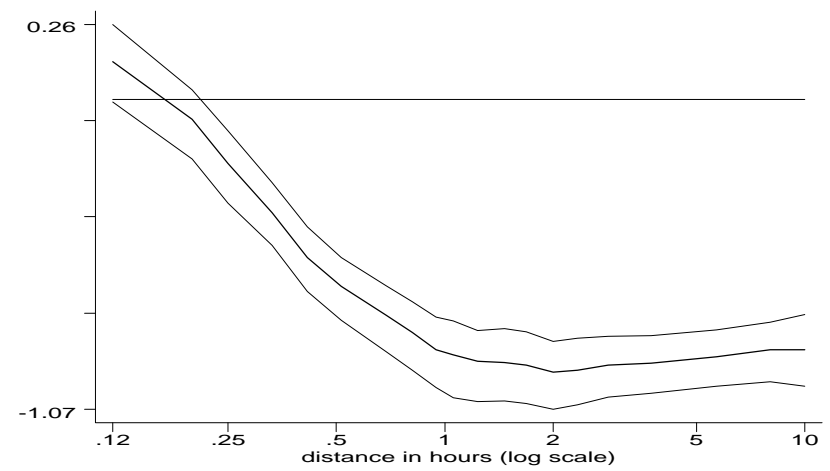
	Mean	Std. dev.	Median
City population within:			
0 -1 hour of travel time	74804	180351	0
1 - 2 hour of travel time	54514	130480	0
2 - 3 hour of travel time	97443	167273	28778
3 - 4 hour of travel time	151752	223457	69968
4 - 5 hour of travel time	164544	225559	103689
5 - 6 hour of travel time	214631	268668	132280
6- 7 hour of travel time	342046	320305	245629
7 - 8 hour of travel time	338632	320061	296365
8 - 9 hour of travel time	288493	299774	188042
9 - 10 hour of travel time	341247	309812	284257

Figure 1. Map of Nepal and Location of Surveyed Villages

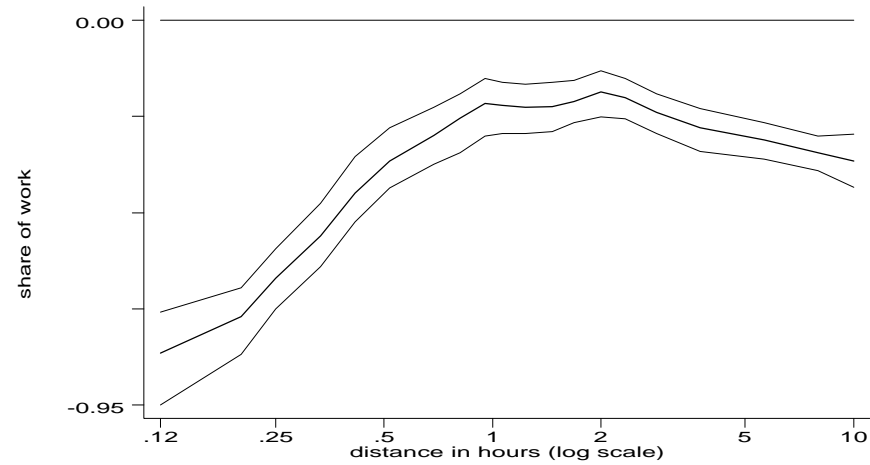




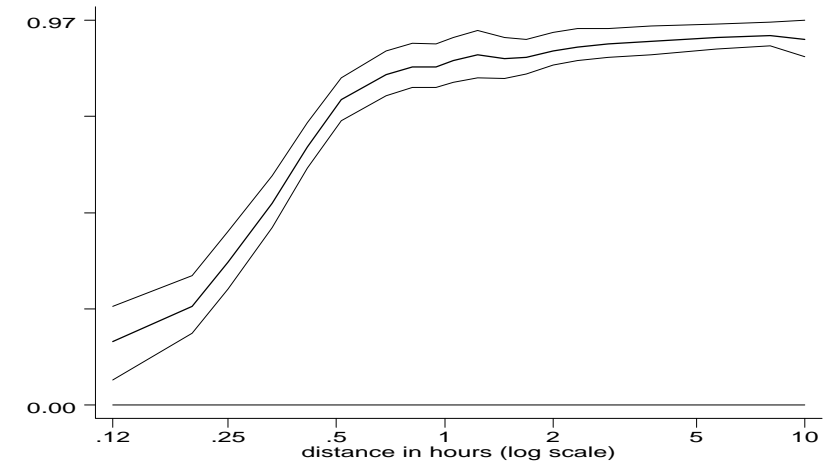
Non-farm wage employment



Non-farm self-employment

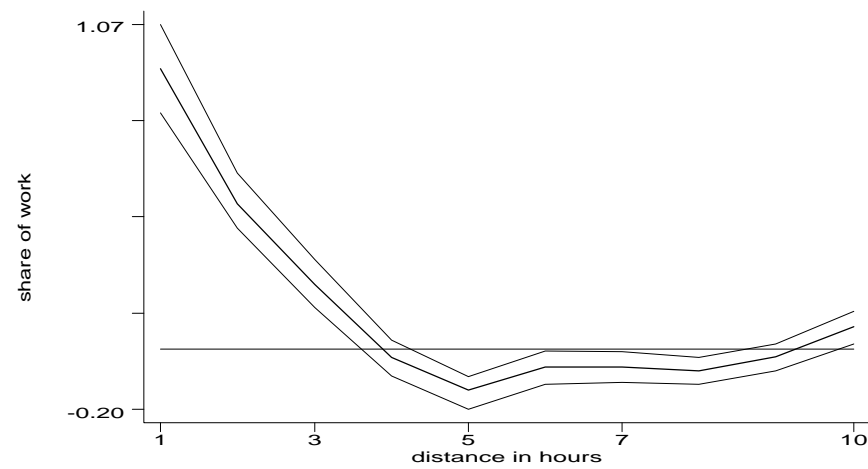


Agricultural wage employment

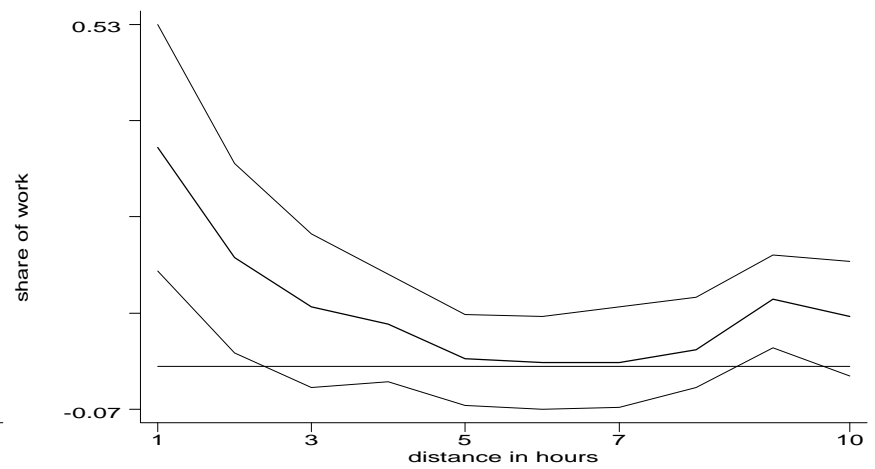


Agricultural self-employment

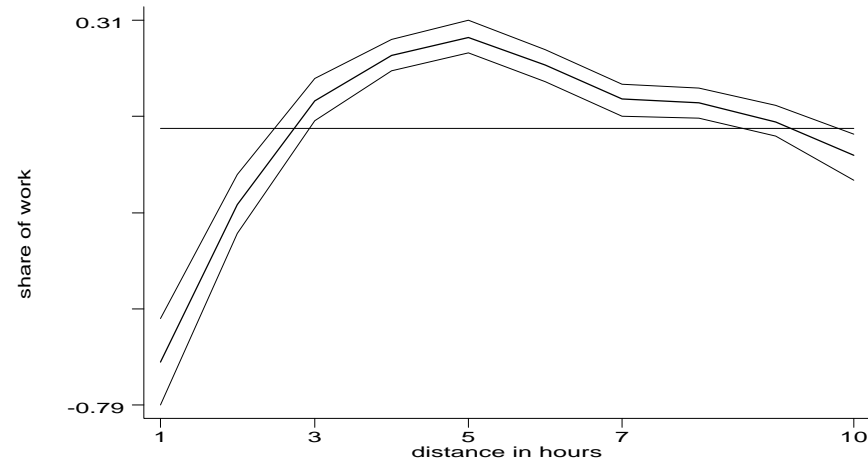
Figure 2. Employment and distance from market



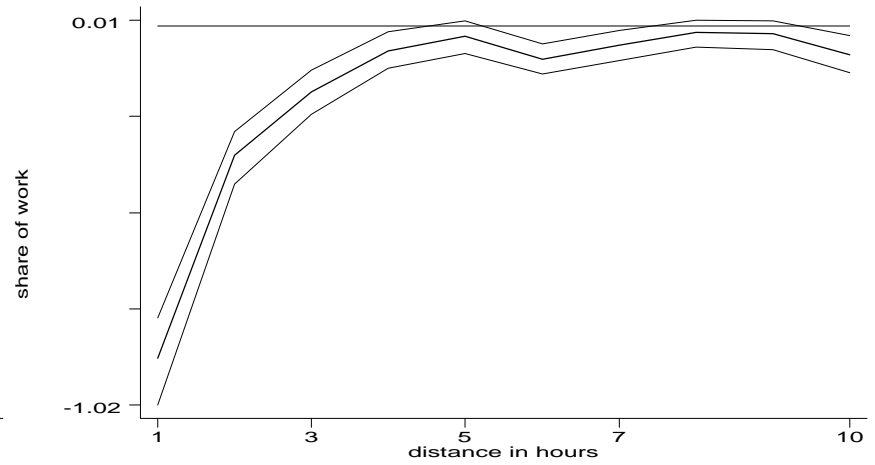
Non-farm wage employment



Non-farm self-employment



Agricultural wage employment



Agricultural self-employment

Figure 3. Employment and distance from cities

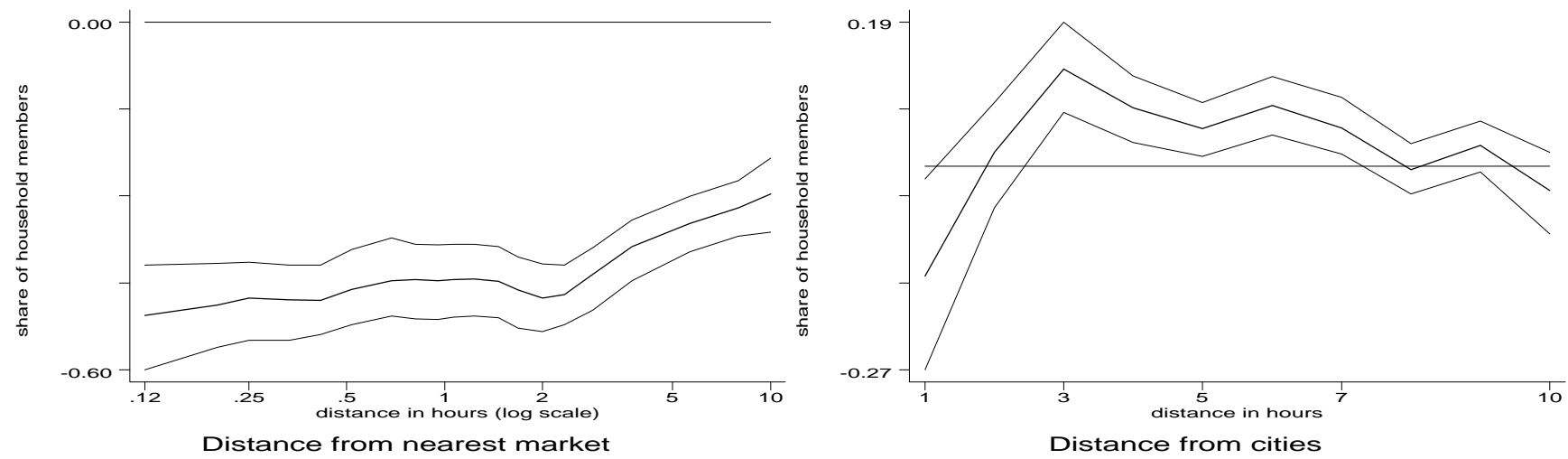
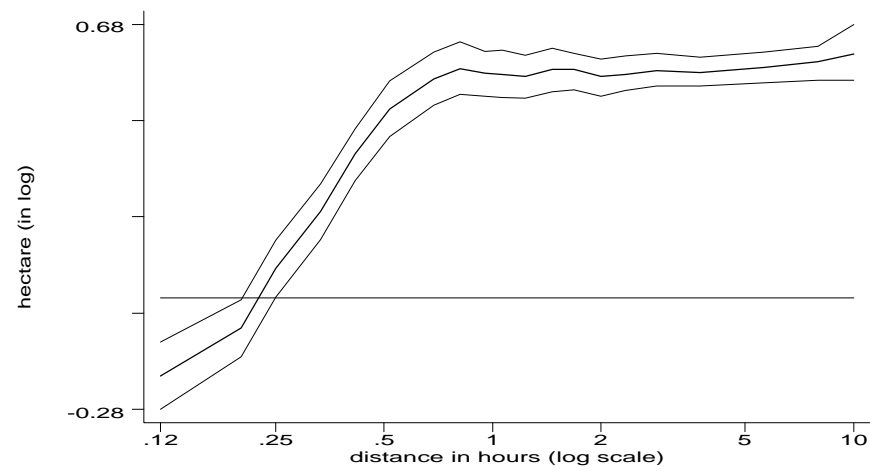
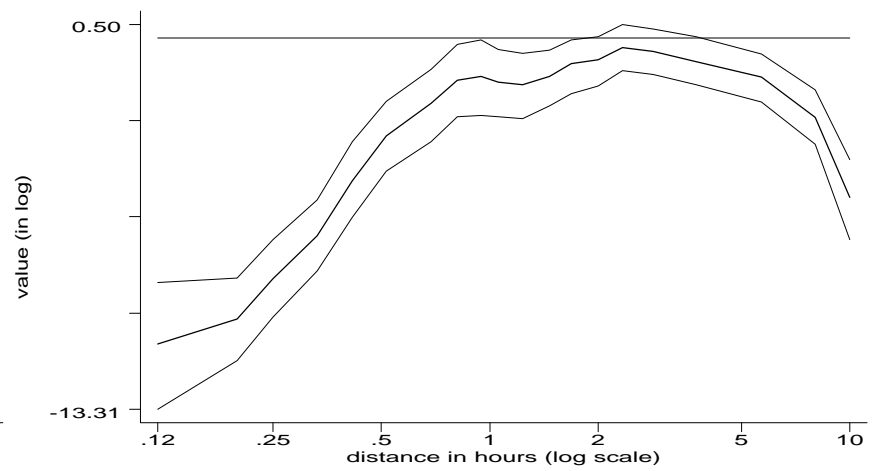


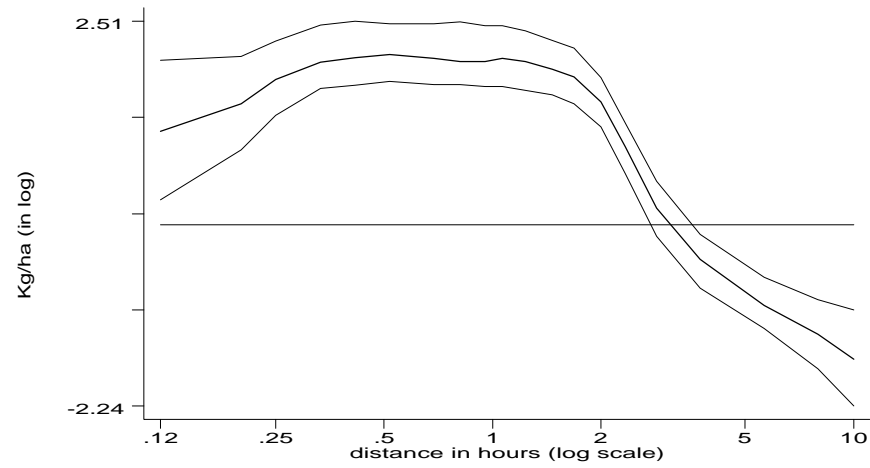
Figure 4. Work migration and distance



Cultivated acreage

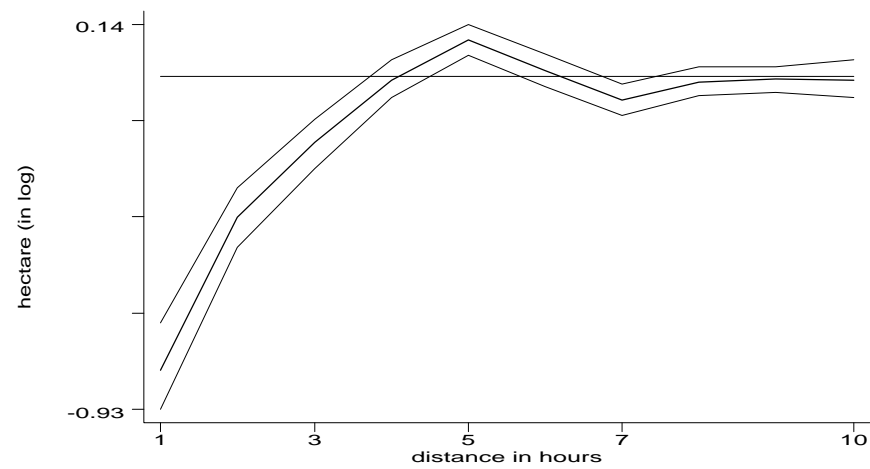


Livestock sales

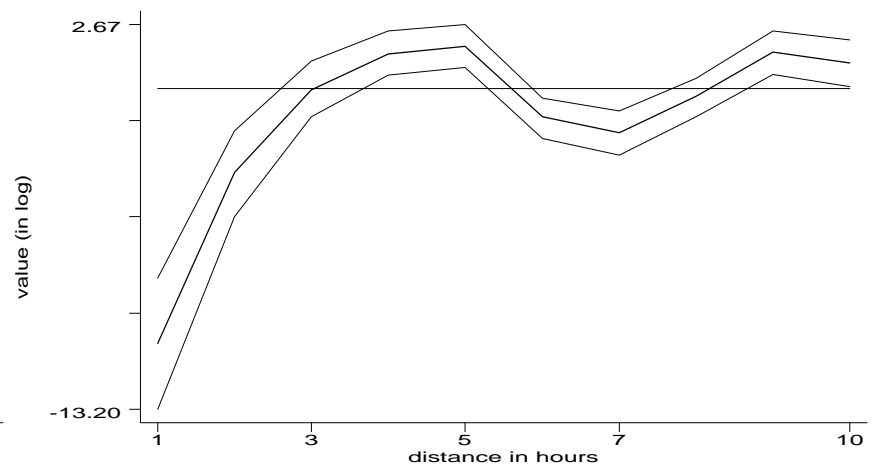


Fertilizer per hectare

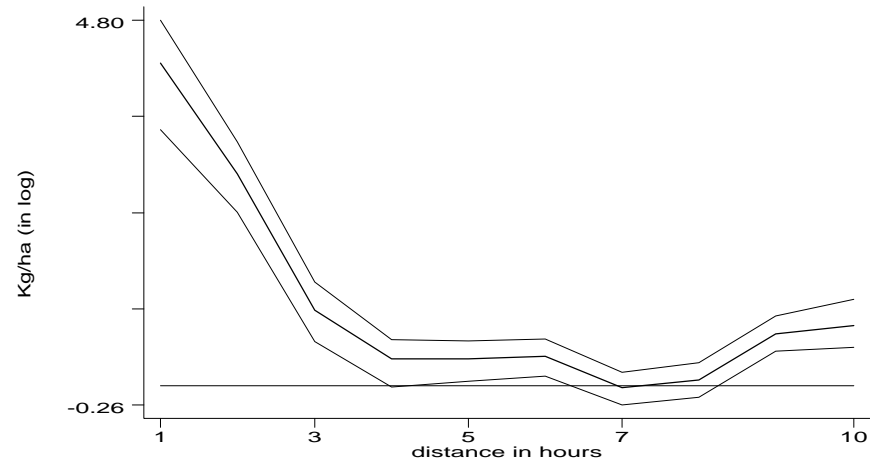
Figure 5. Farming and distance from market



Cultivated acreage

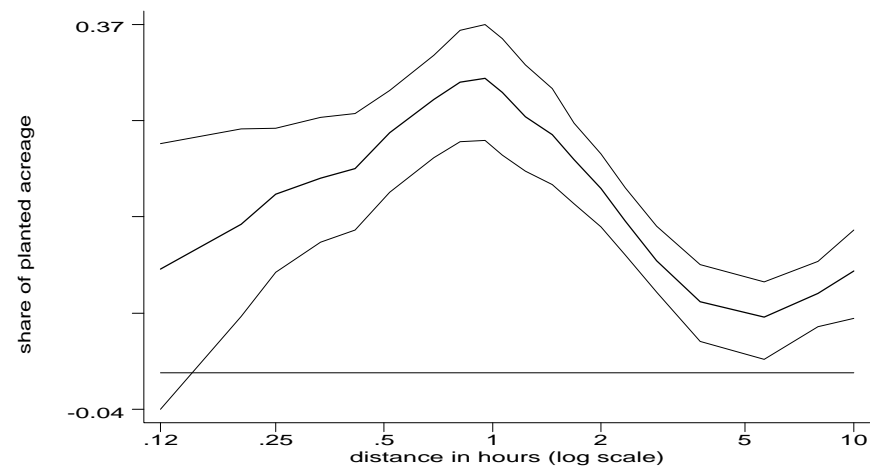


Livestock sales

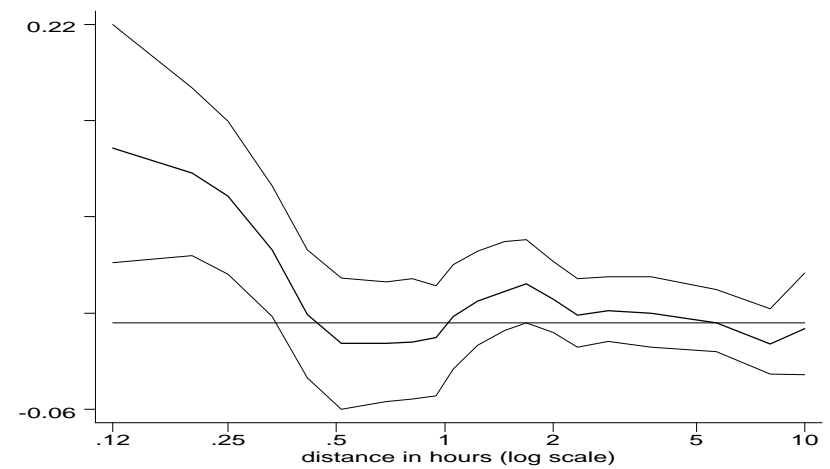


Fertilizer per hectare

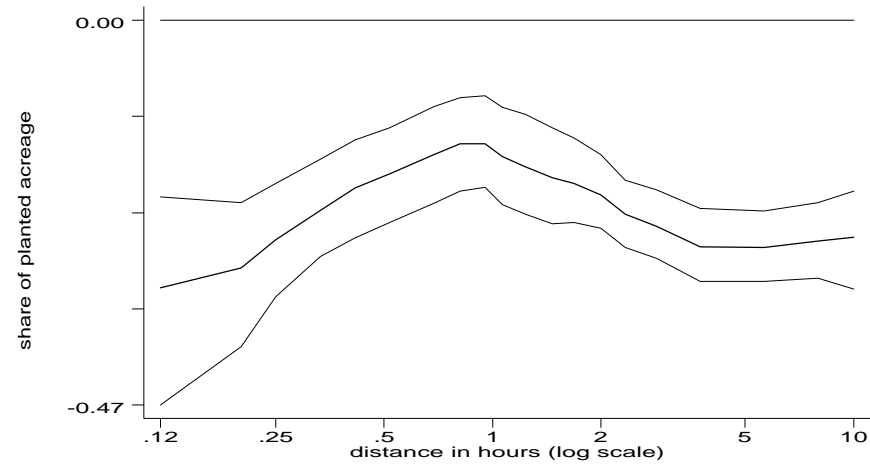
Figure 6. Farming and distance from cities



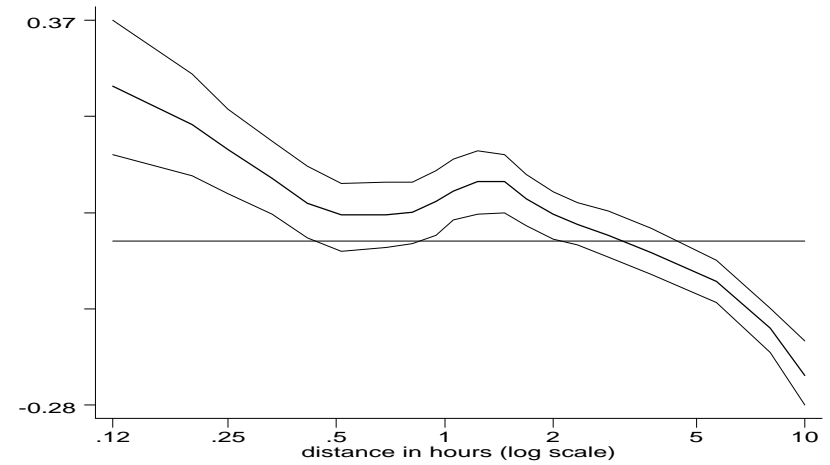
Wet season -- paddy



Wet season -- vegetables

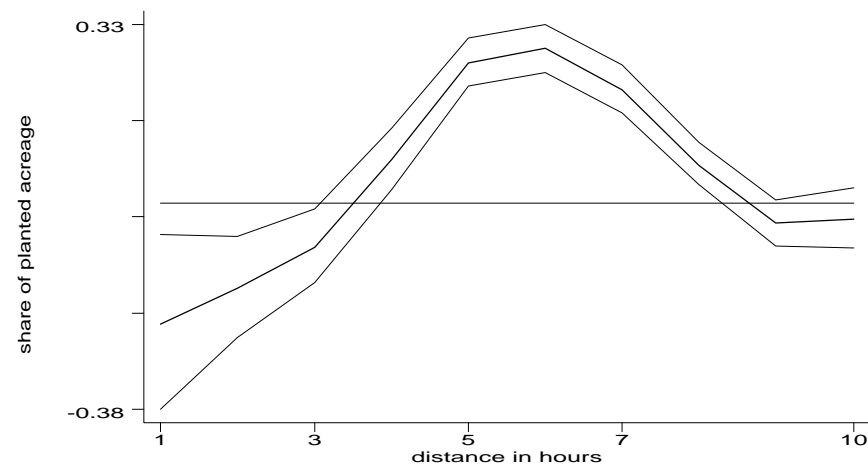


Dry Season -- pulses

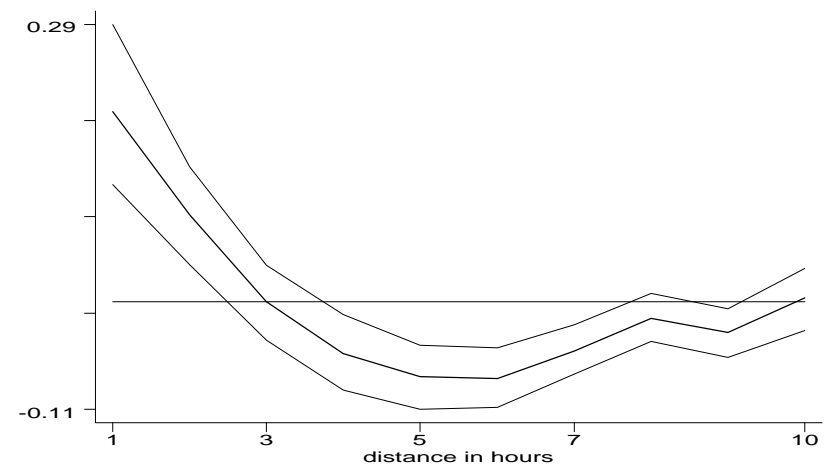


Dry Season -- vegetables

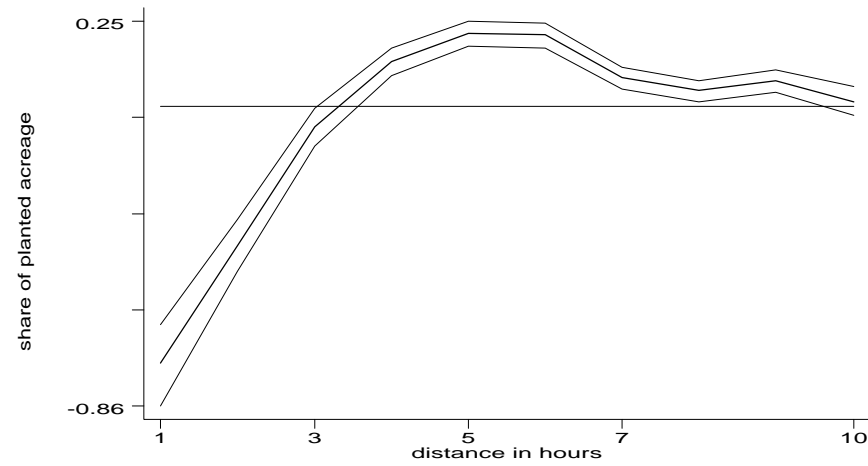
Figure 7. Cropping pattern and distance from market



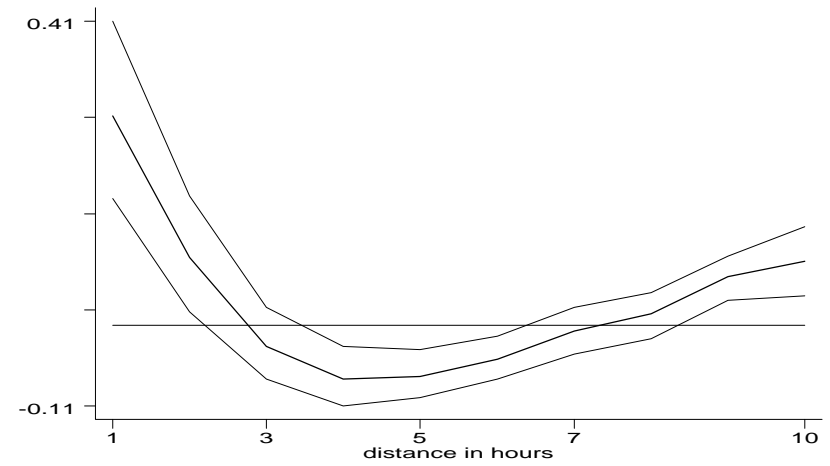
Wet season -- paddy



Wet season -- vegetables



Dry Season -- pulses



Dry Season -- vegetables

Figure 8. Cropping pattern and distance from cities

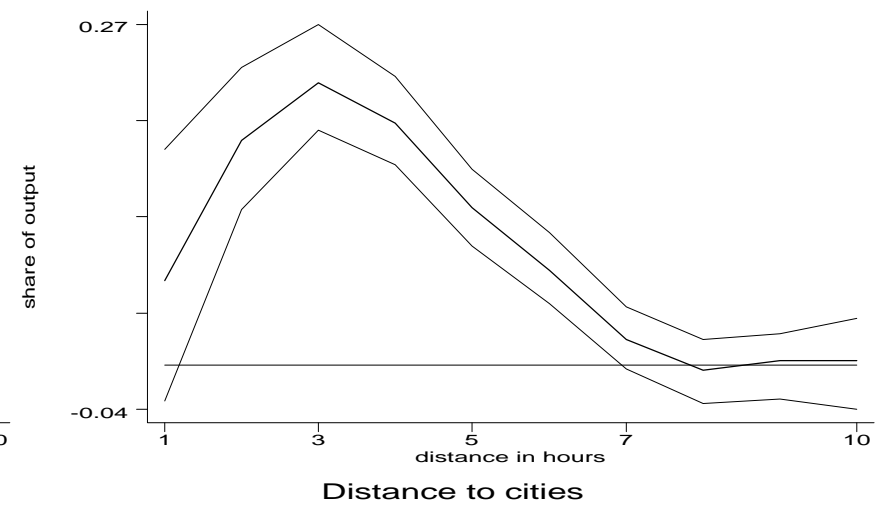
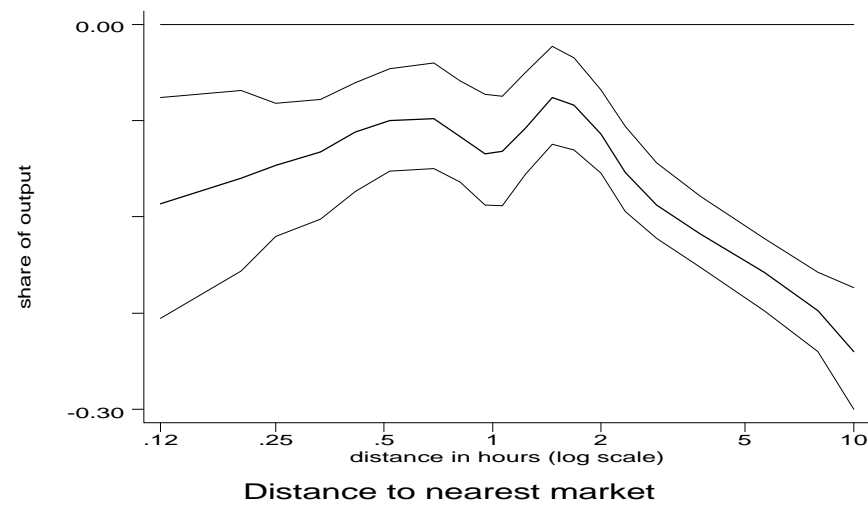


Figure 9. Crop Sales and distance

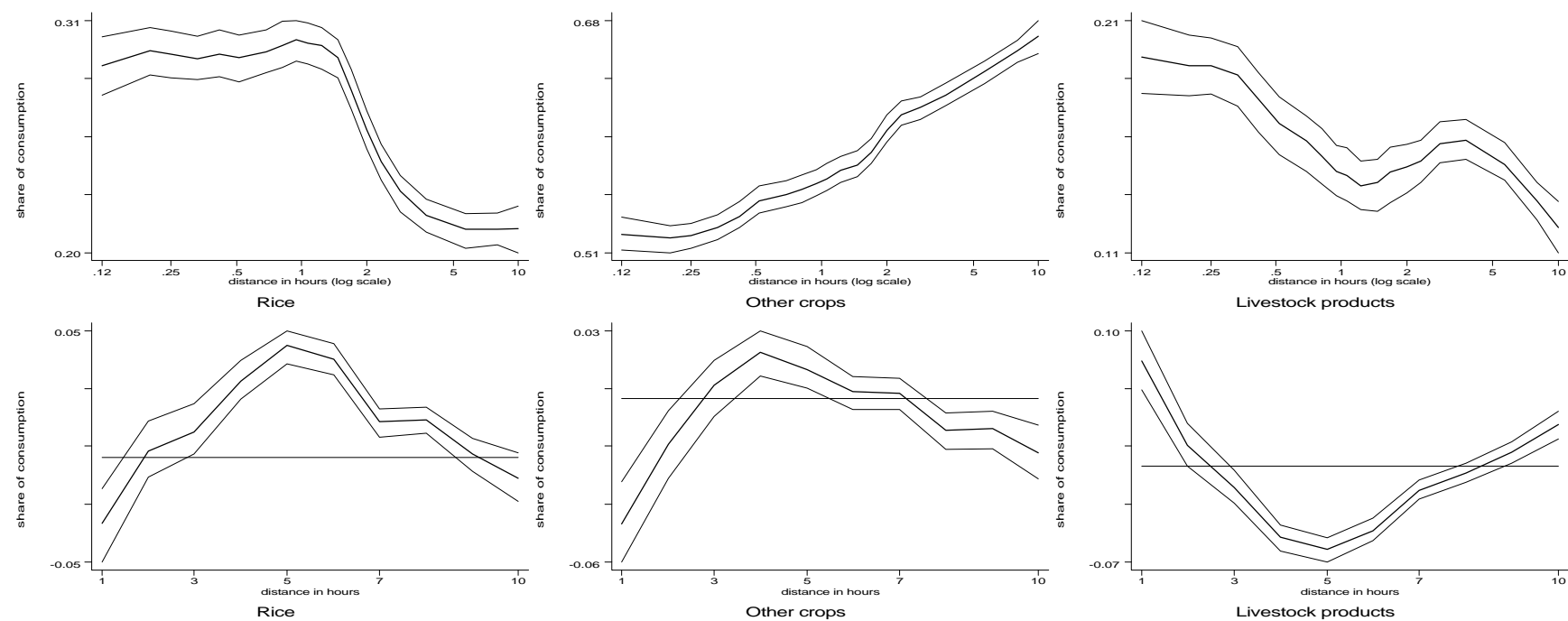


Figure 10. Consumption and distance

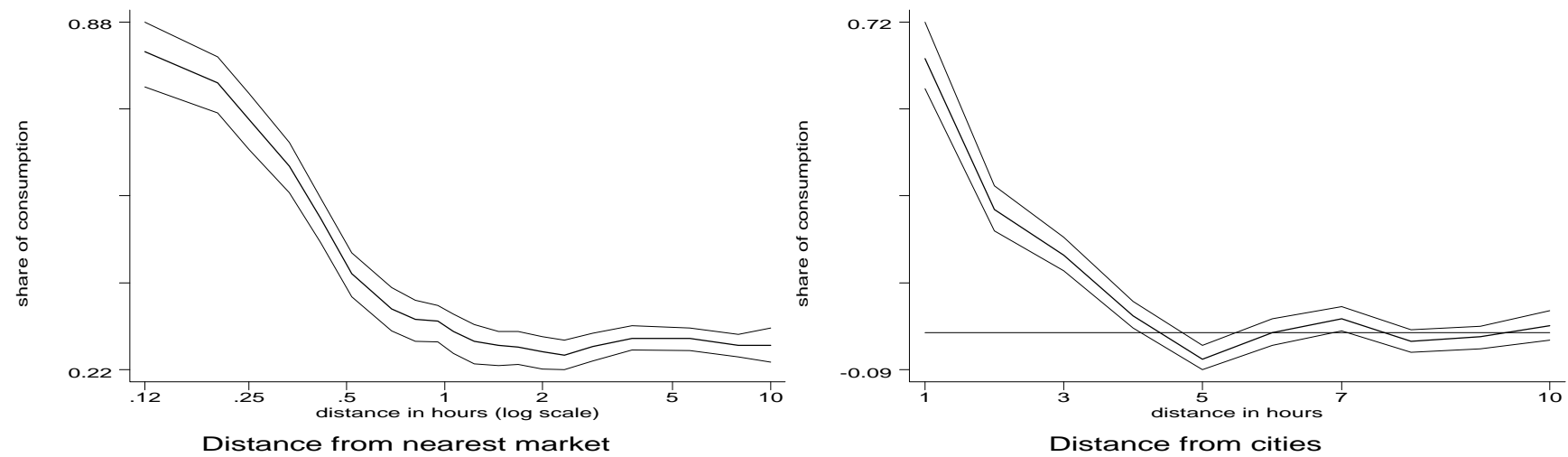
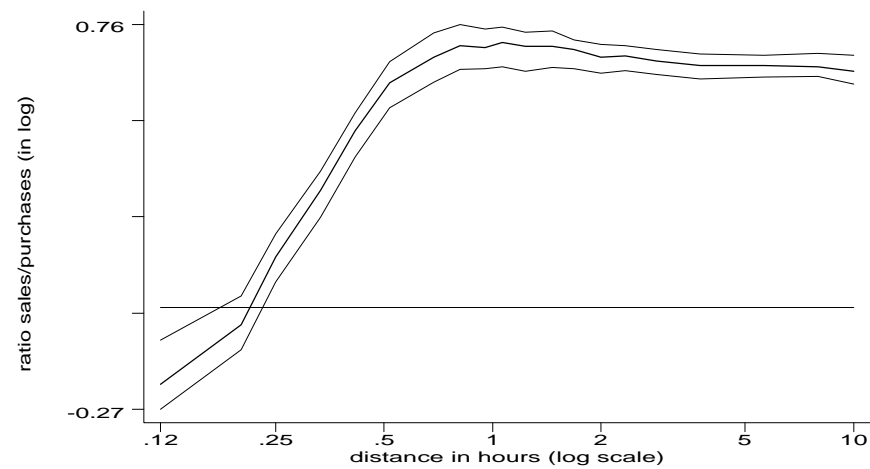
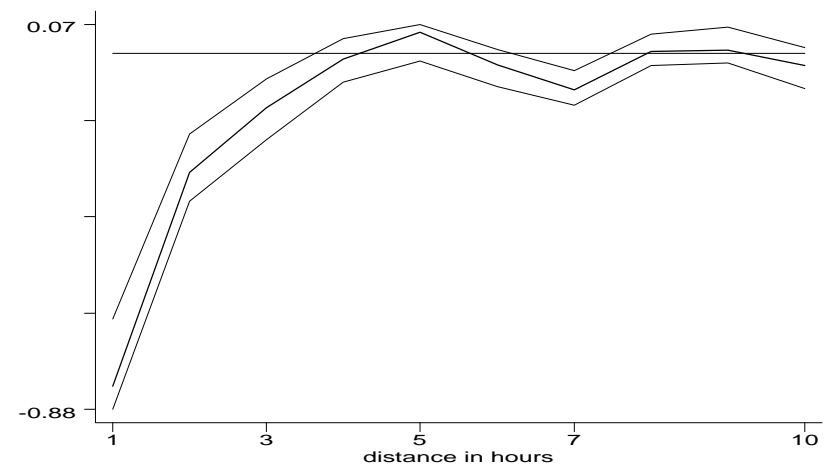


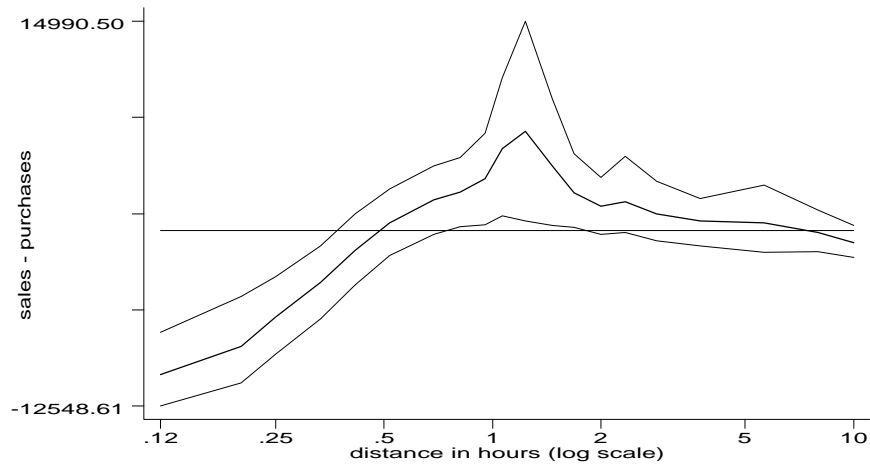
Figure 11. Crop purchases and distance



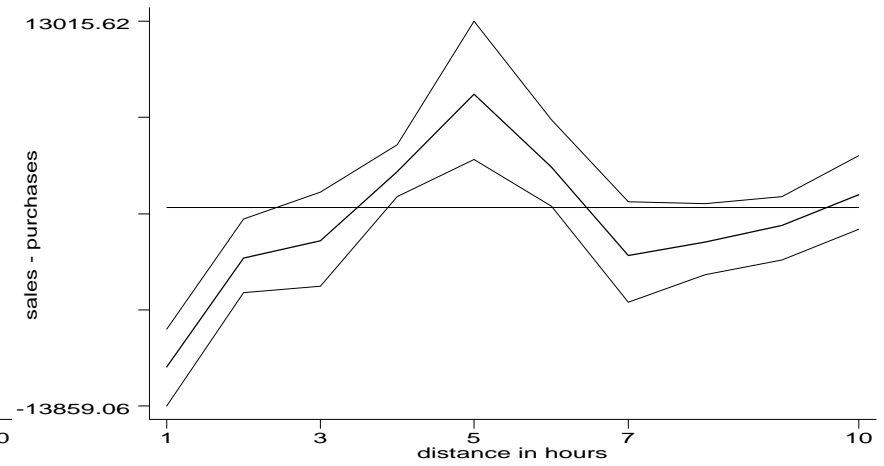
Distance from nearest market



Distance from cities



Distance from nearest market



Distance from cities

Figure 12. Market surplus and distance

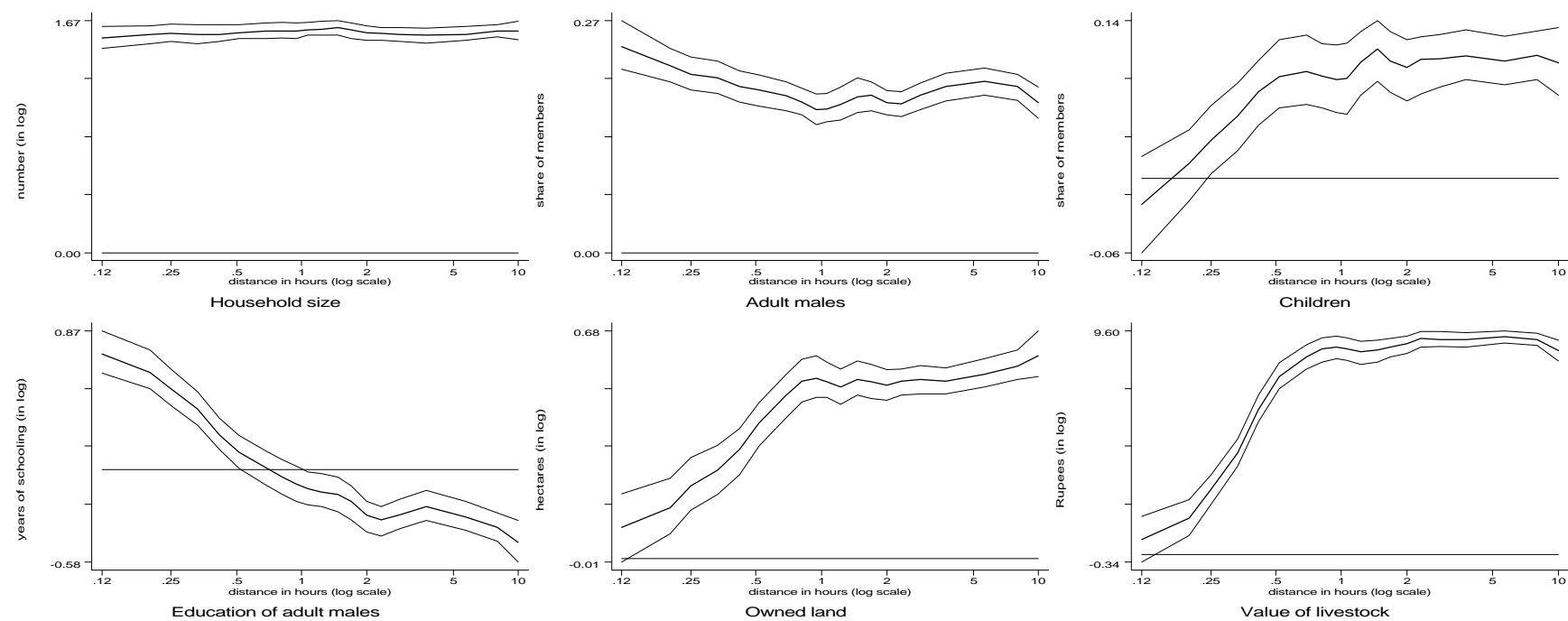


Figure 13. Household characteristics and distance from market

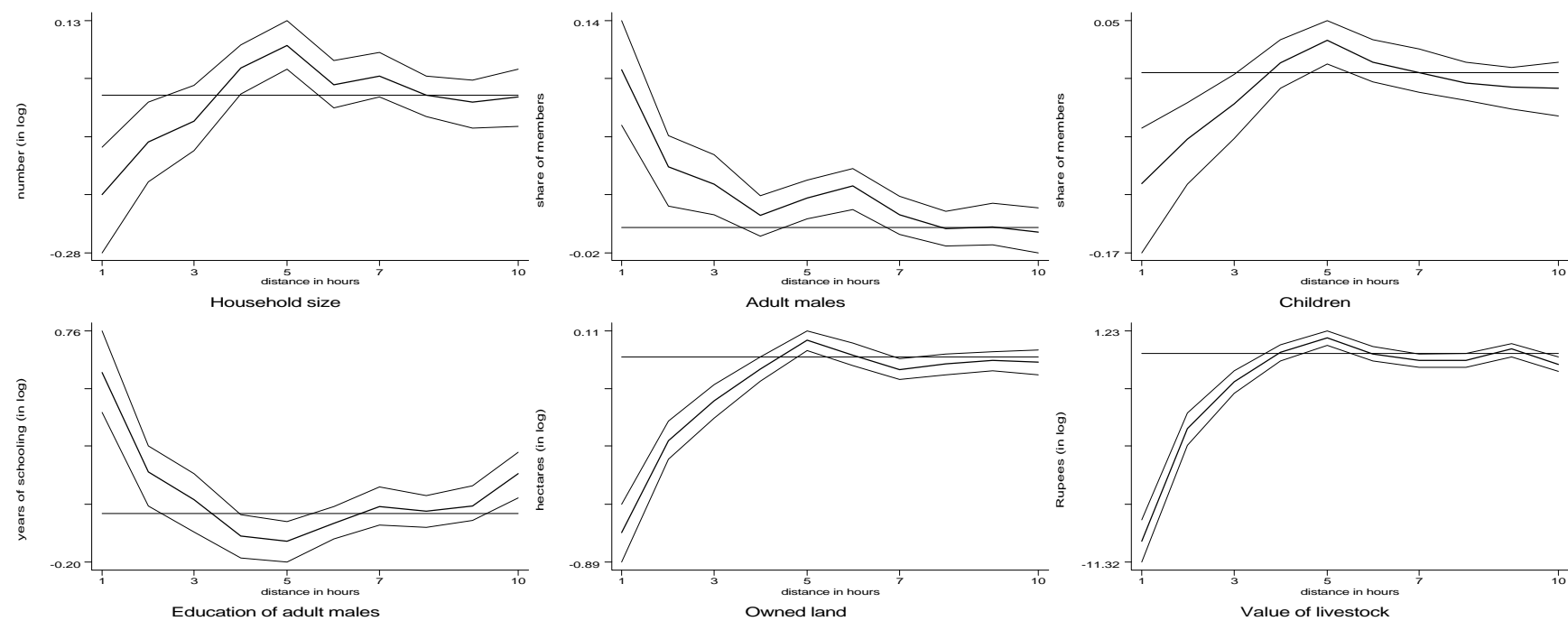


Figure 14. Household characteristics and distance from cities

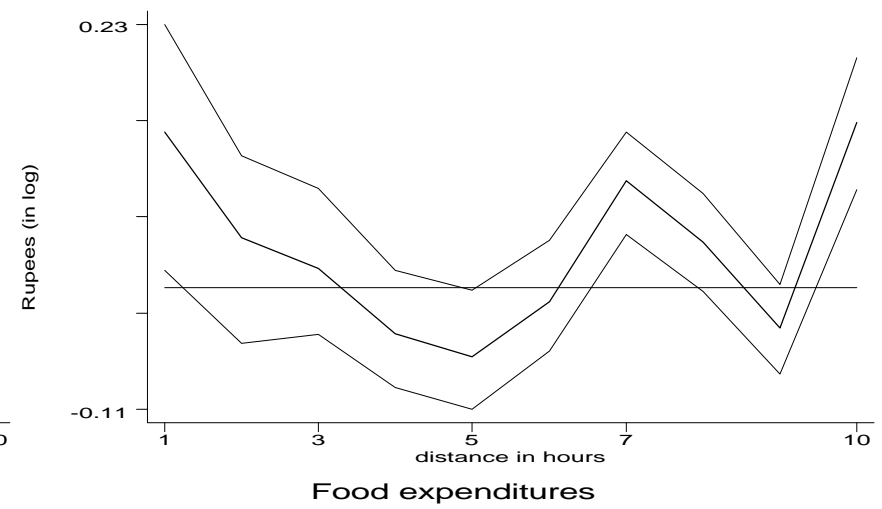
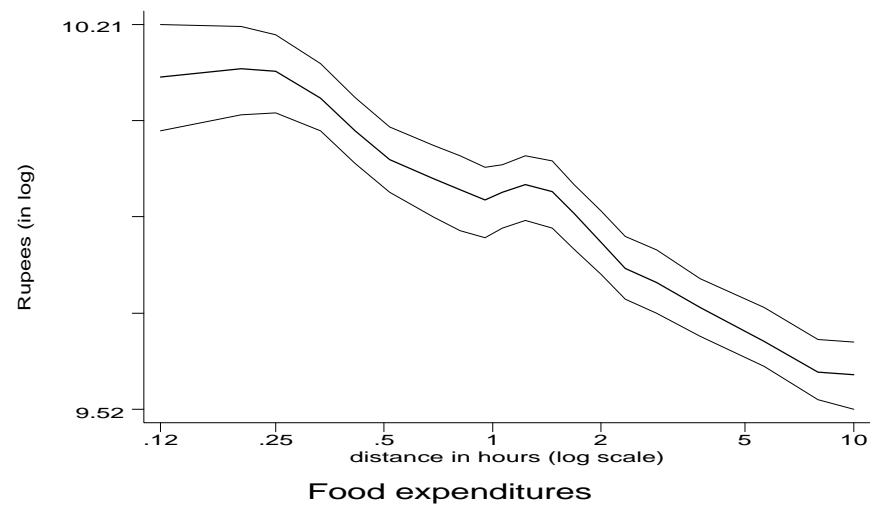


Figure 15. Food expenditures and distance