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The Spatial Division of Labor in Nepal

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Abstract

Fafchamps and Shilpi examine how economic activity and market participation are distributed across space. Applying a nonparametric von Thünen model to Nepalese data, the authors uncover a strong spatial division of labor. Nonfarm employment is concentrated in and around cities, while agricultural wage employment dominates villages located further away. Vegetables are produced near urban centers. Paddy and commercial crops are more important at intermediate distances. Isolated villages revert to self-subsistence. The findings of the study are consistent with the von Thunen model of concentric specialization, corrected to account for city size. Spatial division of labor is closely related to factor endowments and household characteristics, especially at the local level.

This paper—a product of Rural Development, Development Research Group—is part of a larger effort in the group to understand the importance of spatial factors in rural development. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Forhad Shilpi, room MC3-536, telephone 202-458-7476, fax 202-522-1151, email address fshilpi@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at marcel.fafchamps@economics.ox.ac.uk or fshilpi@worldbank.org. May 2002. (62 pages)

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Produced by the Research Advisory Staff

The Spatial Division of Labor in Nepal[1]

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Abstract

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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 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 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. Nepal is a particularly suitable place to study spatial specialization given the extreme diversity of the country in terms of accessibility. At one end of the spectrum, Terai villages are a few hours away by truck from many towns and cities, 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, and non-farm work. To control for differences in road quality, travel time is used as a measure of distance instead of mileage. City population and travel time are instrumented to control for possible endogeneity.

Our contribution is threefold. First, by using several different measures of economic activity and market participation, we provide a detailed and compresensive picture of the spatial division of labor in a poor country. Second, thanks to non-parametric methods, we obtain precise estimates of the distance at which various activities dominate. As a result, we can characterize the various forms that market specialization takes depending on location. Third, we show that spatial effects are large and that city size matters.

Regarding spatial specialization, our results largely confirm the von Thünen hypothesis of concentric circles around cities that vary according to transport costs (e.g. Henderson 1988, Dicken and LLoyd 1990, Abdel-Rahman 1988, Fujita 1988). Nepalese households living near markets and cities are more likely to engage in non-farm (wage) work rather than produce agricultural goods for sale. Fears that cities 'steal' non-farm jobs from the surrounding countryside do not appear justified in the case of Nepal. If anything, it is proximity to markets and towns that fosters non-farm activity, especially wage non-farm employment.

As one moves away from markets and towns, the emphasis shifts progressively from non-farm activity to agricultural production for sale. As anticipated, vegetables tend to be produced close to cities because of their perishability while commercial production of storable crops such as rice and pulses takes place further away. Minten and Kyle (1999) obtain a similar result in Zaire. The emphasis on commercial farming also raises hired labor use. Households located close to towns and markets rely primarily on the market for their consumption needs. Labor migrations are also more frequent in these villages but the effect is not strong.

As one moves further away from towns and markets, households revert to self-subsistence for crops but shift to livestock production as a source of cash income. This is because animals and animal products (e.g., ghee) are more easily transported to distant markets. Isolated villages do not interact with the market at all. These results confirm earlier work in Nepal by Jacoby (2000) and Seddon et al. (1999).

Regarding the spatial range over which certain activities dominate, we find that non-farm wage employment takes place primarily within four hours travel time from large towns. Within villages, non-farm employment is concentrated within one hour of 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. Beyond 5 hours travel time from cities, households no longer sell crops and rely on production to satisfy consumption needs. They also stop purchasing fertilizer. For those located more than 5 hours from a market or city, cash income can still be obtained from livestock but households located more than 10 hours from the market essentially revert to self-subsistence. To our knowledge, this is the first time that a comprehensive quantification of these distance ranges has been presented for a poor country.

Spatial effects are very strong and robust determinants of activity choice and market participation. For instance, a household located right next to a rural market would allocate 40% of its time to non-farm self-employment and 30% to non-farm wage employment compared to 0% for a household located one hour away from the market. Ignoring such spatial effects would undoubtedly bias poverty estimates.

Spatial effects are also important for policy. Our results, for example, show that households located more than 5 hours away from towns and market do not sell crops and do not consume fertilizer. Any effort to promote agricultural innovation would need to take these effects into account to be successful.

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 investigates the role of factor endowments and preferences in activity choice and market participation. Conclusions 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. ?, 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 $z = 1, ..., Z$, 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 be non-linear, with unknown inflection points. The relationship can be written:

$$y_i^z = f(d_i) + u_i \tag{2.1}$$

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 $f(.)$ non-parametrically provides a simple way of testing various hypotheses about the effect of location on economic activity. In addition, inflection points and zeros of the fitted $f(.)$ function provide estimates of the width of various concentric circles, hence providing useful information for policy makers.

Equation (2.1) 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:

$$y_i^z = f(d_i) + \int_0^H g(h) p_i(h) dh + u_i \tag{2.2}$$

The presence of two unknown functions in equation (2.2), the fact that function $g(.)$ 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 $f(.)$ and $g(.)$:

$$y_i^z = \sum_{j=1}^{J} \tau_j D_i^j + \sum_{h=1}^{H} \gamma_h P_i^h + u_i \tag{2.3}$$

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 $f(.)$ and $g(.)$. 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:

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

where T is sample size and λ_τ and λ_τ are penalty parameters.[1] All reported standard errors are robust (White) standard errors corrected for clustering.[2] The purpose of the rest of the paper is to estimate the above model using data on Nepal.

In case y_i^z is dichotomous so that OLS is inappropriate, the sum of squared residuals in equation (??) is replaced by the required likelihood function. Penalty parameters λ_r and λ_γ are 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 $f(.)$. When the dependent variable is censored, we use OLS instead of tobit for two reasons. First, we are interested in how distance affects the unconditional expectation of y_i^z, not how it affects y_i^z conditional on being uncensored. Second, in the presence of heteroskedasticity and clustering, tobit is inconsistent and standard errors cannot be corrected.

[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]As is often the case in survey data, correcting for hetereskedasticity and clustering makes a big difference. To check the possible impact of the roughness penalty correction on standard errors, we compared reported standard errors with standard errors obtained by bootstrapping with 200 replications (with replacement). Given the large sample size and low level of smoothing, bootstrapped confidence intervals are virtually indistinguishable from OLS estimates.

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 (locally called 'hills' to contrast them with the Himalayas) that run East-West parallel to the Himalayas; 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.[3]. 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. Given the mountainous terrain, communications are generally more difficult within Northern Nepal itself than within Terai. 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.

[3]421,000 inhabitants in 1991.

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. Households 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 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).[4] For our purpose, a town is defined as a settlement of more than 10,000 inhabitants. 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

[4] In earlier versions of this paper, we also included population in Indian towns located within 100 km of the Nepalese border. Including them does not affect qualitative results, but their effect on spatial specialization in Nepal is small. They are omitted from the paper because instrumenting urban population and distance for Indian towns raises data and computation requirements beyond what we could handle. This issue is left for further research.

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 distances from each ward. These measures, denoted P_i^h for $h = 1, ..., H$ 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

[5]This 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.

[6]Travel speeds are calculated for various terrains and types of road. Assumed travel times are as follows, in km/hour:

	Highway	Provincial road	Secondary road	Off road
Terai	60	35	10	5
Siwalik	51	29.75	8.5	4.25
Middle mountain	42	24.5	7	3.5
High mountain	36	21	6	3
High Himalayas	30	17.5	5	2.5

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.

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, $\{P_i^1; ...; P_i^{10}\}$ = 0;0; 30,000;0 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. We confine our analysis of urban population effects to a 10 hour radius; beyond 10 hours travel time, urban proximity effects taper off. Population is measured in millions.

Before proceeding with the analysis, we must correct for the possible endogeneity of urban population and travel time. It is indeed conceivable that towns are larger whenever the surrounding countryside produces a food surplus. Observing that wards located to large towns sell more food would then be the result of reverse causation. The same reasoning applies to road construction: public authorities might be more inclined to build roads to areas that produce more agricultural surplus. Since travel is faster on roads, this would result in surplus areas being closer to towns in terms of travel time. Similar concerns about reverse causation apply to non-farm production, vegetable production, etc.

To address these concerns, we instrument city population and travel time as follows. Predicted urban population is obtained by regressing the log of actual population on physical characteristics of the district in which the town is located: the log of its size in square kilometers; the log of its arable land area; the log of the distance to the nearest river; its mean elevation; the standard deviation of the elevation within the district; and a dummy if the district is the mountainous part of the country. By limiting our instruments to physical features, we minimize the risk of that instruments are themselves endogenous. [7] Size is included because larger district can hold more people. Arable land area proxies for food production potential. Distance to the nearest river proxies for accessibility, as roads often follow river valleys. Elevation controls for climate – towns are less likely at higher elevations. The standard deviation of elevation is a measure of roughness in the terrain; towns are more likely in flat districts. The mountain dummy is included for the same reason. Regression results are presented in Appendix 1. The R^2 of the regression is 0.27. Regressors in general have the expected sign but are multicollinear (mean VIF of 8.7), which explains why regressors are not individually significant. Since we are only interested in predicting population, multicollinearity does not matter.

Travel time between a ward and a town is instrumented using foot travel time as well as physical characteristics of the ward and town: size of the district; arable land; mean elevation; distance from the nearest river (available only for the town); standard deviation of elevation; and regional dummies (East-West). Foot travel time is computed using iso-elevation curves to account for the mountainous nature of the terrain. The regression is estimated in log form. Results are presented in Appendix 2. As expected foot distance is the major determinant of travel time. The R^2 of the regression is 0.84. Population variables P_i^h used in the subsequent analysis are constructed using predicted urban population and travel time instead of actual values.[8] As it turns out, results are virtually identical to those obtained with actual values, suggesting that the potential endogeneity of town population and road construction are not a source of bias in these data.

[7] We also experimented with a longer list of instruments, including area of irrigated land and the like. This results in a better fit for town population but the rest of the analysis is unaffected. Additional regressors are omitted in the analysis presented here to minimize the risk of endogeneity and overfitting.

[8] Standard errors are not corrected for the use of predicted regressors. Doing so would be extremely difficult given the way in which regressors are constructed. The fact that instrumented and unininstrumented results are very similar suggest that inference is very unlikely to be affected.

4. Econometric Results

We now turn to the econometric analysis. 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. Since respondents are interviewed at their place of residence and most commute to work by foot, we expect reported employment patterns to reflect working conditions in the vicinity of the place of residence. 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. Results are presented in graphical form to facilitate interpretation. All Figures report coefficient estimates as well as the bootstrapped 95% confidence interval around them.[9]

The shape of function $f(.)$ is shown in Figure 2 for each employment variable; the shape of function $g(.)$ is shown in Figure 3. Distance to towns varies across wards only; the distance to the nearest local market varies across households within the same ward. Function $f(.)$ thus controls for within ward spatial variation. Figure 2 (and all subsequent figures relative to within-ward spatial variation) uses distance percentiles, not actual distance, on the x axis.[10] The effect of actual distance is much steeper than shown. With this caveat in mind, the resemblance in the shape of both functions is cunning. Non-farm wage employment decreases sharply with distance from market and urban centers. Within a ward, it tapers off within one hour walking time from the nearest market (Figure 2). Non-farm self-employment also decreases with distance from the local market but it is not significantly affected by proximity to urban population (Figure 3).

[9] Surveyed wards represent only a small proportion of all wards and are located far apart. It is therefore extremely unlikely that standard errors suffer from bias due to spatial autocorrelation. Correcting standard errors using, for instance, the method proposed by Conley (1999) is not necessary. Reported standard errors do, however, correct for cluster effects, that is, correlation in household residuals within wards.

[10] Dummies used in estimation – and thus confidence intervals – are constructed using percentile intervals.

These results indicate that proximity to urban population raises the probability that a household is involved in non-farm wage employment. Wage employment outside agriculture thus appears to be primarily an urban phenomenon. Within a ward, households involved in non-farm employment are located in or very near market centers, 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. These findings are consistent with road construction evaluation reports that document the rapid increase in non-farm activities and the relocation of villagers along a newly created road and rural markets (e.g. Rapp 1994, NECMAC 1998, Bajracharya, Aryal, Sharma, Manandhar and Pyakuryal 1990).

These results are in line with the conclusions of the Government of Nepal (1999). They also indicates that city size matters: the larger the urban population, the stronger the effect on non-farm wage employment, indicating a relationship between firm size and city/market size ((Fafchamps and Shilpi 2001)). 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 or five hours of travel time away from the town itself – much further away than normal commuting time.[11] This suggests that the development of non-farm production in rural areas is intimately related to their proximity from large urban centers. In Nepal, proximity to towns and market centers increases non-farm output, not isolation.

Figures 2 and 3 also present results for self-employment and wage employment in agriculture. The dependent variable is the share of household labor in these two categories. As anticipated, the time households devote to farming increases sharply as one moves away from markets and urban centers. But the pattern varies between self-employment and wage labor: self-employment

[11] This result is not an artifact of the instrumentation of travel time: virtually identical results are obtained with actual travel time corrected for road transport.

in farming rises as soon as one gets out of the town and remains high. In contrast, wage employment in agriculture peaks in households residing 1 hour from local markets and in wards located 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.[12] 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 are predominantly an urban phenomenon.

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, migrations are concentrated among those households further away from the nearest market, but the effect is not significant. Taken together, these results suggest that temporary work migration is slightly more 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.

Turning to farming in more detail, we see that operated land mirrors agricultural employment

[12] Jacoby, however, does not control for nearby urban population.

– it increases with distance from markets and towns (Figures 5 and 6). Farmers 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 preferred mainly by households residing between 1 to 4 hours from the local center and more than 4 hours from towns.

Agricultural input use is also influenced by distance. Figures 5 and 6 report a sharp decrease in fertilizer use as one moves away from cities and market centers – presumably because of transportation costs.[13] Similar results are obtained by Jacoby (2000). But our estimation method suggests that the effect is not linear. Fertilizer use is highest among households residing within 2 hours of a market center, after which usage drops sharply.[14] 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 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. 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 $f(.)$ and $g(.)$, respectively. We find that vegetable production, as predicted, is highest in the vicinity of cities and local markets, both during the dry and wet season. The

[13] 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 different distances.

[14] Virtualy identical results obtain if one uses fertilizer per cultivated area.

magnitude of the effect is large but it is seldom significant. Vegetable production also increases in wards located far from towns, something we had not anticipated. Contrary to results reported so far, spatial cropping patterns are quite different when actual population and travel time figures are used. In that case, we find a stronger and clearer relationship between vegetable production and proximity to towns. The difference suggest a tendency for Nepalese roads to be built to serve vegetable producing areas.

Land devoted to paddy initially increases with distance from the local market. This effects, however, tapers off in more remote parts of the ward. There, more emphasis is put on subsistence crops. Areas located near urban centers produce slightly more paddy, but the effect is not significant. Here too, the difference with uninstrumented regressions is large, suggesting that roads are built to paddy producing areas. 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).[15] By construction, the regression is limited to farming households. Results show a lot of variation in crop commercialization initially among households located near markets and towns. As Jacoby (2000), we find that commercialization initially increase with the distance between households and local markets, but the effect is not significant. Up to 6

[15] Regressions for individual crops yield similar results.

hours of travel time, distance from towns has the expected monotonic effect on crop sales: more distant wards sell less. Crop sales are zero on average for households residing 6 hours or more from a large town, an indication of the self-subsistence focus of agricultural production.

Next we turn to consumption. We first regress consumption shares in major food products on distance to markets and cities. Taken together, these products account for 86% of measured consumption. Results are summarized in Figure 10. Rice consumption tends to fall with distance from markets, but proximity to towns has no significant effect. Among households residing more than two hours away from the nearest market spend roughly 25 percentage points 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. In contrast, consumption of other crops increases with distance from markets. Livestock expenditures, in contrast, show no clear pattern. Proximity to urban centers is shown to raise the consumption of livestock products (nearly significant) and reduce the consumption of cereals other than rice. Contrary to expectations, consumption patterns in isolated wards resembles more that of peri-urban areas than that of intermediate wards. We revisit this issue in the next section.

The 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. Results for all crops combined are summarized in Figure 11. They indicate a systematic decline of the share of purchased consumption with distance: households residing near a town or market 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.[16] The effect is large in magnitude

[16]The question is whether this is the only reason. We revisit this issue in the next section.

both within wards and between wards and towns; it is very significant in all cases. Residents of wards located less than 3 hours away from a town rely massively on the market to fulfill their consumption needs. In contrast, households living more than four hours from a city do not at all rely on the market for their consumption of agricultural products. Taken together with earlier findings about the sale of crop output, these results 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. We use two definitions of marketed surplus: first, as the ratio of crop production over consumption;[17] second, as the difference between production and consumption. The first definition emphasizes self-sufficiency, that is, the degree to which a household is in surplus or deficit, irrespective of the size of its output. The second definition emphasizes the absolute size of the marketed surplus. Results, presented in Figure 12, show that food self-sufficiency increases rapidly with distance from towns and markets. Given that all households are included in the regression, this outcome largely reflects the fact that households located near cities and market centers spend less time producing food and more time producing non-farm products and services.

In terms of absolute magnitude, marketed surplus is largest at intermediate distances. Marketed surplus is largest one hour or more from a market center and four hours from towns; the latter effect, however, is not significant. 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 value of the marketed surplus drops among households residing 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

[17]Because the resulting ratio has a highly skewed distribution, we use the log(1+ ratio) instead as dependent variable.

more than four hours from a local 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. We were able to show that the range of distance over which non-farm wage 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.[18] In terms of agriculture, several forces are at work. The dominant force is that which affects commercialization. Proximity to towns 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 their consumption, and they can afford to rely on the market because traded quantities are higher. Fertilizer purchases follow the same pattern, suggesting that technology adoption is related to crop 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 livestock products either transport themselves (live animals) or have a high value to weight ratio (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. The effect, however, is not as strong as anticipated. Concentric circles of specialization in Nepal nevertheless

[18] This issue is the object of future work.

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 precise spatial range of particular phenomena.

5. Controlling for Household Characteristics

We have seen that what Nepalese households do varies systematically with proximity to towns and market, but we do not know why. Our preferred interpretation is that what people do is influenced by market access, but other explanations are possible as well. In particular, preferences or talent may vary systematically with proximity to markets in such a way as to generate the relationships described in the previous section. Wage work, for instance, might be more frequent in the vicinity of towns simply because people there are better educated and educated workers are more productive in a salaried workplace.

To show this formally, consider a producer in location j having to choose among various activities indexed by i. Let the output price be denoted p_{ij}.[19] There is a single production factor, labor. Output Q_{ij} of activity i depends on employment L_{ij} in activity i, with $Q' < 0$. Profit maximization dictates that marginal value product of labor equal the wage rate w_j in location j, i.e., that:

$$p_{ij}Q'(L_{ij}) = w_j$$

from which we see that the optimal choice of L_{ij} increases with p_{ij}: if output prices p_{ij} for certain activities are higher closer to cities and markets, so is L_{ij}. More labor is used in remunerative activities.

[19] What matter for activity choice are only relative prices. Prices are normalized by setting one price to one.

Now consider an alternative model in which output depends on two factors of production, labor L_{ij} and human capital H_{ij}. Further assume that relative output prices are the same across locations. Factor prices are written w_j for labor and r_j for human capital. Relative factor prices depend on their relative scarcities: locations with a lower H_j/L_j have a higher r_j/w_j. Comparative advantage dictates that locations specialize in the activities using more intensively the factor they have in abundance. So, for example, if activity k uses more human capital and human capital is abundant in location j, labor used in activity k will be higher in locations with a higher human capital, i.e., L_{ij} is an increasing function of H_j. Further assume that H_j varies systematically with proximity to town and market, say, because schools are located near towns and market centers. Regressing L_{ij} on proximity to town and market, as we have done so far, would show a relationship between L_{ij} and distance even in the absence of differences in relative prices, i.e., in the absence of market effects.

The above discussion suggests an indirect way of testing whether patterns of production vary because of differences in factor endowments or because of differences in marginal returns possibly driven by proximity to markets. Say we have data on factor endowment H_j. First regress H_j to ascertain whether it varies systematically with distance. If it does, differences in factor endowment might be responsible for the measured effect of distance on activity. To test this possibility, regress L_{ij} on H_j as well as distance: if including H_j drives the effect of distance to zero, factor endowment differences might be responsible for the observed spatial division of labor. If distance remains significant, distance affects marginal returns through some other process, possibly relative prices, possibly other unobserved endowment. A similar reasoning can be extended to choices other than production. Consumption, for instance, may vary systematically across locations not because relative prices are different but because incomes vary with location.

Implementing the above approach is the object of this section. Before presenting the results, however, it is important to understand its limitations. First of all, we can only test the effect of observed endowment differences. In the absence of panel data, unobserved differences such as activity specific skills or preferences cannot be controlled for.[20] Second, the validity of the test rests on H_j being exogenous. Suppose that this is not the case, i.e., that factors are either perfectly mobile across space or that they can be accumulated instantaneously, so that factor prices are equalized across space. Further assume that prices vary systematically with location. Profit maximization dictates that:

$$\begin{aligned} p_{ij}\frac{\partial Q(L_{ij}, H_{ij})}{\partial L_{ij}} &= w \\ p_{ij}\frac{\partial Q(L_{ij}, H_{ij})}{\partial H_{ij}} &= r \end{aligned}$$

which implies that L_{ij}, H_{ij}, and $H_j = \sum H_{ij}$ vary systematically with p_{ij} and thus with distance. The endogeneity of H_j generates multicollinearity with distance since H_j depends on relative prices and by assumption $p_{ij} = \sum_{k=1}^{J} \tau_k D_j^k + \sum_{h=1}^{H} \gamma_h P_j^h + \varepsilon_{ij}$ where ε_{ij} represents factors other than distance that affect relative prices – and thus L_{ij} and H_j. When ε_{ij} is large, H_j is much more correlated with L_{ij} than distance itself. Including H_j in the regression thus biases the distance coefficients toward zero.

Since we do not have instruments for endogenous placement of households, we cannot control for the possible endogeneity of H_j. We nevertheless propose to do two things: (1) regress household characteristics H_j on distance and see whether H_j vary systematically with distance; and (2) add H_j to all regressions presented in section 4. Given that H_j is potentially endogenous, it is important to understand the limits of this procedure. If distance coefficients become

[20] Plans are underway to collect a second round of NLFS panel data in Nepal but the data will not be available for several years.

non-significant when we include household characteristics, it could be because the location of endowments drives economic activity, or because households locate endogenously. We cannot tell. If, however, distance is still significant after we include household characteristics, then we can reject the hypothesis that differences in observed factor endowments are responsible for spatial division of labor. If, in addition, observed factor endowments or preference shifters do not vary with distance, then they can safely be ruled out as the driving force behind spatial division of labor.

The household characteristics used in the analysis are measures of human and physical capital for which we have data – age of household head, household size, household composition by sex and age, average education of adult males and females, and inherited wealth. The age of household head controls for experience and life cycle effects. Household size and composition control for labor supply and food preference effects.[21] Average years of schooling for adult males and females our measure of human capital. Children education is ignored because it is less likely to affect activity choices but more likely to be influenced by it through income. Inherited wealth is our proxy for wealth. Measures of current wealth such as land and livestock cannot be used because they depend on current activity choice (farming). To control for other geographical effects, we also include regional dummies (east, west, mid-west, far-west, and central – the omitted category) and elevation dummies (mountains, hills, and Terai – the omitted category). To control for income effects, regressions relative to consumption (expenditures on certain food categories; food purchases; and marketed surplus) also include total expenditures as additional regressor.

We begin by examining whether household characteristics vary systematically with distance

[21] Household composition variables are the share of adult males, the share of adult females, the share of children, and the share of youths (the omitted category).

to market and towns. Results are summarized in Figures 13 and 14.[22] Households residing close to markets have fewer children and more adult males. Household heads residing close to towns tend to be younger. As expected, schooling levels of male and female adults drop with distance from towns and markets. This could be due either to supply effects – school are located closer to market center – or demand effect. The latter would arise if higher returns to schooling near the market center incites educated residents and migrants to locate closer to the market and encourages parents to invest in their children's education.

We also examine whether inherited wealth and total consumption vary systematically with distance. Results, presented in Figure 15, show that inherited wealth increases dramatically with distance from towns and markets. This is consistent with the emphasis on agriculture and the role of land and livestock in agricultural production. The lower half of Figure 15 also shows that consumption drops dramatically with distance, albeit it is unclear how much of this drop simply reflects lower food prices in rural areas.

Observed household characteristics vary with distance. Are results reported in the previous section ultimately driven by differences in endowments and preferences? To investigate this possibility, we estimate regressions of the form:

$$y_i^z = H_i'\beta + \sum_{j=1}^{J} \tau_j D_i^j + \sum_{h=1}^{H} \gamma_h P_i^h + u_i \tag{5.1}$$

where H_i stands for household characteristics and regional dummies. The model is estimated using the roughness penalty correction as before. To save space, we omit the Figures themselves and simply discuss the differences with Figures 2 to 12.

Our first set of results relate to non-farm work. They can be summarized as follows. The

[22]Some household characteristics are omitted from the figures because non-significant but included in the subsequent analysis.

effect of distance from urban population is reduced by about 30% by adding H_i but distance coefficients remain significant if they already were. We can therefore rule out the possibility that the effect of proximity towns is due to differences in observed household characteristics. Within wards, however, distance is much less significant. One possibility is that rural markets locate where educated households reside. A more likely interpretation is that residential mobility and reallocation of productive resources within wards are sufficient to match workers with location-specific occupations. This would be the case, for instance, if households interested in trade or crafts move to the market center. This would be in line with field observations made by Rapp (1994) and Bajracharya et al. (1990). Without more data, however, we cannot be more conclusive on this issue. The effect of proximity to towns on the propensity to migrate is unchanged.

Next we turn to farming. Results concerning operated land, livestock, fertilizer use, cropping patterns, and crop sales (Figures 5 to 9) are by and large unaffected as far as distance to towns is concerned. But distance to the local market is no longer significant in nearly all cases. The key determinants are education and inherited wealth (which determines the start-up capital available for farming): these regressors account for most of the within-ward variation in farming as more educated households farm less, while those with more inherited wealth farm more. These results are consistent with Fafchamps and Quisumbing (1999) and Yang (1997).

We also reestimate our consumption, crop purchases, and marketed surplus regressions (Figures 10 to 12). Since consumption choices depend on income, consumption shares and crop purchases are likely to be affected by income effects which, in turn, are affected by activity choices. As a result, market participation results presented in the previous section may be spurious because driven by income differentials.

To control for income effects, we add total consumption expenditures (in log) and its square to the list of household characteristics. Results indicate that distance to local market is no longer significant in all three sets of regressions. Household characteristics, especially consumption expenditures, account for observed within-ward differences. The situation is quite different for distance to towns: results here are stronger than before the introduction of household characteristics. As before, crop purchases decrease with distance from towns and, as a result, self-sufficiency increases. The effect remains strong and significant. The consumption of farm products depends on distance to towns, but in ways that become clearer after income effects are controlled for. This is shown in Figure 16. In particular, rice consumption is much higher near towns, while the consumption of other crop and livestock products increases with distance to towns. This is in line with 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).

6. Conclusion

Combining household level data with information on distance to markets and towns, we have examined the spatial division of labor in Nepal. A semi-parametric model was used to avoid restricting the shape of the relationship between spatial specialization and distance to markets and towns. Distance is measured in hours of travel time. To control for possible endogeneity, city population and travel time are instrumented using physical characteristics of surveyed wards and districts. Coefficient estimates with and without instrumentation are very similar, thereby suggesting that endogeneity of city size and road construction is not a serious concern.

Result 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 towns. The effect is strong for towns of all sizes. 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 vary with distance to town and with their size. Vegetable production in both seasons is somewhat 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 towns. 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, the proximity to markets and size of towns are strongly associated with different patterns of production among Nepalese households. Towns 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. Surprisingly, this is not the zone where fertilizer consumption is highest.

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 fit the von Thünen model of concentric specialization, except that our results also show the importance of town size. Less anticipated is our finding that villages located near towns also participate in 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, contrary to what is sometimes assumed. This appears to be linked not so much to income effects but rather to reliance on the market for the satisfaction of consumption needs.

These results are partly associated with differences in factor endowments and preferences. Distance between surveyed households and the nearest market is no longer significant in most regressions once we control for household characteristics. Without household panel data, we are unable to tell whether it is proximity to market that drives household factor endowments (through internal migration or accumulation) or whether it is the opposite. Distance to towns, however, remains strongly significant even after household characteristics are included. This suggests that distance to towns has an effect on economic activity and market participation beyond that of differences in (observed) factor endowments. These issues deserve further research.

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Table 1. Characteristics of Surveyed Households

1. Household composition	Unit	Mean	Std. dev.	Median	N. obs.
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

1. Labor	Unit	Mean	Std. dev.	Median	N. obs.
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

7. Nearest City within	Number of Wards	Percent	Number of Households	
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

Appendix 1: Intrumenting equation for town population
(dependent variable is the log of town population)

	unit	coef.	t-stat
Area of district in which town is located	log(square km)	-0.472	-1.38
Total arable land area	log(ha)	-0.592	-1.18
Distance to nearest navigable part of river	log(km)	-0.206	-1.04
Mean elevation of the district	meters	-0.000	-0.04
Standard deviation of district elevation	meters	0.001	0.97
Mountainous terrain	yes=1	-1.218	**-1.85**
Intercept		21.034	**3.63**
Number of observations		34	
R-squared		0.2705	

Source: distance to river, elevation, and area of district come the Nepal GIS data base. Arable land comes from the Statistical Yearbook of Nepal.

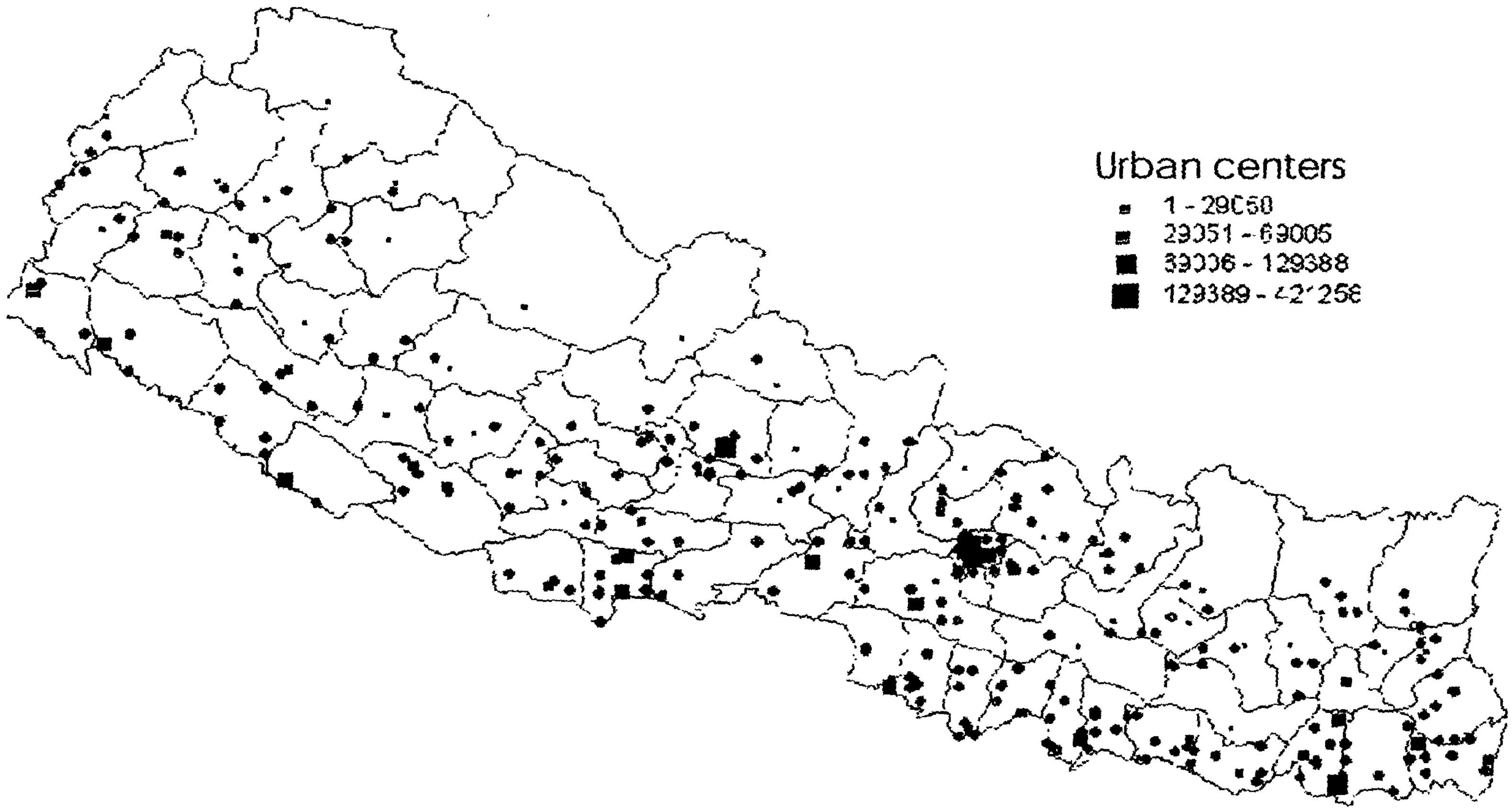
Appendix 2: Instrumenting equation for travel time

(dependent variable is the log of travel time between ward and town)

	unit	coef.	t-stat
Foot travel time between ward and town	log	0.677	**174.12**
Ward characteristics			
Area of district in which ward is located	log(square km)	0.202	**21.65**
Total arable land area of district	log(ha)	-0.145	**-12.82**
Mean elevation	meters	0.000	**14.02**
Standard deviation of district elevation	meters	-0.000	**-6.71**
Central region	yes=1	-0.229	**-24.06**
West region	yes=1	-0.281	**-26.65**
Mid-west region	yes=1	-0.219	**-14.90**
Far-west region	yes=1	-0.199	**-11.98**
Town characteristics			
Area of district in which ward is located	log(square km)	0.067	**5.34**
Distance to nearest navigable part of river	log(km)	0.048	**7.28**
Total arable land area of district	log(ha)	-0.005	-0.30
Mean elevation	meters	0.000	**8.18**
Standard deviation of district elevation	meters	-0.000	**-6.35**
Central region	yes=1	-0.150	**-11.40**
West region	yes=1	-0.186	**-15.86**
Mid-west region	yes=1	-0.172	**-9.55**
Far-west region	yes=1	-0.082	**-4.20**
Intercept		-1.780	**-9.37**
Number of observations		9187	
R-squared		0.8443	

Source: foot travel time computed from GIS data correcting for elevation.
Other variables as in Appendix 1. Eastern region is the omitted region.

Figure 1. Map of Nepal and Location of Surveyed Villages



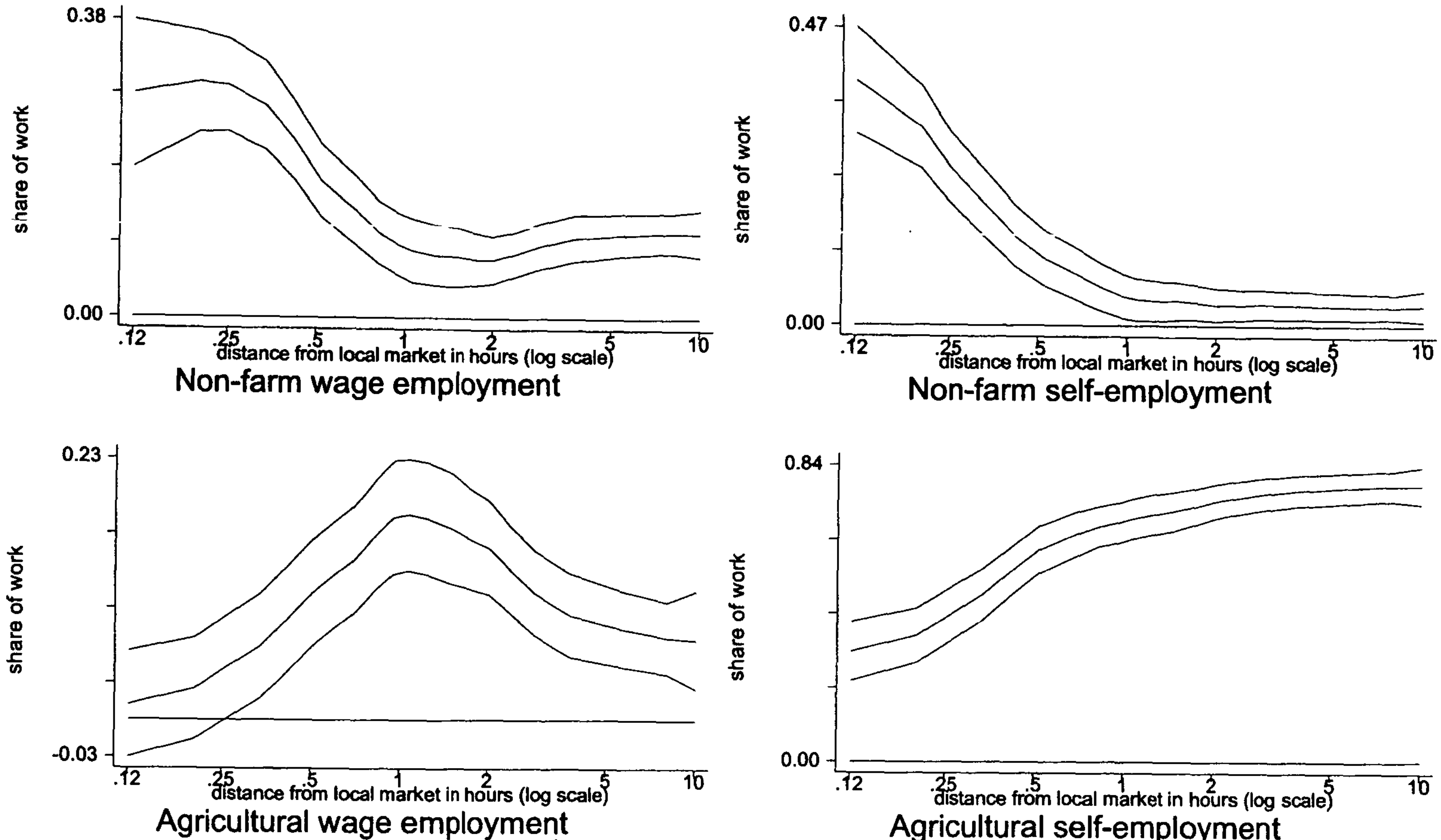


Figure 2. Employment and distance from local market

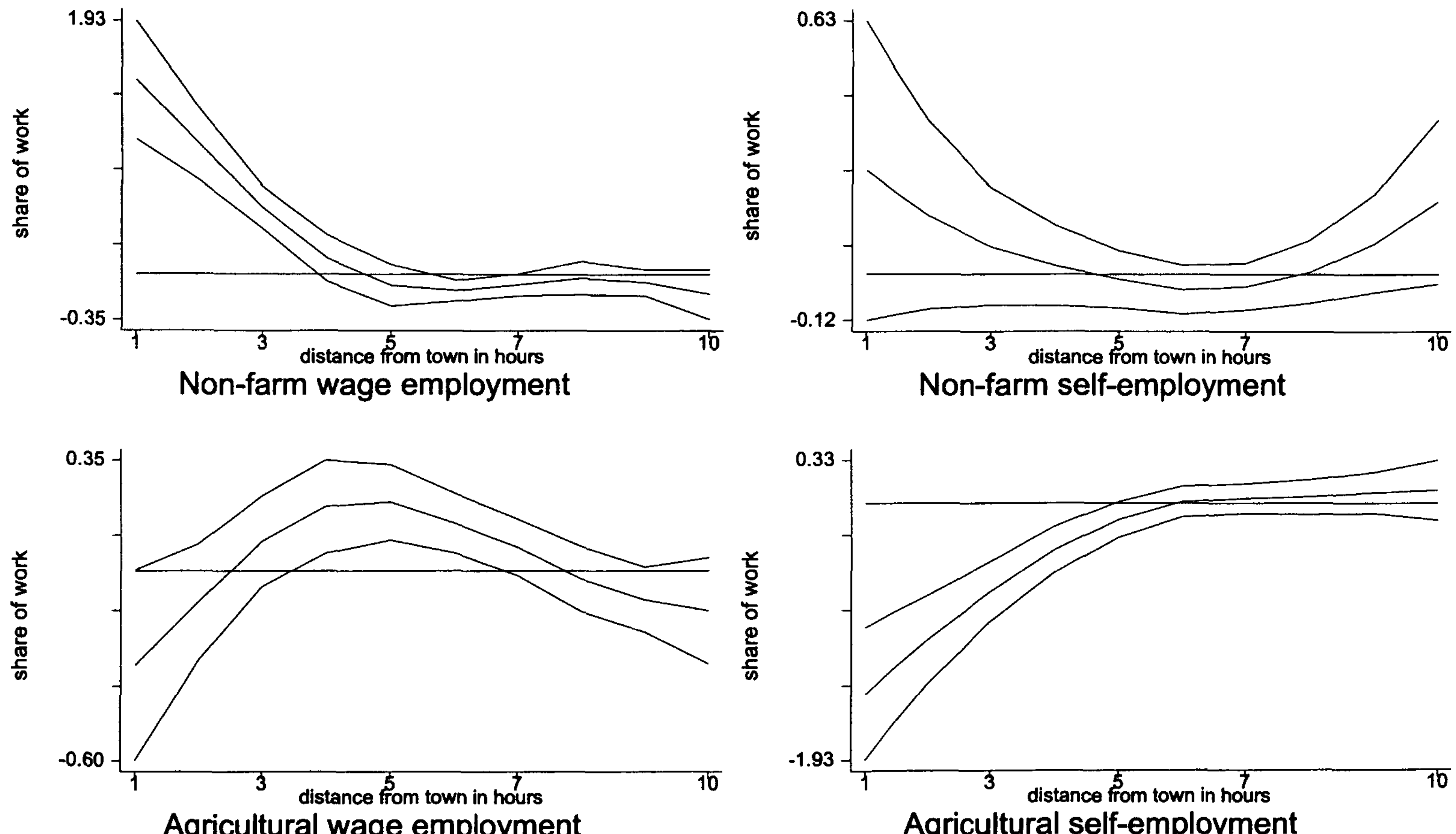


Figure 3. Employment and distance from towns

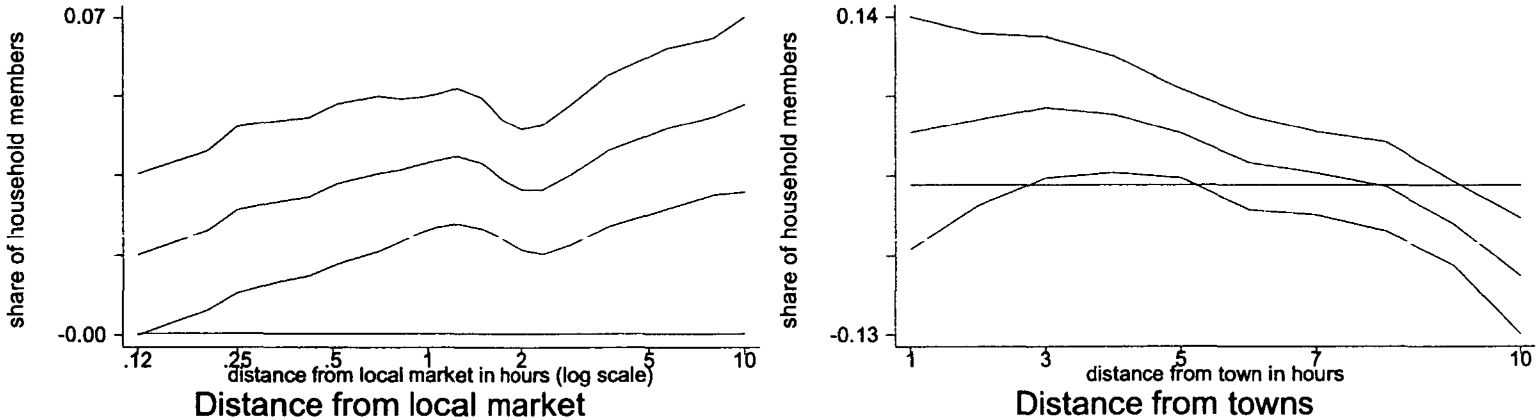


Figure 4. Work migration and distance

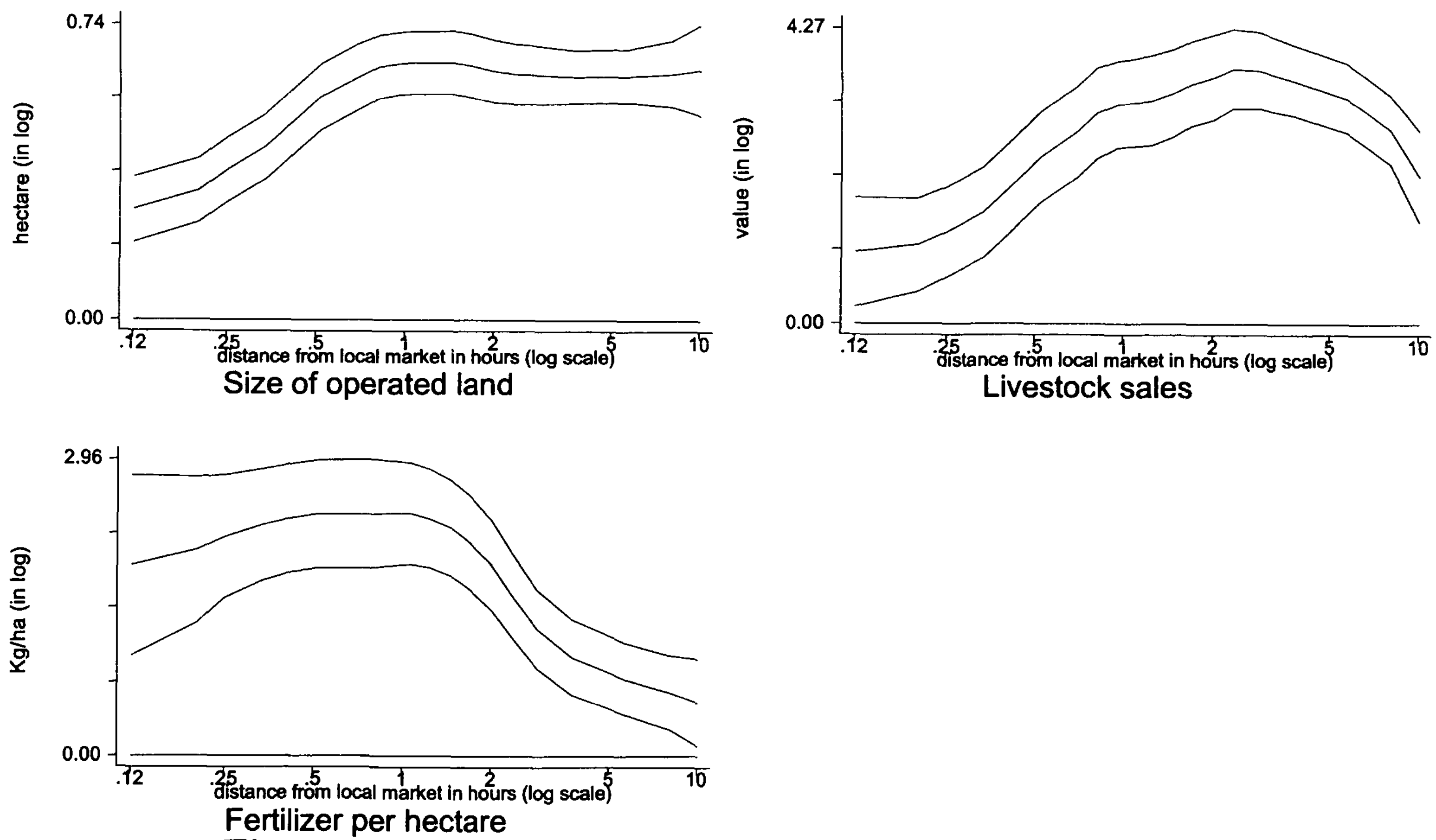


Figure 5. Farming and distance from local market

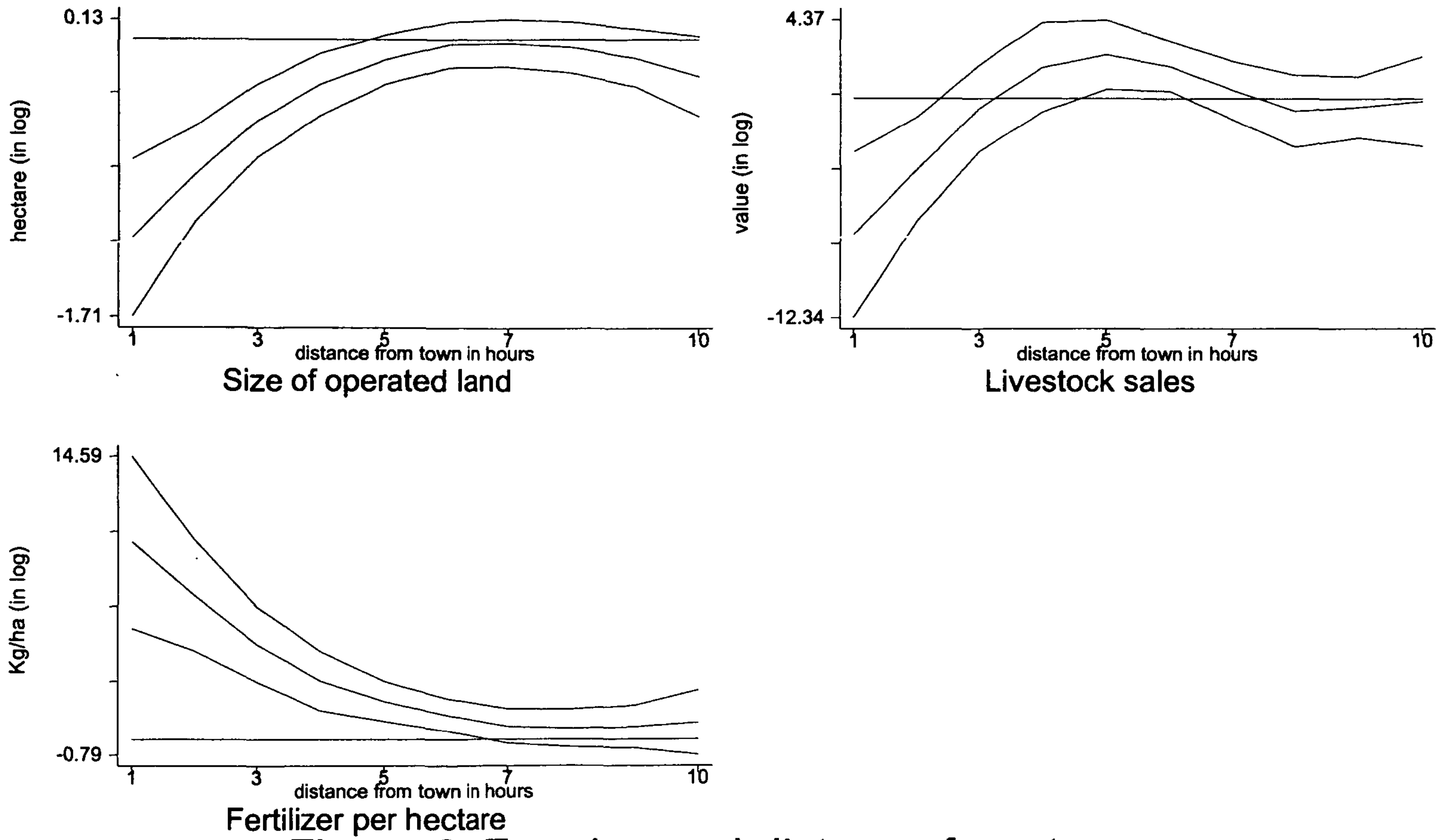


Figure 6. Farming and distance from towns

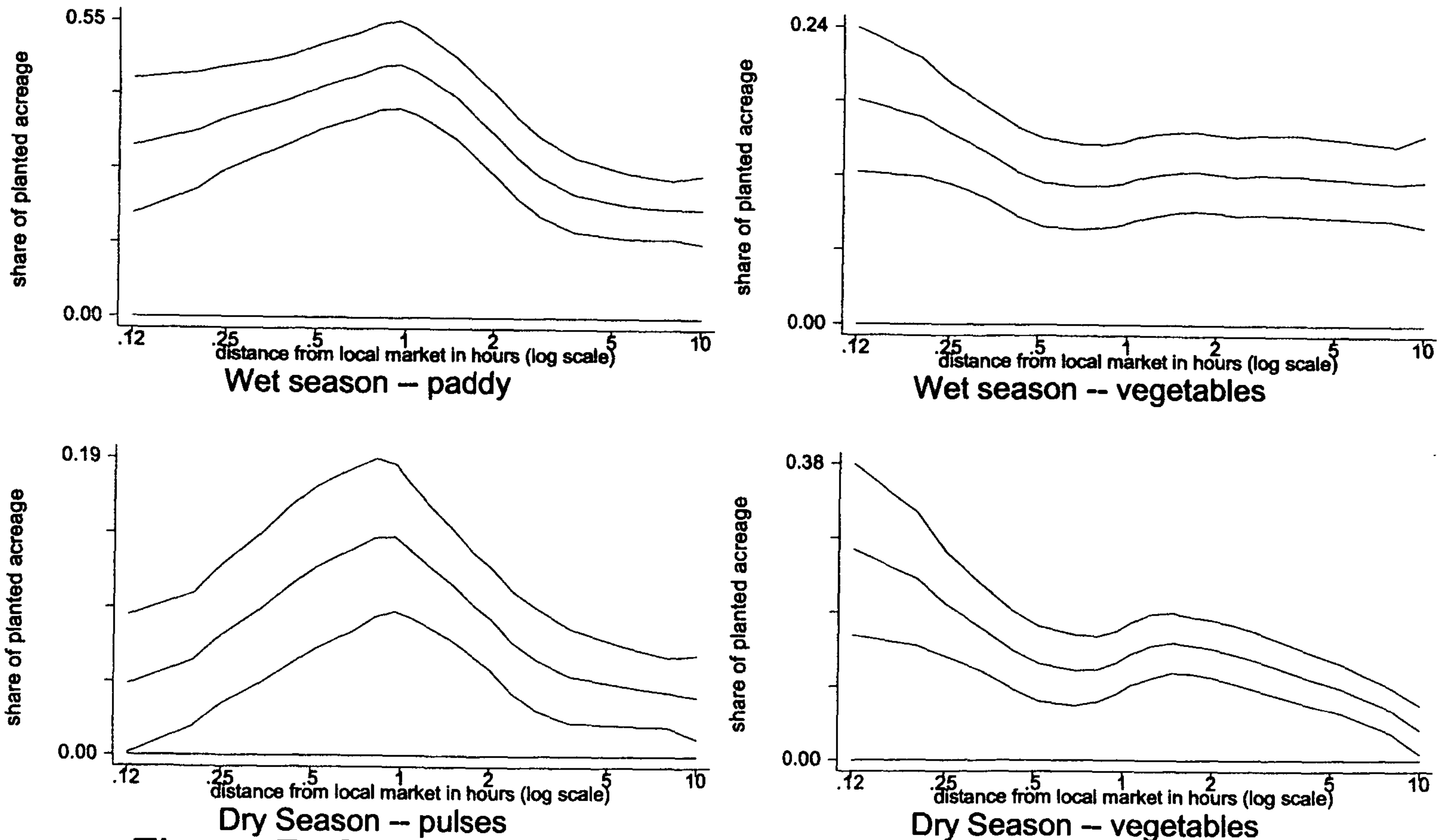


Figure 7. Cropping pattern and distance from local market

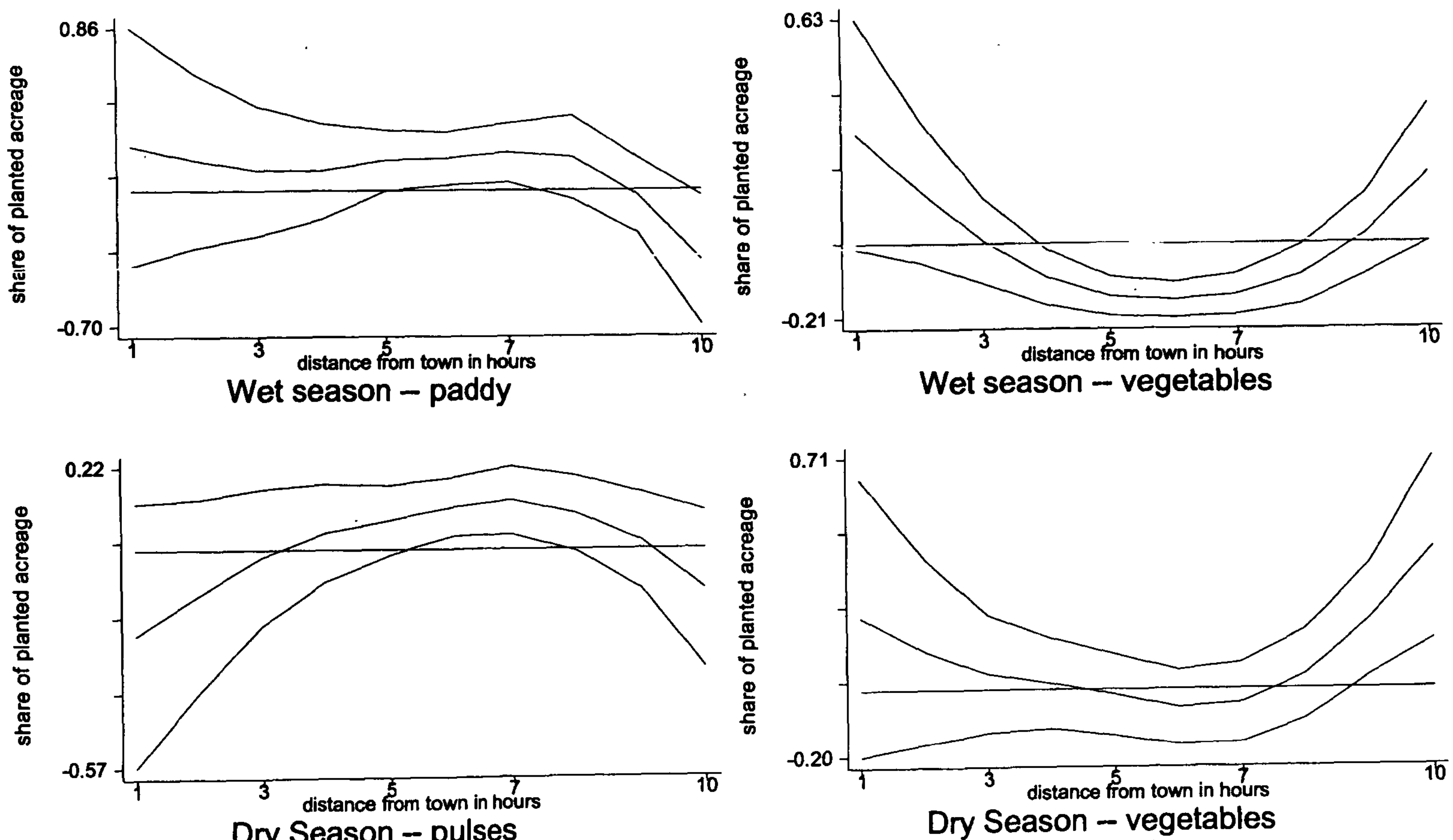


Figure 8. Cropping pattern and distance from towns

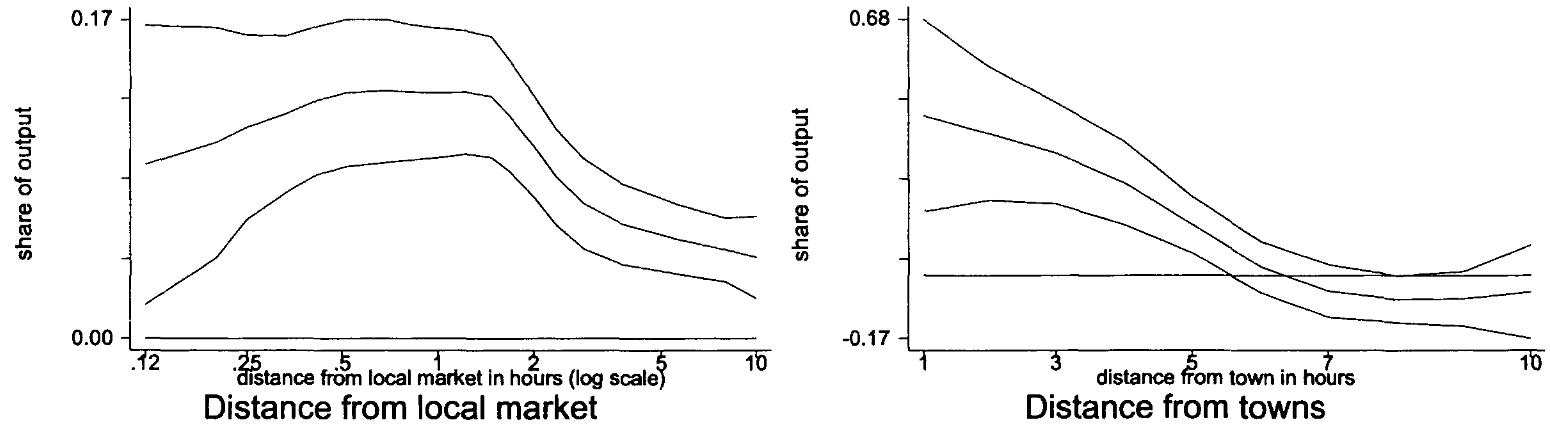


Figure 9. Crop Sales and distance

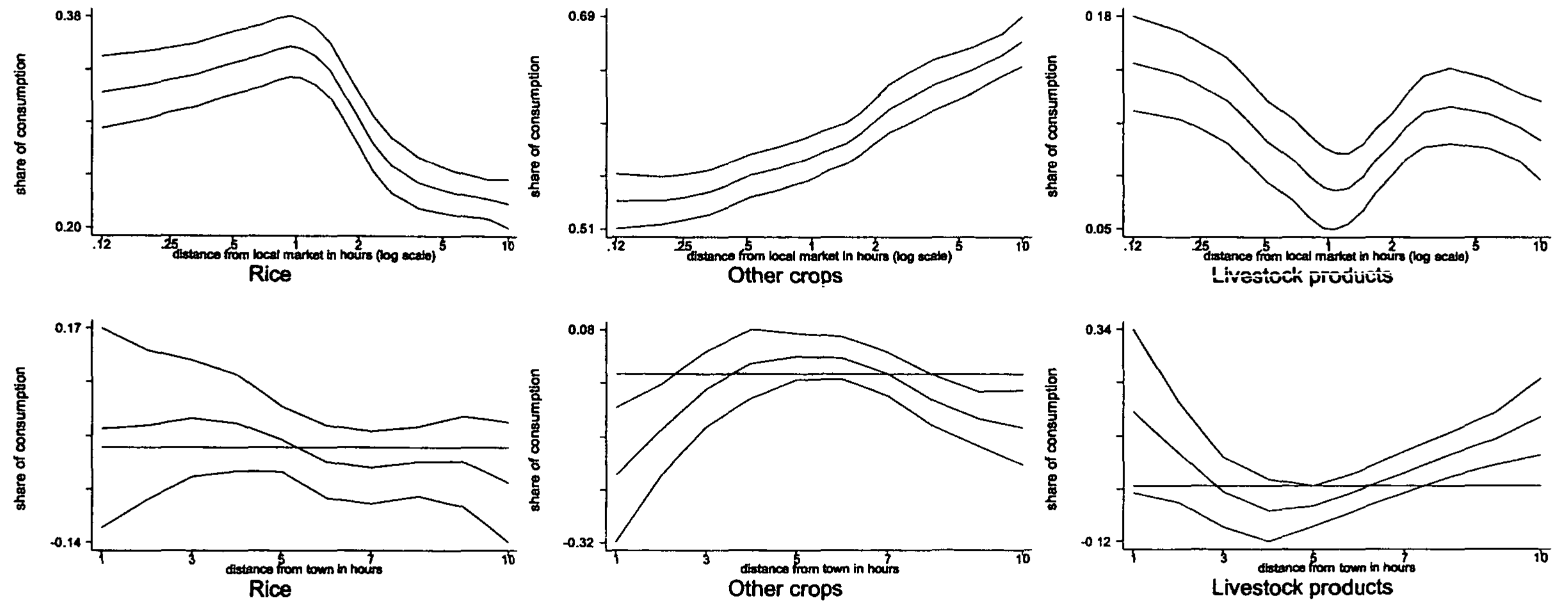


Figure 10. Consumption and distance

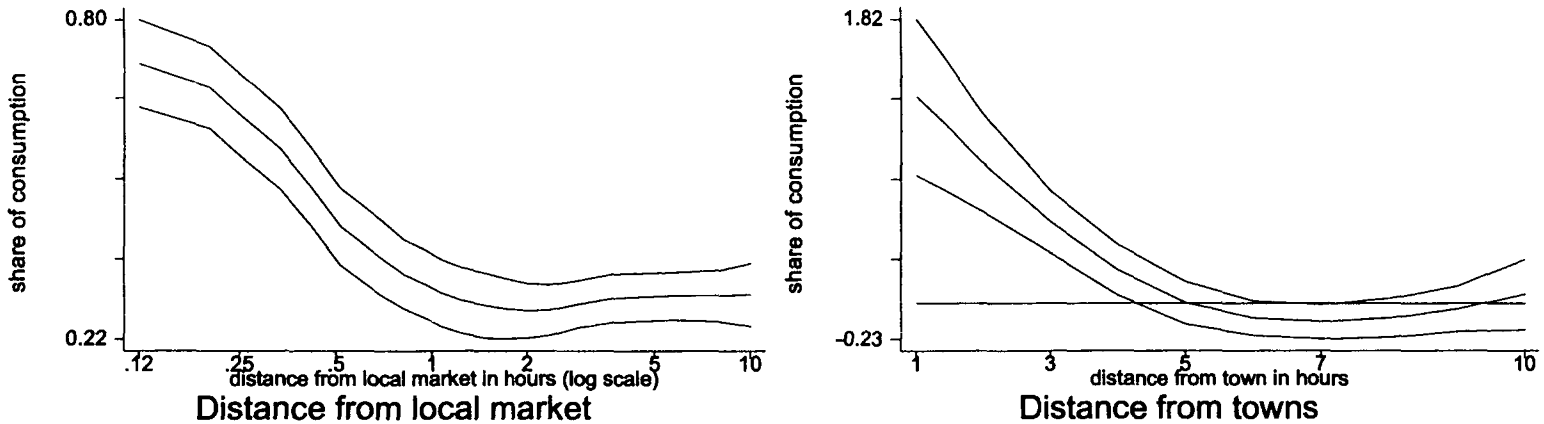


Figure 11. Crop purchases and distance

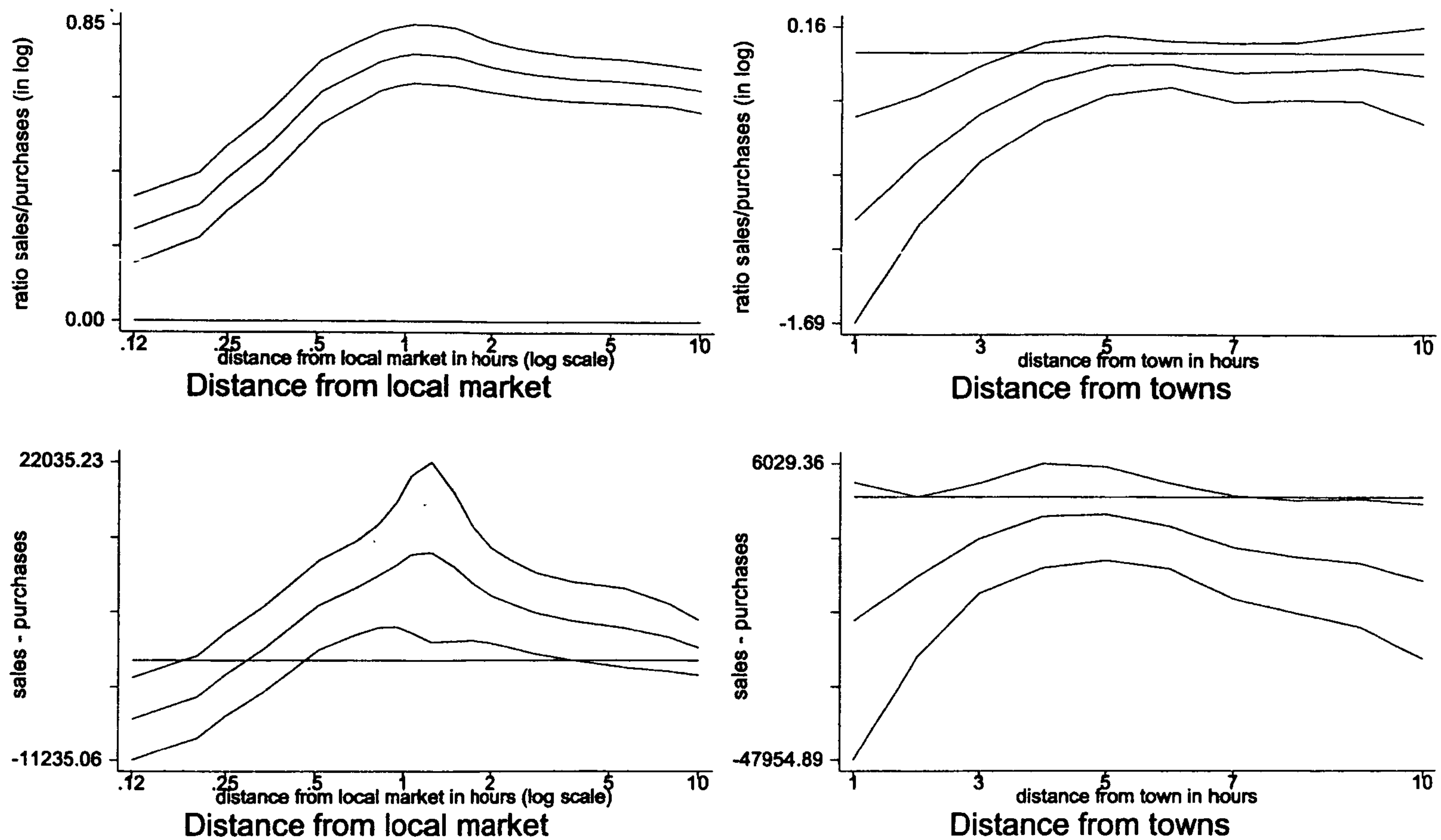


Figure 12. Market surplus and distance

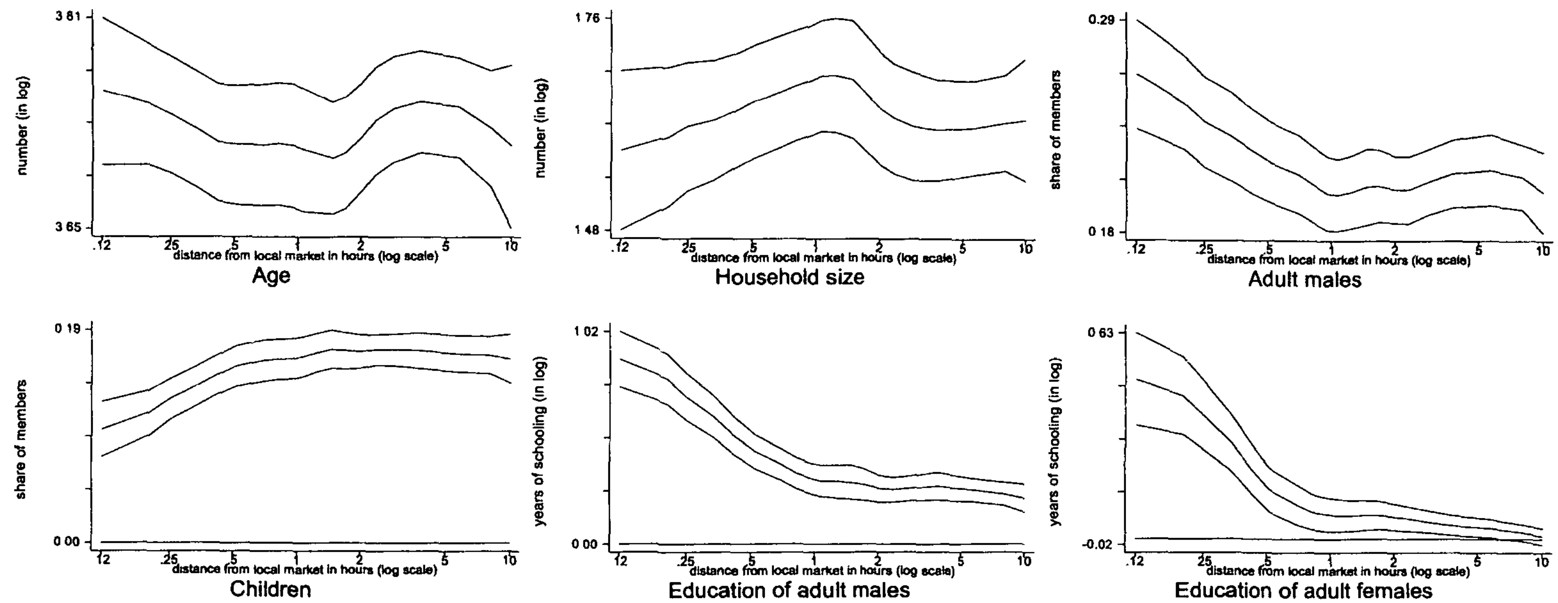


Figure 13. Household characteristics and distance from local market

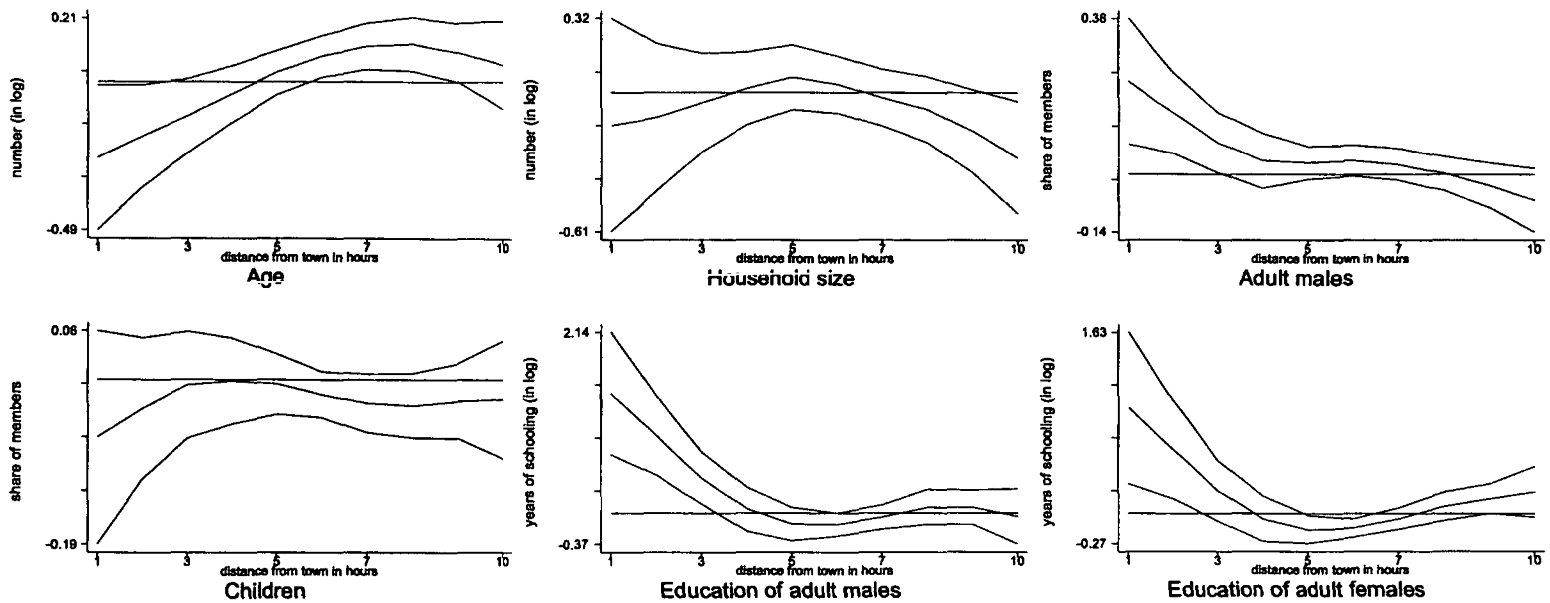


Figure 14. Household characteristics and distance from towns

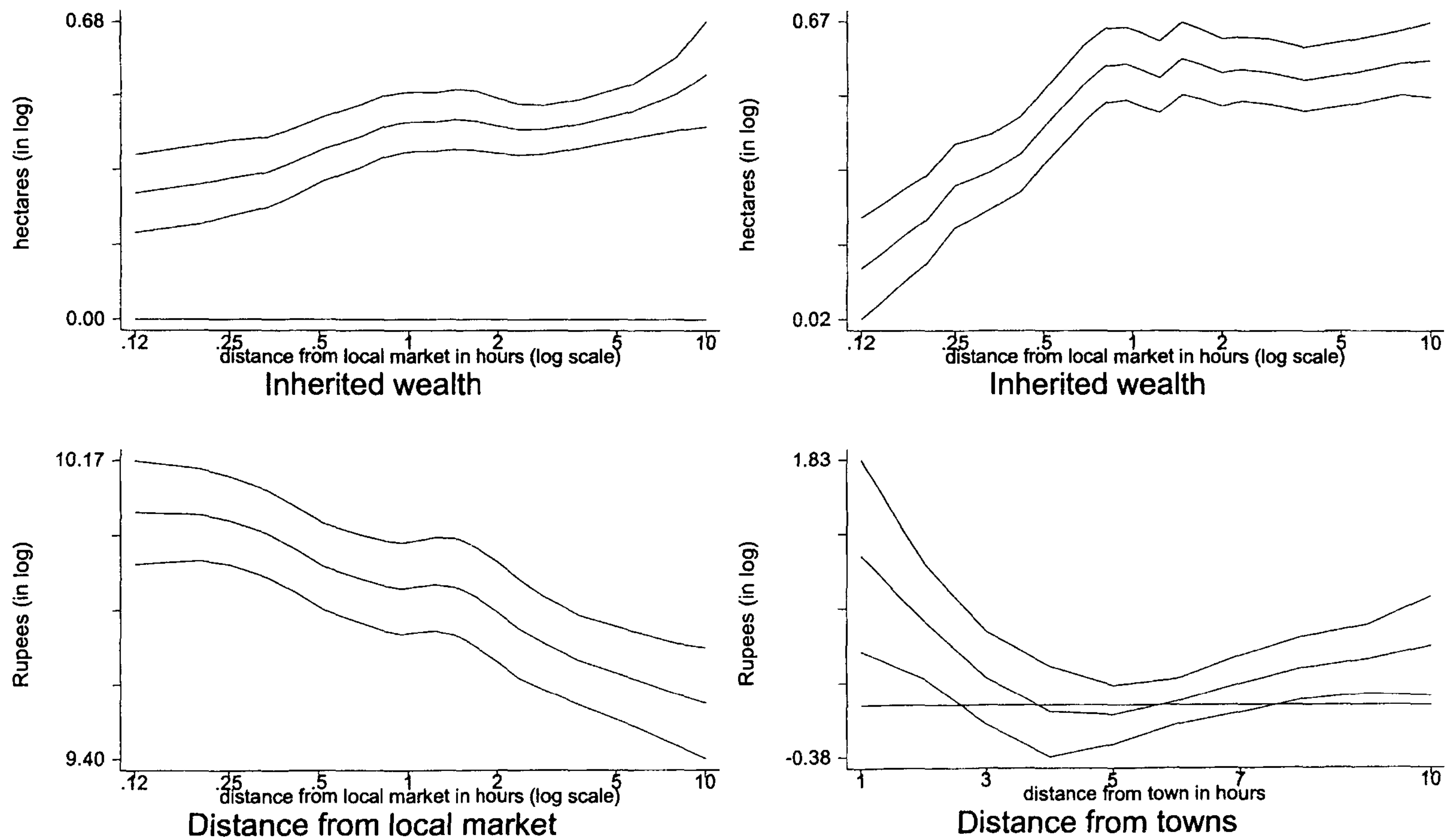


Figure 15. Inherited wealth, food expenditures, and distance

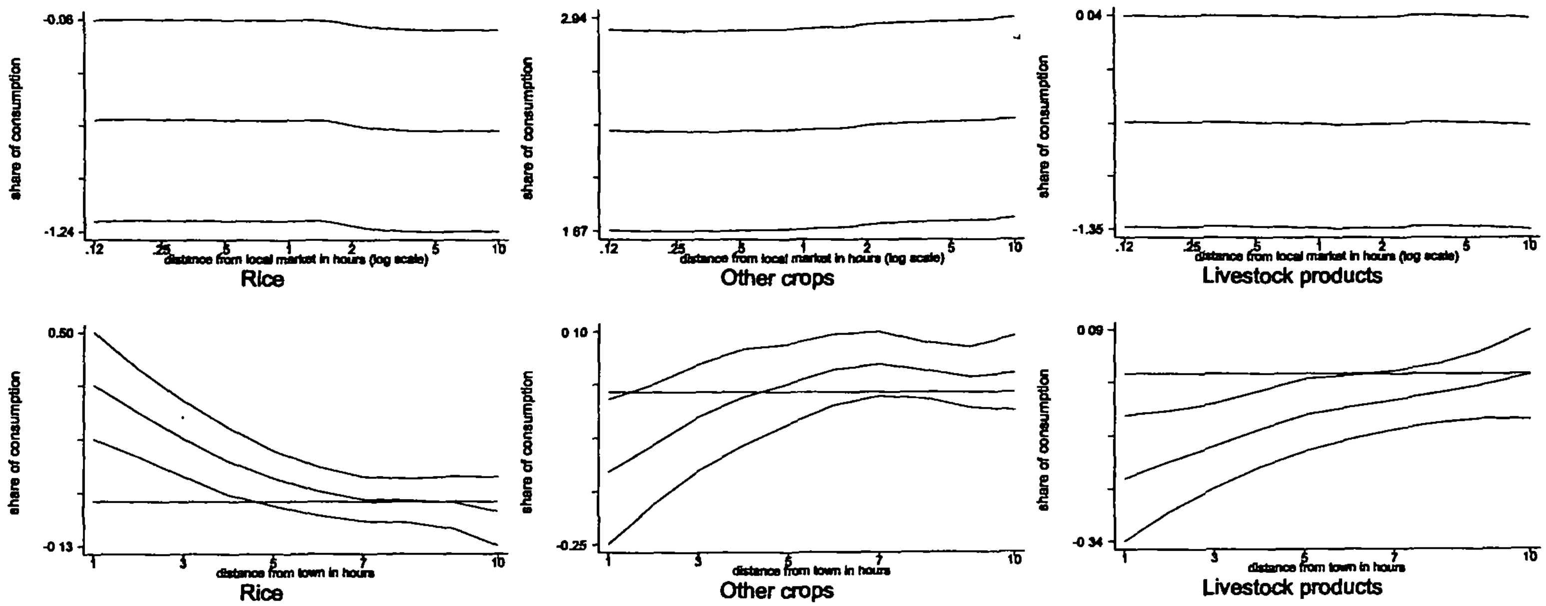


Figure 16. Consumption and distance with household characteristics

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