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HOUSEHOLD STRUCTURE AND LABOR DEMAND IN AGRICULTURE: TESTING FOR SEPARABILITY IN RURAL CHINA

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Abstract: Economic reforms in China have brought rapid growth in nonagricultural employment in rural areas and a substantial shift in the structure of rural employment. These changes have led researchers to question the conventional view of rural China as a labor surplus economy with poorly functioning factor markets. We contribute to this debate by testing for separability between the labor demand and supply decisions of households in a typical rural county in northern China. Our test, which makes use of unique panel data that enable us to control for time-invariant unobservable household characteristics, yields the following results: (1) separability is rejected across a variety of specifications, indicating that factor markets in the early 1990s remained underdeveloped; (2) the conventional view of surplus labor oversimplifies the situation as we find that, while some localities have a labor surplus, others may face labor shortages; and (3) separability does hold in areas where substantial employment opportunities exist at the township level, suggesting the need for employment opportunities that transcend village borders so as to create competitive pressures on villages and promote the inter-village movement of resources.

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Introduction

In China farm production is carried out by households that both demand and supply labor. If these households are able to exchange land and labor freely through reasonably competitive factor markets, then the amount of labor used in production would in theory be independent of their consumption and labor supply considerations. That is, farm households would choose to employ the amount of labor that maximized their profits at market prices and wages, regardless of family preferences or labor supply decisions. This independence of household production and consumption decisions is referred to as "separability." Separability is made possible by the exchange of land and labor: if the desired supply of household labor exceeds the profit-maximizing level of labor input in production, then the household can hire labor out; if household labor supply is less than this amount of labor input, then the household can hire labor in. The exchange of land and labor thus allows households to achieve their desired levels of labor and leisure while employing the profit-maximizing level of labor in household farm production, and so promotes an efficient allocation of resources among farms.

Separability is a relevant issue for China because of questions regarding the structure of rural labor markets and employment. The conventional view is that, despite substantial economic reforms in rural China, the development of factor markets has lagged (Lin, 1988). Underdeveloped factor markets may constrain households' ability to exchange land and labor, and so generate nonseparability. Moreover, many observers inside and outside China believe that China is characterized by surplus, underemployed rural labor (Cook, 1996; Knight and Song, 1995 and 1996; Taylor, 1988).[1] Surplus labor goes hand in hand with nonseparability, as in a typical surplus-labor economy households with underemployed family members work their land more intensively, thus interlinking their labor supply and demand decisions.

Evidence of substantial shifts in China's rural employment, however, raises questions about the conventional characterization of employment and labor markets (Parish, Zhe and Li, 1995). The

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[1]Estimates of surplus labor in rural China range from 120 to 150 million (Cook, 1996, p.28; World Bank, 1997, p. 45), equivalent to 25-30% of the rural work force.

government has actively supported development of nonagricultural production, especially township and village enterprises (TVEs), so as to provide employment for the perceived surplus of rural labor (Du, 1988). Nonagricultural employment in rural China has indeed grown rapidly. Employment in TVEs has grown from 30 million in the early 1980s to 135 million in 1996 (State Statistical Bureau, 1997, p.400). Private and individual sideline businesses, which have also benefited from economic reform policies, now employ about 35 million workers in rural areas according to official sources (State Statistical Bureau, 1997, p.97). Rural-to-urban migration has been a third, but not fully sanctioned, form of labor absorption. One source estimates the stock of rural migrants in cities in 1993 at about 39 million people (Knight & Song, 1995, p.114, citing the Rural Development Institute). By the early 1990s, then, these three forms of off-farm employment provided at least 150 and perhaps over 200 million jobs, equivalent to a third or more of China's rural work force of about 450 million workers (State Statistical Bureau, 1997, p. 363).[2]

Classical two-sector models of development predict that growth in nonagricultural employment can cause a transition from a low-income, labor-surplus economy to a high-income economy where labor use in both rural and urban sectors is allocated through markets and determined by market wages (Lewis, 1954; Fei & Ranis, 1964). Recent trends in China suggest that this process is taking place. Indeed, Rawski and Mead (1998), after calculating revised estimates of China's agricultural work force, conclude that "labor market behavior of farm households contributes to an emerging national market that links supply and demand for urban as well as rural workers (p. 776)." This alternative view maintains that rural household behavior is increasingly linked to markets, suggesting that labor supply and demand decisions may now be separable.[3]

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[2]Rawski and Mead (1998), moreover, point out that the official statistics probably understate the actual transfer of rural workers into nonagricultural employment.

[3]Note that nonseparability could persist even in economies without surplus labor and with relatively developed labor markets due to supervision costs, imperfect information, and other imperfections in the labor market (see, for example, Binswanger and Rosenzweig, 1984). Benjamin's (1992) empirical

In this paper we pursue these issues empirically by testing for the presence of separability using panel data from a survey of Chinese farm households. Our data are for the years 1990-1993, by which time progress in the reform of rural policies and growth in off-farm employment had been substantial both nationwide and in the survey locale. The survey locale is Zouping County, a rural county in Shandong Province with trends in overall growth, income and employment that are reasonably typical for North China. While care must be taken in generalizing from the experience of one county, analysis of these data provides useful evidence on whether and how the reforms have affected the allocation of labor in farming.

Our empirical approach builds on the work of Benjamin (1992), who tests for separability by examining whether labor demand in household farming is a function of household composition. Under separability, household labor demand should be independent of household composition. Benjamin conducts this test using cross-section data, and his results are driven by variation among households in household composition and labor use. His specification of the test is therefore only valid if he is able to control for all relevant variables, in particular, for all determinants of labor demand that may also be correlated with household composition. Below we argue that the potential for unobservable characteristics of households, such as human ability and land quality, to come into play is particularly high when estimating rural labor demand.

By using panel data and fixed-effects estimation,[4] we are able to test for separability while controlling for time-invariant unobservable household characteristics. Thus the assumptions needed for our test to be valid are less restrictive than for Benjamin's test. In addition, the panel nature of our data provides information on whether changes in composition within households are associated with changes in their labor use in cultivation. It is these changes that are the basis for our separability test results.

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study, however, finds separability in rural Indonesia despite the possible presence of such imperfections.

[4]We use the terminology fixed-effects estimation to refer to within groups estimation.

We find that labor demand in household farming is a function of household size and composition and reject the hypothesis that labor demand and supply are separable. The rejection of separability is robust to allowing for differences in the efficiency levels of labor inputs[5] and treating male and female labor as imperfect substitutes. These results suggest that, despite considerable progress in market reforms in rural China and in our survey area, in the early 1990s households apparently still faced difficulties transferring labor and land optimally in response to changes in household size and composition. While this conclusion is not entirely surprising,–indeed, it is consistent with the conventional views discussed above,–further analysis of the data suggests that nonseparability may be associated with labor scarcity as well as surplus, and that growth in nonagricultural employment in some localities appears to have proceeded to the point where separability has in fact been achieved.

If labor allocation is driven by the presence of surplus labor, then one might expect to find differences in labor use among localities with more or less farmland per capita, or with more or less off-farm employment per capita (Parish, Zhe and Li, 1995). In these regards inter-village differences are relevant in China, because after decollectivization villages divided the collective land among households on a per capita basis so that land distribution within villages is relatively equal. We therefore divide the sample into three sub-samples of households that reside in villages with relatively abundant, medium, and scarce land per capita, and then test whether separability holds for all three groups. Interestingly, we find that separability is rejected not only in the group with relatively little land, but also in the group with relatively abundant land. The only group for which we cannot reject separability is that with medium amounts of land. These results raise questions about the uniform characterization of rural China as having labor surplus. While the empirical test cannot identify whether separability is driven by labor shortage or labor surplus, nonseparability in land-abundant locales suggests the possibility of labor shortage in some

[5]We allow adult male, adult female and non-adult (children and elderly) workers to have different efficiency levels.

areas. In other words, these results are consistent with an environment of underdeveloped factor markets where in some areas households face labor surplus and in others labor scarcity.

We also divide the sample into subgroups based on the extent of nonagricultural employment at the village and township level. One would also expect that, holding land quality and other variables constant, problems of surplus labor and nonseparability would be lower in villages and townships with more nonagricultural employment. The results show separability for households in townships with substantial township-wide nonagricultural employment, but not for households in villages with substantial within-village nonagricultural employment. These findings suggest that the policy of promoting TVEs to absorb surplus labor can be successful only when the enterprises generate a market for labor that transcends village borders.

Testing for separability and model specification

Separability of production and consumption greatly simplifies empirical analysis of farm production or consumption behavior, and so empirical studies usually assume that separability holds. Empirical studies that do not make this assumption and test for nonseparability are relatively few. Examples include Lopez (1984, 1986), Pitt and Rosenzweig (1986), Benjamin (1992), Jacoby (1993), and Skoufias (1994). Only two or three studies examine separability in China (Brandt and Benjamin, 1997; Cook, 1996; Sicular, 1986).

Studies testing for separability generally take one of two broad approaches. One approach, which we will refer to as the "structural approach," involves estimating a production function, using the estimated parameters to calculate shadow wages (given by the marginal product of labor), and then testing whether the shadow wages are equal to observed wages (Jacoby, 1993; Skoufias, 1994) or, in the absence of good wage data, whether the shadow wages are a function of household composition (Cook, 1996). The main drawbacks of this approach are that construction of the shadow wages can be sensitive to mis-specification of the production function, and that production function estimation is subject to simultaneous equation bias because levels of inputs and outputs are jointly determined. These drawbacks of the structural approach argue in favour of working with profit functions or derived input demand functions.

The second approach indeed employs profit and derived input demand functions. This approach involves estimating a profit or labor demand function and including independent variables that should in theory influence consumption but not production. Tests of the significance of these variables reveals whether separability holds. Thus, Pitt & Rosenzweig (1986) estimate farm profits as a function of farmer health status. The health status of household members should not have a significant effect on profits under separability, because in the event of illness households should hire labor to replace family labor. Similarly, Benjamin (1992) estimates the demand for labor in farm production as a function of household demographic variables. Household structure should affect consumption, but not production, if separability holds. Benjamin's test for separability is particularly appealing as it is flexible and uncovers nonseparability regardless of its source.

Theory tells us that in the case of separability labor demand should be a function of relative prices and, if it is fixed or quasi-fixed, land area (Benjamin, 1992). Households maximize profits by equating the marginal product of labor to the market wage w given a fixed amount of land A:

$$F_1(L;A) = w \tag{1}$$

where L is total labor demand, F is the production function, and the output price has been normalized to 1. Thus, under the null of separability, labor demand will only be a function of its price and land

$$L = L(w,A). \tag{2}$$

In contrast, under nonseparability households will not follow the above rule in determining their labor demand, but rather will set

$$F_1(L;A) = w^* \tag{3}$$

where w^* is their shadow wage and a function of household characteristics. These simple equations form the basis for Benjamin's (1992) test of separability.

Since the shadow wage is unobserved, it cannot be included directly in the empirical labor demand equation, but rather it must be specified as a function of household composition variables. Benjamin's empirical specification is:

$$\ln L_{jt} = \alpha + \beta \ln w_{jt} + \gamma \ln A_{jt} + \delta_0 \ln n_{jt} + \sum_{i=1}^{D} \delta_i \frac{n_{jt}^i}{n_{jt}} + \epsilon_{jt} \quad j=1,...,J;\ t=1,...,T \tag{4}$$

where L is labor demand for crop production, w the wage, A cultivated land area, n household size, n^i household structure variables (such as the number of adult females, elderly, and children in the household), and ϵ an error term.[6,7] J refers to the number of households and T to the number of time periods. The coefficient δ_0 gives the elasticity of labor demand with respect to household size, and the coefficients δ_i capture the response of labor demand to changes in household composition.[8] This specification has the

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[6]The functional form of this labor demand function implies a Cobb-Douglas production function. Since the production function is not used in the test, we follow Benjamin and do not limit ourselves to this restrictive specification, but rather augment this equation with other factors that may influence labor demand (Benjamin, 1992, p.303). In addition, in writing Benjamin's specification this way we have implicitly assumed that the δ's contain the multiplicative factor β. We do so to simplify the discussion and because, as we discuss below, we are unable to identify β in our analysis.

[7]Benjamin estimates labor demand in rice production and his land variable is harvested area. We estimate labor demand in all crop cultivation, and our land variable is cultivated area. These differences arise in part because the data sets differ, and in part because while rice is the dominant crop in Indonesia, in North China households cultivate many different crops including wheat, corn, cotton, rapeseed, vegetables, and fruit, using a variety of crop rotations, and frequently with multiple cropping.

[8]Note that one category of household members must be omitted. Below we omit the share of adult males in the household.

appealing property that, if there are no household demographic effects, the shadow wage will equal the market wage (p.303). The null hypothesis is that $\delta_0 = \delta_i = 0$ for all *i*. Rejection of the null hypothesis implies nonseparability.

We adopt Benjamin's specification with certain modifications. Benjamin's analysis relies on cross-section data and thus *T*=1. With cross-section data identification of the δ's stems from variation across households in composition and labor use. Ideally, one would prefer to test for separability by asking whether changes in a household's structure affect its use of labor in production. Here we have panel data with *T*=4. Panel data allow us to augment the across household information with variation within households. Use of fixed-effects estimation with panel data further restricts the identification of the household composition coefficients to only within household variation in composition and labor use. Thus, our test of separability asks whether a change in a household's composition influences its labor demand.

The validity of this test depends on the consistency of the estimates of the δ's. If the labor demand equation (4) is correctly specified such that all relevant variables are included and the error term is uncorrelated with the explanatory variables, then the estimates of the δ's and their standard errors will be bias free and will yield an appropriate test of separability. A problem with the above specification is the possible endogeneity of certain explanatory variables. For example, cultivated land area could be endogenous because decisions regarding land and labor use may both be determined by other common factors (such as labor market conditions) that are not captured in the regression (Benjamin, 1992, p.315). To correct for this possibility, we instrument cultivated land using household land endowments and quota levels for grain and cotton.

Household size and structure could also be endogenous. This raises two issues. First, simultaneity bias could arise if labor use determines household size or composition. For the purposes of testing separability, however, such simultaneity bias is not a concern (Benjamin, 1992). When the assumptions underlying separability do not hold, household structure affects labor use and vice versa. In other words, simultaneity is implied by and entirely consistent with nonseparability. The presence of simultaneity, therefore, does not invalidate our test.

Second, and more problematic, is possible correlation between the error component of labor demand and household size or structure. As discussed in Benjamin (1992, p.304-5), this is a statistical problem that could occur due to measurement error or omitted variables. Measurement error may occur due to the mis-measurement of labor use or household composition or, in the case of panel data, the mis-measurement of the timing of changes in household composition relative to labor use. Errors of this type bias the household composition coefficients toward zero, making the acceptance of separability more likely. Since we reject separability, the possible presence of measurement errors only strengthens our conclusions.

A larger problem is that of omitted variables that are correlated with the household composition variables.[9] Household size and composition may very well be correlated with unobserved variables that influence labor demand. The direction of the bias in this case is unknown and therefore brings into question the interpretation of the separability test results (Benjamin, 1992, p.305). Such unobservables are particularly problematic when estimating labor demand in rural developing areas, where differences among households in human capital, land quality, and other relevant variables may be substantial and difficult to measure. Ideally, use of instrumental variables would control for the endogeneity of household structure variables, but good instruments unfortunately do not exist.

Benjamin attempts to minimize this problem by using cluster fixed-effects and by including measures of land quality so as to reduce heterogeneity that might cause correlation between household structure and labor use. He also controls for characteristics of the household such as age and education that belong in the labor demand equation (Benjamin, 1992, p.305). We follow Benjamin in using village

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[9]Omitted variables cause a problem even if they are not correlated with any explanatory variables, because their omission biases the standard errors upward possibly leading to false acceptances of separability.

level and time effects and in including land quality, age and education variables.[10] In addition, because we have panel data, we can go one step further. If the omitted variables are time-invariant unobserved household characteristics, then the omitted variable bias can be removed by using fixed-effects estimation.[11,12] Thus with panel data we are able to control for many of the possible impurities in the error term, and we indeed find that fixed-effects estimation yields different coefficients for some household variables than both random-effects estimation and OLS estimation without controlling for household unobserved heterogeneity. All specifications, however, reject separability. One caveat is that, if the unobserved factors affecting labor demand and household composition are transitory rather than fixed over time, then our use of panel data and fixed-effects estimation will not eliminate omitted variable bias.[13]

The estimation of labor demand functions using cross-section data requires reasonably complete and accurate price and especially wage data, but in the context of rural developing areas such data are often problematic. In these areas the structure of prices and wages can be complex, varying across seasons and among types of workers (e.g., male and female, long-term versus short-term). Furthermore, rural labor markets are typically characterized by a variety of wage payment schemes (Binswanger and Rosenzweig, 1984). These features of rural developing areas complicate the choice of appropriate wage and price

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[10]Benjamin (1992) and Skoufias (1994) include variables that measure land quality and human capital. In our sample the land quality variables do not exhibit much within-household variation. The education variable, which is measured as average years of adult education, does exhibit within-household variation. Changes in this variable occur when a child enters working age, an older adult becomes elderly, or an adult leaves or enters the household.

[11]Skoufias (1994), who also uses fixed-effects estimation with panel data to test separability, discusses this issue (p.221). Skoufias, however, uses the structural approach.

[12]Alternatively we could estimate the model using random-effects estimation. However, random-effects estimates are only consistent if the unobserved household characteristics are not correlated with the other regressors. Given the broad range of characteristics for which we cannot control, this is likely not true in practice.

[13]Transitory factors at the village level are controlled for in our specification through village*year dummy variables.

variables for use in estimation. Thus, Benjamin (1992) excludes harvest labor from his regressions, because harvest labor is rarely hired on a spot market at a straightforward fixed wage (p.301). An additional problem arises because farm households self-supply labor, so that wages may not be observed for a subset of the sample. This problem is noted by Benjamin, who has no choice but to drop 15% of his original sample because the households do not hire labor in and therefore have incomplete wage data (p.301). In our sample only 20% of the households hire in labor, making such a restriction impractical. Use of off-farm wages is also impractical because only half of the households in our sample hire labor out.

Since we do not have adequate wage or price data, we include dummy variables for year, village, and year*village cross-effects. Use of village and time dummy variables reduces difficulties arising from complex price and wage structures and from incomplete price and wage data. Within a particular locale at a particular time, the prices for goods and wages for labor of identical quality should be uniform. Village and time dummy variables will therefore capture some of the influence of prices and wages on labor demand.[14] In addition, controlling for household level unobserved heterogeneity will capture household-specific differences in labor quality and other variables that are constant over time. Under reasonable assumptions, then, the inclusion of location and time dummy variables in conjunction with fixed-effects estimation makes wage and price variables redundant. We note that the inclusion of year*village effects does affect the source of identification of the δ's. Since household changes occur over the same time interval as the allowed variation in village effects, households within a village that do not experience a change in composition will determine the village*year effects. Conditional on these village*year effects, households for which there is variation in composition will then determine the δ's.

[14]Benjamin (1992, p.309) discusses this advantage of cluster dummy variables and presents results from within-cluster estimation.

Our final model is therefore:

$$\ln L_{jt} = \alpha + \gamma \ln A_{jt} + \delta_0 \ln n_{jt} + \sum_{i=1}^{D} \delta_i \frac{n_{jt}^{i}}{n_{jt}} + \sum_{i=1}^{K} \theta_i D_i + \sum_{i=1}^{M} \zeta_i X_i + \epsilon_{jt} \quad j=1,\ldots,J;\ t=1,\ldots,T \qquad (5)$$

where D_i are the year, village, and year*village dummy variables, and X_i. are additional variables included to control for land quality and human capital.[15] Under the fixed-effects estimation specification the variables represent deviations from their means at the household level.

In our base specifications labor demand L is defined as total person-days used to cultivate crops on land cultivated by the household. Aggregation of different types of labor could bias the results. To this end we explore two different specifications of labor demand that address the potential problem of aggregation bias. First, we allow the efficiency units of adult female, adult male and non-adult (children and elderly) labor to differ. Second, we specify male and female labor as imperfect substitutes in the production function and estimate separate labor demand equations.[16] The rejection of separability is robust to both specifications.[17]

The survey data and economic setting

The data used in this study are from a stratified random sample of 259 farm households in 16 villages in Zouping County, a county situated south of the Yellow River in central Shandong Province. The

[15]Research by Sicular (1995) suggests that in China nonseparability may be related to procurement quotas and related market restrictions. Therefore we estimated specifications that included independent variables measuring quota levels for grain and cotton. These variables were uniformly insignificant, so we do not report the results. Their insignificance could be explained by lack of variability over time and/or by correlation with the time and location dummy variables.

[16]Small sample sizes prevent the separate estimation of non-adult labor use. Thus, for this specification we separate all labor use by gender only.

[17]We also disaggregated labor use between peak and slack seasons and found nonseparability holds in both seasons. These results are available upon request.

survey followed the households over four years (1990-93), providing 1036 observations. After eliminating observations for households that did not engage in cultivation or where data are missing, the sample contains 258 households and 1015 observations.

While this data set is relatively small, it has desirable features. Zouping remains one of the few counties to which foreign researchers have been granted access to conduct an independent survey directly supervised by the researchers. The survey questionnaire was designed by the researchers and tailored to provide rich information on a wide array of economic, social, and political variables. Close supervision and careful consistency checks ensured data of relatively high quality.[18] In addition, the panel nature of the data makes it unique, as panel data sets for China and developing countries in general are relatively rare.

Official statistics show that Zouping is an unexceptional rural county.[19] Zouping experienced rapid economic growth during the 1980s, but its per capita GDP in the early 1990s was still 18% below the national average (the national average is pulled up by industrial production in major urban centers). In 1990-93 the income of rural households in the county averaged 701 yuan per capita (in constant 1990 prices), slightly below the national average of 717 yuan. Rapid development of nonagricultural activities in the county has caused agriculture to decline in importance as a source of income and employment. In 1990 agriculture contributed 56% of county GDP, but by 1993 agriculture's share had fallen to 30%. For Zouping's rural households, however, agriculture remained the major source of income: in 1990 agriculture contributed 65% of the net income of rural households, and in 1993 it contributed 71%. Cultivation of wheat, cotton and corn accounts for the majority of agricultural output value.

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[18]The data were collected through an independent survey organized by Terry Sicular and Jonathan Morduch (Harvard University). See Cook (1996), chapter 3, and Sicular (1998) for a discussion of the survey and survey sample.

[19]National-level information in this paragraph is from State Statistical Bureau (1994); county and township statistics here and elsewhere were provided by the Zouping County government. Zouping's GDP per capita in 1990 was 1280 yuan and in 1993 2303 yuan (current prices). For a more extensive description of the county see Cook (1998b), Sicular (1998), and Walder (1998).

Regarding employment, official statistics for the county show that the share of the rural labor force employed in agriculture declined from over 90% in 1980 to 76% in 1993. This shift in employment is close to that for rural areas nationwide, for which the agricultural share of the rural labor force declined from 94% in 1980 to 75% in 1993.

The survey sample captures key features of the county. (See table 1.) Between 1990 and 1993 net income (in constant prices) of households in the sample averaged 1165 yuan.[20] During these four years the share of household income from agriculture declined, but agriculture remained by far the dominant income source, on average contributing over 70% of household income. Cultivation of crops alone accounted for two thirds of household income.[21] Among working-age individuals in the surveyed households, 97% undertook some agricultural work, 66% worked only in agriculture, and 34% engaged in nonagricultural work, either wage jobs or in household-run private businesses (Cook, 1998b).[22]

The focus of this paper is on separability of household consumption and production. We test for separability by analyzing whether labor used in cultivation is affected by changes in household size and structure. In our survey a household is defined by place of residence: a household consists of a group of individuals who reside for one or more months of the year in the same house or residential compound. In theory households can contain individuals who are not relatives, but in practice this is rare. Most households in the sample consist of nuclear families–parents with children, and, less frequently, a married

[20]This number is larger than that given by the official sources cited above, but the two numbers are calculated differently and so not directly comparable. For example, the official figures for net income of rural households value retained grain at below-market planned prices, while the survey figures value such output at market prices. The official figures also subtract depreciation and new purchases of productive assets, while the survey figures do not.

[21]Note that the sample does not include urban residents, so agriculture plays a larger role for the sample households than for the county as a whole.

[22]These statistics are for 1990. As discussed in Cook (1998b), the survey data give higher nonagricultural employment levels than the official statistics because the survey identifies individuals who work in more than one activity.

couple living alone. The sample also contains inter-generational households of older married couples that live with a son, daughter-in-law and grandchildren, or households composed of younger married couples living with their children and one or both parents.

In rural Zouping the age of marriage has risen over time. Older people married in their late teens, and young people now usually marry in their mid-twenties (in the early 1990s over 90% of newlywed brides in the county were age 23 or older). Rural Zouping, and much of rural China, is characterized by patrilocal customs under which married couples typically settle in the husband's home or village. While in the past newlyweds often moved in with the husband's family, now it is more common for them to establish independent households. Young couples start a family immediately after marriage. The first child is usually born within one or two years of marriage.

Due to changing family planning policies and preferences, family size has declined over time. Current policies in Zouping permit a second child with spacing after the birth of the first. These practices are reflected in the average household size for the sample of 3.97, equal to the county average. The dependency ratio (ratio of non-working age household members to working-age household members) for the sample is about 0.3. Although government policies strongly discourage higher-order births, our sample contains a few couples who have had a third or even a fourth child since 1979, when the government adopted strict limits on family size.

Changes in household size and structure occur as the result of aging, birth, death, or marriage. Aging affects household structure and labor supply when children mature, finish school and become full-time working members of the household, and when older adults become less active economically.[23] Births

[23]We treat household members below the age of 18 as children and above the age of 65 as elderly. Household members aged 18-65 are treated as working-age adults. Eighteen is used because it is the usual age of completion for senior middle school. By 18 most children in our sample have completed or left school. Males tend to leave school between the ages of 16 and 18, while females leave between 14 and 18. In the data we find very little labor is performed by non-adult members (children or elderly): less than 3% of all households employ non-adult labor. Note that we use age instead of actual school completion to

of course increase and deaths reduce household size. Marriage of an adult child typically reduces the number of adult workers in a household, but in cases where newlyweds reside with their parents, marriage increases household size through the addition of a daughter-in-law to the household.[24]

Table 2 presents data from our sample on such changes. Change in household composition is measured by changes in the population of the household and by changes in the fractions of working-age men and women, elderly, and children. Of the 258 households in the sample, 132 (52%) report one or more changes in household composition so measured during the four years of the panel. Most common are changes in the fractions of children and adult men and women. More than three-quarters of the households that report changes in the fraction of children have had a child enter working age (18-65). Less than one-quarter of the households that report changes in the fraction of children have experienced an increase due to the birth of a new child. Changes in the fraction of adult men and women are largely due to older children entering working age.

About one-third of the households report a change in household size during the four years of the survey. Changes in household size occur for a variety of reasons, including death of a parent, birth of a child, and marriage in or out. No single factor dominates, but death of a parent and departure of an adult child are more common than births and the addition of a daughter-in-law.

Since nonseparability is likely to be driven by incomplete factor markets, in table 3 we present some indicative statistics on land and labor exchange and use in cultivation. Cultivated land area in the sample is 7.19 *mu*, close to the county average.[25] This land area consists largely of what we call the land

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mitigate problems (discussed above) with the endogeneity of household composition changes.

[24]As mentioned above, marriage customs are patrilocal and consequently the addition of a son-in-law to the household of a bride's family is rare.

[25] 7.19 *mu* equals approximately 1.2 acres. The county average is 6.64 *mu*, but this is calculated over both rural and urban residents.

"endowment", that is, collectively-owned land allocated to the household by the village through the household responsibility system. In some villages endowment land also includes some reclaimed land or former private plot area. National laws state that all rural households have rights to receive land from the village under the household responsibility system. This land was initially allocated by the village on a per capita basis, and cultivation rights usually are linked to a contract that requires the household to pay the agricultural tax and fulfill a grain quota. National laws mandate that households have the right to cultivate this land for 15-30 years, and cultivation rights can be transferred to other households or passed from parents to children.

The fact that land endowments are allocated on a per capita basis raises the issue of changes in land being perfectly correlated with changes in household size. In fact, most villages in Zouping do not reallocate land every year, but rather follow a practice of reallocating land every third year or so. In our sample the correlation between the event of a change in household size and that of a change in land endowment is only 0.32. Furthermore, land endowment is not a function of household composition. Indeed, the correlation between the event of a change in composition (without a change in size) and a change in land endowment is effectively zero. Thus, we take the timing and size of the changes in land endowment to be exogenous to the household.

What may not be exogenous is the actual land area cultivated by a household. Actual land area cultivated differs from the "endowed" area because households transfer land among themselves and with their villages. For example, households that do not want their full allocation of contract land from the village may transfer the land to another household or simply return the land to the village. Households that want additional land sometimes make arrangements to transfer in land from another household or rent additional land from the village. Some villages auction or lease to individual households collective land that has not been distributed to households under the responsibility system, for example, former collective orchards or vegetable plots.

Such transfers constitute the beginnings of a market for land, but the extent of land transfers in Zouping has remained small. Only 11% of households engage in such transfers, and the average transfer is less than 6.4% of the average land endowment. Land transfers among households often do not involve any rental payment. The receiving household, however, is usually responsible for meeting any quotas and paying any taxes associated with the land. This lack of a land market is common to rural China and is also a feature of Java, the location studied by Benjamin (1992). In Java land sales, leasing and sharecropping are rare (p.303).

Labor used in cultivation by households averages 442 days a year (see table 3). Some observers have noted that work in the fields is done disproportionately by women (Parish, Zhe and Li, 1995; Peng and Xueli, 1996; Rawski and Mead, 1998), but in our sample while the average amount of female labor used in cultivation exceeds that of male labor, it is only 11% higher. The survey data suggest that labor markets, like land markets, are as yet underdeveloped. A noticeable share–20%–of households use non-family labor in cultivation, but the amounts used are small. On average only 1% of labor used for cultivation is non-family labor. Moreover, two-thirds to three-quarters of this non-family labor is unpaid labor exchanged informally among households. Such exchange often occurs between relatives living in distinct households, say, between parents and their adult children, or between families of adult siblings. These features of Zouping county are similar to other rural areas in China, but are distinctly different from Benjamin's Java where 85% of all households hired in paid labor.

While the descriptive statistics in table 3 suggest that factor markets are underdeveloped, they do not tell us why. One explanation could simply be that since the distribution of land in Chinese villages is fairly equal on a per capita basis, marginal returns are more or less equal across households, obviating the need for much exchange. In this case lack of exchange does not necessarily lead to nonseparability. Anther explanation, however, could be that barriers, such as policies inhibiting land transfers and labor mobility, or absence of legal mechanisms for enforcing land or labor contracts, impede exchange. In this case lack of exchange is likely to be associated with nonseparability. As discussed below, the evidence supports the second interpretation.

Base results

In table 4 we present regression results from four different specifications of equation (5). The first two specifications do not take into account the panel nature of the data and are presented for comparison purposes. Columns 1 and 2 show OLS results using cross-section data from a single year (1993) and for the pooled sample, respectively.[26] The next specifications utilize the panel via fixed-effects estimation. These are our preferred specifications. Column 3 contains the results from the base fixed-effects estimation and column 4 shows the two-stage least squares fixed-effects estimation results instrumenting for land. The fixed-effects estimates with and without instruments are very similar. Indeed, the Durbin-Wu-Hausman test of the exogeneity of land yields a $\chi^2(1)$ statistic of 0.614 indicating that cultivated land can be treated as exogenous.[27] For this reason, and because the regression results in later sections of the paper are not sensitive to instrumenting for land, below we only present results without the use of instruments.

All four specifications in table 4 tell the same basic story with respect to separability. The household size and composition variables are, for the most part, highly significant individually. F-tests on their joint significance show that they are jointly significant at the 1% level of confidence in all regressions.

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[26]Huber/White standard errors are reported for the pooled cross-section estimates.

[27]The R^2 for the first stage regression is 0.605. The set of instruments are jointly significant determinants of cultivated land with an F-statistic of 121.9. For a discussion of the Durbin-Wu-Hausman test see Newey (1985) and Davidson and MacKinnon (1993). This test requires an estimate of the variance of the error term. One can use either the estimate from the fixed-effects estimation without instruments or that with instruments. The test statistic reported above is based on the estimates from the specification without instruments. The same conclusion is reached using the estimate from the specification with instruments.

We therefore reject the null hypothesis of separability and conclude that household production and consumption are nonseparable.

Other variables that are consistently significant across the specifications are education and the village and time dummy variables. Education is significant and negative. This may reflect that workers with more education work more efficiently. Alternatively, if educated workers have a greater chance of obtaining off-farm employment, then households with more educated workers would face a relative shortage of workers and thus use less labor in cultivation. As a group the location and time dummy variables are highly significant.[28] Their significance indicates the importance of village and time effects.

Two variables differ across the specifications. First, land is significant in the cross-section estimations but not in the fixed-effects estimations. The significance of land in the cross-section estimations reflects the fact that these specifications use the between-household variation, and that land shows nearly three times as much between-household as within-household variation (table 3).[29] Second, the coefficient on the adult female variable changes sign, magnitude and significance in moving from the cross-section to the fixed-effects specifications. This, and the fact that random-effects estimation produced results similar to the pooled cross-section specification, indicates that the unobserved household component is likely correlated with household composition.[30]

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[28]Due to space limitations, the coefficients on the time, location, and time*location dummy variables are not reported in the tables.

[29]With regard to our earlier discussion of the possible multicolinearity between land and household composition, we also ran the fixed-effects estimation excluding all household demographic variables and then excluding only household size. In both cases land is significant with the coefficient increasing to 0.163 (0.068) in the first case and 0.220 (0.070) in the second. However, the household composition variables remain significant in the second regression ($F(3,695)=5.20$) implying nonseparability is robust to this specification change. Since changes in household size are only partially correlated with land changes and exhibit considerably more within household variation, we maintain the specification that includes both household size and land.

[30]The random-effects estimates are only consistent if the time-invariant unobserved household components in the error structure are uncorrelated with the regressors. The Hausman test did not reject this

Focussing further on the household composition variables, we note that the coefficient on household size, which can be interpreted as the elasticity of labor demand with respect to household size, is positive, indicating that larger households employ more labor in cultivation. This result is consistent with the fact that under nonseparability adding a person to the household should increase the household supply of labor and so lower the shadow price of labor. While this elasticity is less than one, it is nevertheless fairly large–about 0.5 in all regressions–implying that a 10% increase in household size would increase labor use in cultivation by 5%, or that increasing household size by one member increases labor use by 54 person days or 12% at the mean.

The coefficients on household composition–the fractions of female adults, elderly and children,–in the preferred fixed-effects specification are all negative and significant, indicating that household composition, not just size, influences labor use in production. These coefficients are difficult to interpret directly, so in column 1 of table 5 we present the implied elasticities for these variables.[31] The elasticities for adult males and females are large and statistically significant. Adding an additional adult male to the household increases labor use by 24% or 106 person days at the mean and adding an additional adult female increases labor use by almost 10% or 38 person days. This less than one-to-one increase in adult work time in cultivation when an adult is added to the household likely reflects reallocation of time between cultivation and other activities. Having an extra hand to help with work in the field could free a household member to take up off-farm employment or allow more time for livestock production or household chores.

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specification of the unobserved heterogeneity. However, given the probable correlation between the household composition variables - our main variables of interest - and the unobserved components, we prefer the fixed-effects estimates.

[31]The formula for the elasticities is given by $\eta_{L,n^i} = \frac{n^i}{n}[\delta_0 + I*\delta_i - \sum_{j=1}^{D} \delta_j \frac{n^j}{n}]$ where I is an indicator function equal to 1 if household category i is not the omitted category of adult males and 0 otherwise (Benjamin, 1992, p.304).

The smaller impact of adult females could be explained in several ways. First, the adult female coefficient is derived from comparing the response of labor use to variation in the fractions of adult males and females, and the main source of this variation is the maturation of sons and daughters into adulthood. Daughters may leave school and begin to work in the fields at an earlier age, so that reaching age 18, the age of completion for senior middle school, shows less of an effect.[32] Second, household time budget studies have shown that wives/mothers take on the burden of substantial child-rearing and domestic work in addition to their usual work in the field, especially when children are young. When a daughter matures, then, she can take on some of the mother's workload. The daughter's increased work time is offset in part or in whole by the mother's reduced work time, thus having little net effect on total labor use in the field.

Children and elderly household members have smaller effects on labor use. The addition of a child increases labor use by 6% while the addition of an elderly person decreases labor use by 5%. While an extra child requires care and so may divert time from other uses, it also increases the number of mouths to feed and so may induce the parents to work more hours in the field. This desire to increase income and consumption by working more hours apparently dominates. The small, and insignificant, change for elderly members could reflect that our analysis does not distinguish between two types of elderly people, those who are healthy and contribute labor to the household, and those who are not healthy, require care, and divert time from farm production.

Comparison with Benjamin's results

Our findings differ from those of Benjamin (1992). Benjamin does not reject separability for his sample of Indonesian farm households, and his result is robust to different specifications and estimation

[32]As noted in footnote 23, we find evidence of females leaving school earlier than males in our data. This type of measurement error will bias the effect of changes in adult females toward zero. Thus our results likely understate the effects of household composition, particularly the fraction of adult females, on labor demand. Despite this potential bias, the coefficient is still significant.

methods. We reject separability for our sample of Chinese farm households, and our result is also robust to different specifications and estimation methods. Our findings differ both in statistical significance and in magnitude. For example, Benjamin's estimates of the elasticity of labor demand with respect to household size range from 0.032 to 0.097, and none are significantly different from zero. Our estimates of this elasticity range from 0.492 to 0.543, roughly ten times the size of Benjamin's, and all are significant at the 1% level of confidence. In addition Benjamin's elasticities with respect to household composition are small and generally insignificant, whereas we find large and significant effects.

These differences raise the question of whether we reject separability because we use different specifications and estimation techniques than Benjamin, or because China is different than Indonesia. In particular, since we have argued that fixed-effects estimation with panel data is preferable to cross-section estimation because of potentially important household level unobservables, it is important to ask how controlling for possible unobserved heterogeneity influences the results. Comparison of the cross-section and fixed-effects estimation results in table 4 provides some answers to these questions.

Our single year cross-section specification is more or less analogous to Benjamin's base specification. These estimates, and our estimates for the pooled cross-section specification, do not correct for household level unobservables. Even in these two cases we find nonseparability, which suggests that Benjamin's finding of separability in Indonesia and our finding of nonseparability in China probably reflect not only differences in specification or estimation methods, but also underlying differences in the two economies.

While the nonseparability result holds both for the cross-section and fixed-effects estimations, controlling for household level unobservables does affect certain household composition coefficients, in particular, the estimated coefficient on the fraction of adult women in the household. The pooled cross-section estimate for the coefficient on the fraction of adult females in the household is relatively small, less than 0.18 in absolute value, and not significant. This would suggest that the effect of changing the fraction of adult females in the household does not differ substantially from that of changing the fraction of adult males (the omitted numeraire). In the fixed-effects estimation, however, this coefficient is large–about -0.57–and significant, indicating that the effects of changing the proportion of adult females and adult males are different.

Controlling for unobserved heterogeneity, in other words, reveals that household labor use in farming is sensitive to the gender composition of the household. Comparing columns 1 and 2 of table 5, for example, we find the fixed-effects estimates imply that the addition of an adult male has a large effect, changing predicted household labor demand by 24%. In contrast, the addition of an adult female has a smaller effect, changing predicted labor demand by less than 10%. The same calculations using the pooled cross-section estimates yield a much smaller gender difference. The addition of an adult female increases labor use by 20%, compared to 17% for an adult male. (Note that, while daughters have a larger effect than sons, the difference is not statistically significant.)

The differences between the cross-section and fixed-effects estimation results point to the presence of correlation between households' unobserved characteristics and their composition. For China, allowing for this correlation via fixed-effects estimation strengthens the rejection of separability and alters the interpretation of the effect of household composition changes on labor demand. These findings illustrate the potential importance of controlling for household unobservables and raise questions about the interpretation of results based on cross-section data.

Alternative specifications of labor use

In the above specifications total labor use L is the sum of all person-days used in cultivation in a year regardless of the type of labor—male, female, adult or non-adult. This aggregation is only appropriate if these different types of workers supply the same efficiency units of labor and are perfect substitutes in production. We first consider the former form of aggregation bias. It is possible that labor demand should be specified as

$$L^{*} = L_M + \alpha_F L_F + \alpha_N L_N \tag{6}$$

where L^* is the total efficiency units of labor demanded; L_M, L_F, L_N are the labor units (person-days) of adult males, adult females and non-adults, respectively; and α_F (α_N) are the efficiency conversion factors for converting adult female (non-adult) labor into efficiency units. The efficiency factor of male labor has been normalized to 1. Under the null hypothesis of separability, L^* will not be a function of household composition variables, but L may be. Thus, our rejection of separability may stem from an inappropriate aggregation of labor units.[33]

Estimates for the efficiency factors for adults can come from wage data. Under separability market wages will reflect the productivity (efficiency) differential between males and females. Estimates of the female-male wage differential in rural China vary depending on the region and estimation method, but they usually fall in the range of 0.6 to 0.9 (Hare, forthcoming; Parish, Zhe and Li, 1995; Meng, 1998). Available information for Zouping County suggests a female-male wage ratio of 0.75 to 0.80. Data on the average village wages of unskilled male and female labor collected from the leaders of the villages in the Zouping sample show an average female-male wage ratio of 0.79, while data on off-farm wages reported by the households in the sample show an average ratio of 0.76. The efficiency factor for non-adult labor cannot, in general, be measured from market wages. It is, however, common practice to treat the elderly and children as half as efficient as adult workers and set α_N equal to 0.5.

[33]Benjamin (1992) also discusses the possibility of efficiency factors varying across worker types, but he only examines differences between hired and family labor. He does not address the question of differing efficiencies among males, females, and non-adults, presumably because his data do not directly distinguish between these types of labor. As the percentage of hired labor in our sample is extremely small, we do not sub-divide the data into family and hired labor, but rather focus on gender and age differences.

An alternative means of deriving the efficiency factors is to estimate them directly from the data. Benjamin (1992, p.317) derives the following equation (modified here to fit our model)

$$\ln L_{jt} = \alpha + \gamma \ln A_{jt} + (1-\alpha_F)\frac{L_{Fjt}}{L_{jt}} + (1-\alpha_N)\frac{L_{Njt}}{L_{jt}} + \sum_{i=1}^{K} \theta_i D_i + \sum_{i=1}^{M} \zeta_i X_i + \epsilon_{jt} \quad j=1,\dots,J;\ t=1,\dots,T \tag{7}$$

to test whether the efficiency factors are equal to one, i.e., $1-\alpha_F=0$ and $1-\alpha_N=0$. Estimates from this equation provide a consistency check on the wage ratios given above, which could be inappropriate for agricultural labor or contaminated by discrimination and other non-market factors. These estimates also provide a check on our adoption of the conventional $\alpha_N=0.5$.

Fixed-effects estimation of equation (7) yields a coefficient of 0.193 (0.093) on the fraction of adult female labor and 0.595 (0.140) on the fraction of non-adult labor.[34] These coefficients are significant, indicating that efficiency levels do in fact differ among different types of individuals, and they imply that $\alpha_F=0.81$ and $\alpha_N=0.40$. These factor estimates are surprisingly close to those derived from the wage data and used by convention providing support for our use of those factors.

Estimates of labor demand using efficiency units of labor with α_F equal to 0.79 and α_N equal to 0.5 appear in column 1 of table 6.[35] The following conclusions emerge. First, the rejection of separability is robust to the efficiency units specification. In fact, the *F*-statistic increases from the base specification

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[34]Benjamin points out that the labor shares should be instrumented due to division bias. He uses household composition variables for instruments, as under separability they should not be related to total labor use but may be related its composition. As we show below, separability is rejected here invalidating the household composition variables as instruments. Unfortunately, alternative instruments are not available in our data. Thus, we use the estimates from equation (7) only as a guide in our choice of efficiency factors and check the sensitivity of the results with respect to alternative factor values.

[35]We use the male-female wage differential from the village surveys rather than that from the household off-farm employment figures, because the latter is subject to selection bias and therefore is less likely to represent a pure measure of the male-female productivity differential. We also conducted the analysis for a range of efficiency factors to determine the sensitivity of the results. We allowed α_F to vary between 0.7 and 0.8 and α_N to vary between 0 and 0.5. In all cases separability was rejected.

(table 4, column 3) by a factor of 1.5 due to the higher significance level of the adult female variable. Second, the coefficients on the household structure variables do not significantly differ, individually or jointly, from those in our base specification.[36] Thus, while the efficiency factors appear to be different from 1, aggregation on a one-to-one basis does not appear to significantly bias our coefficients or lead to a false rejection of separability.

A second possible cause of aggregation bias in the labor demand estimates is if male and female labor are not perfect substitutes. In this case the production function should be specified as having 3 inputs: land A, male labor L_M, and female labor L_F.[37] Then, under separability, the first order conditions for male and female labor would be

$$F_1(L_M,L_F,A) = w_M \text{ and } F_2(L_M,L_F,A) = w_F \tag{8}$$

where w_M and w_F are the market wages for male and female labor, respectively. In this case the demands for male and female labor should be estimated separately, and under separability neither should be influenced by household demographic variables.

Note that unless the markets for both male and female labor are separable, one should expect to find that household composition variables affect both types of labor. For example, if there is a market for male labor but not for female, then L_F is a fixed factor, like land, and will affect the usage of male labor. The test for the separability of male labor may then reject separability even when there is a market present, and, therefore, the tests for male and female labor only provide information about the workings of the entire labor market.

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[36]Only when α_N is set equal to zero do we find a significant deviation between the results with and without efficiency factors, and in this case only the children variable varies significantly.

[37]Because the fraction of non-adult labor is so small we do not treat it as a separate input, but rather separate it by gender and combine it with the measures of female and male labor.

Fixed-effects estimates of total, male, and female labor demand functions appear in columns 2-4 of table 6. To maintain the same sample of households across all three specifications, we drop observations for households that report zero use of either male or female labor. The estimates for aggregate labor demand in this restricted sample are similar to the results for the larger sample reported in table 4.

We first investigate whether male and female labor are substitutes in production. A test of the equality of all coefficients in the male and female labor demand regressions yields a $\chi^2(77)$ statistic of 322.89. A test of the equality of only the thirteen economic coefficients shown in table 6 yields a $\chi^2(13)$ statistic of 56.54. Both tests reject the hypothesis that the male and female labor demand coefficients are equal, indicating that male and female labor are not perfect substitutes in production.

We then test for separability. For both male and female labor some or all of the household variables have significant coefficients. Tests of the hypothesis that the coefficients on all household structure variables equal zero reject the null hypothesis at the 1% level of confidence for both male and female labor. Thus nonseparability is robust to disaggregation by gender.

We once again calculate the household composition elasticities so as to compare the different effects on male and female labor use (columns 3 and 4 of table 5). These calculations reveal that the effect of changes in household structure on male and female labor use indeed differs. The addition of an adult male has a large effect on male labor use increasing it by 45%, but virtually no effect on female labor use. The same holds for the addition of an adult female in that female labor use rises substantially, albeit less, while male labor use is unaffected. These findings could reflect the fact that work is divided into 'male' and 'female' tasks and that male and female labor are not easily substituted. The presence of an additional child increases both male and female labor use around 10%, but the addition of an elderly household member only has an effect on male labor use, reducing it by 12%. The latter result may again reflect the composition of elderly household members in our sample.

Exploring nonseparability: Land availability and surplus labor

Presumably the extent of surplus labor in rural China depends on the amount of arable land per capita. If land quality and other variables are held constant, surplus labor should be more severe in localities with less land per capita than in localities with more land per capita. We explore this possibility by dividing the sample into three groups based on land availability. Land availability is determined using village-level statistics on average amounts of cultivated land per capita obtained from interviews with village leaders. The division of households into groups is therefore not based on data from the household survey.[38] Group I consists of households in villages with, on average, less than 1.5 *mu* per capita; group II of households in villages with between 1.5 and 2 *mu* per capita; and group III of households in villages with more than 2 *mu* per capita. These cut-offs were chosen in line with the observed clustering of land amounts among the villages, and they divide the sample into three groups of roughly equal size (groups I and II each contain 320 observations, and group III contains 390 observations).[39]

Regressions were estimated over the whole sample, but the household composition variables are now group-specific.[40] This permits comparison of their estimated coefficients among the groups.[41] The

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[38]In addition, place of residence is largely determined by family history and exogenous. When children form new households they locate in the groom's village, and collective ownership of land prevents the movement of established households between villages. Therefore selection into these groups is not an issue.

[39]In rank order from small to big, the average amount of land per capita for each village was: 0.94, 1.05, 1.12, 1.36, 1.41; 1.57, 1.63, 1.647, 1.652, 1.72; 2.10, 2.11, 2.14, 2.23, 2.29, 2.35. Note that land area per capita varies geographically within the county, with villages in northern townships having more land than villages in southern townships.

[40]Since the efficiency results were not significantly different from the base specification and the conclusions regarding separability were the same for both male and female labor use, for simplicity we use L (total person-days) as our measure of labor use in the remainder of the paper.

[41]Note that variation in household size and composition variables is spread fairly evenly among the three groups, so that within household variation in the household structure variables is sufficient for identification.

regression results appear in table 7, column A.[42] As expected, the household composition variables are significant for households in villages that are land-short (group I) and thus prone to surplus labor. They are also significant, however, for households in villages that are land-abundant (group III). The only group for which separability cannot be rejected is villages with medium-sized land endowments (group II).

These findings suggest that the relationship between land availability and separability is not straightforward. One interpretation of these results is that they reflect an environment where labor surplus in some localities coexists with labor shortage in other localities. While households in land-scarce villages face surplus labor, households in land-abundant villages face labor shortages. This situation would arise if inter-village labor and land markets are underdeveloped, preventing the exchange of labor between households in the two groups. Separability for households in the middle group could reflect that these households operate near the corner solution, so that separability can be achieved by exchanging small amounts of labor or land. Such exchanges can be carried out through informal arrangements within villages or between neighbours even where factor markets are not well-developed.

If this interpretation is correct, then generalizations about surplus labor in rural China are off the mark. The underlying problem is not surplus labor *per se*, but the absence of mechanisms that permit the transfer of labor between labor-surplus and labor-scarce localities.

Exploring nonseparability: Off-farm employment

The Chinese government has adopted reforms to promote the development of nonagricultural activities in rural areas, and the resulting substantial growth in nonagricultural employment has the potential to create the conditions for separability of household production and consumption decisions. While we find nonseparability for the sample as a whole, uneven development of off-farm employment

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[42]Equality of the household coefficients across the groups is rejected at the 5% level of significance ($F(8,686)=2.08$), suggesting that the three groups are different.

among villages in our sample permits us to investigate this proposition. In some villages covered by the survey, for example, households have access to employment both in village enterprises and outside the village in the township or county seat. In other villages most nonagricultural employment consists of private businesses such as food stalls, transport, or commerce run by households, or the main form of nonagricultural work is casual wage labor, mostly in construction or transportation, taken on a seasonal or temporary basis. In yet other villages nonagricultural employment of any sort is minimal. (See Cook (1998b) for a discussion of differing employment patterns among villages in the survey.)

We capture some of these differences by classifying villages in three categories based on the extent of nonagricultural employment in the village and township.[43] The first category is for villages with little or no off-farm employment, private or collective, either within the village or in the township (category I). A second category is for villages with significant collective or private nonagricultural employment within the village (category II). A third category is for villages located in townships that provide substantial nonagricultural employment beyond the boundaries of the village (category III).[44] Our hypothesis is that households in category I would be characterized by nonseparability, and households in categories II and III by separability.

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[43]These groupings are not based on data from the household survey but on information from interviews at the village and county levels. Note that Zouping County contains eighteen townships, about 860 villages, and a rural population of 620,000. Townships typically encompass between 35 and 80 villages, and villages usually contain 200 to 300 households.

[44]Four villages are located in townships that report nonagricultural employment near or exceeding 50% of total employment (47%, 47%, 50% and 73%). Households in these villages belong to category III. Three villages report the presence within the village of collective or private enterprises that jointly employ 100 or more people in one or more years. Households in these villages belong to category II. Nine villages report zero or near-zero employment in collective and private enterprises within the village, and also are located in townships where nonagricultural employment is well below 50% of total employment (12% to 42%). Households in these villages belong to category I. Note that one village in group III also has a relatively high level of village employment (II). Testing revealed that category III was the appropriate classification for this village.

As above, regressions are estimated over the whole sample, but the household composition variables are allowed to vary among the three categories.[45] The regression results appear in table 7, column B.[46] Household composition variables are significant for categories I and II, but not III. That is, nonseparability prevails in villages with little or no off-farm activity, and also in villages with off-farm activities within the village. Separability is not rejected for households that are in villages located in townships with substantial off-farm employment.

These results suggest that separability depends not on the employment situation within the village, but on employment opportunities outside the village. Why would this be so? One explanation is that employment within villages is not allocated through competitive market mechanisms. Collective enterprises within villages are often managed by village-level officials who reportedly allocate jobs on the basis of political and social criteria. When hiring employees for collective village enterprises, village leaders may give preference to their relatives, or if concerned about equity within the village they may give preference to poor households or distribute jobs equally among households. Similarly, village leaders have the power to promote or hinder private enterprises within the village, and so within-village employment opportunities in the private sector may also be driven by non-market criteria (Cook, 1998a and 1998b; Ho, 1994; Yao, 1997)

Village leaders' control over job allocation within the village, however, can be eroded by competition from outside the village. If nonagricultural job opportunities are available in the wider township, and if village residents have relatively competitive access to those jobs, then labor allocation within the village will be influenced by market forces from the outside. Such opportunities could take the

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[45]Within household variation in household size and composition variables is again spread fairly evenly among the three groups and so is sufficient for identification.

[46]As with the land groupings, the equality of the coefficients across the groups is rejected at the 5% level of significance with an F-statistic of 2.22.

form of employment in township collective enterprises or of casual wage labor. By the early 1990s farmers in some parts of the county reported that casual or temporary wage employment outside the villages in sectors such as construction and transportation was available to whomever wanted such jobs, without need for personal or political connections (Cook, 1998b). In the presence of such wider opportunities, households would have freer access to outside employment, and so would be able to achieve separability in the use of labor in household farm production.

A second factor that could underlie our empirical results is that the main barriers to the exchange of labor (or land) are between villages. In the absence of well-developed factor markets, within-village reallocation of labor can still be carried out by village leaders who can make adjustments in land allocations and who hire employees for village enterprises, or by informal exchange among neighbour households. These sorts of informal intra-village reallocation mechanisms, however, do not function well between villages. Indeed, evidence suggests that in most regions households rarely use labor from outside the village (except for the occasional exchange of labor with families of daughters-in-law or wives from other villages), that village land is rarely rented or transferred to people from outside the village, and that private and collective enterprises within villages rarely employ workers from outside the village.[47]

If nonseparability is largely caused by barriers to factor movement among villages, then the development of nonagricultural employment within a village would not necessarily eliminate nonseparability. The development of labor (or land) markets that transcend the villages is needed to promote separability and the efficient allocation of labor.

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[47]Cook (1998a, 1998b) and author interviews, Zouping County. In Zouping village collectives make an exception to the rule of employing only people from within the village if no villagers want additional jobs or if they need technical expertise that is not available within the village. Technical experts, however, usually come from urban areas rather than from other villages in the county. In this regard Zouping resembles other parts of China. Parish, Zhe and Li (1995) based on a study of ten counties scattered widely through the eastern two-thirds of China, find that "few regions have sufficient labor demand to create the vacancies at the village level that pull in outside labor" (p. 714).

Conclusions

In this paper we test for separability between labor supply and demand decisions in rural China using panel data. The availability of panel data enables us to control for time-invariant unobservable household characteristics. The presence of such characteristics and the inability to control adequately for them with cross-section data has long been noted in the literature. We show that while controlling for unobserved heterogeneity via fixed-effects estimation does not change the basic finding of nonseparability for our sample, it does affect the size and significance of individual coefficients for certain household composition variables. In particular, it reveals that household labor use in cultivation is sensitive to the gender composition of the household, raising important questions about the substitutability of male and female labor in both on-farm and off-farm work. Such results indicate that unobservable household components are likely correlated with household structure and gender composition, and they suggest the need for panel data when estimating household labor demand and supply in rural areas of developing countries.

Our finding of nonseparability implies that in the early 1990s factor markets in a typical rural county in northern China remained underdeveloped despite more than a decade of economic reform and market liberalization. The conventional view that rural areas are characterized by surplus labor, however, appears to oversimplify the situation. Our results suggest that while some localities have a labor surplus, others may face labor shortages. Thus the underlying problem is not simply the existence of surplus labor, but also the absence of mechanisms that facilitate labor mobility among localities.

Has growth in township and village enterprises and, more generally, rural nonagricultural employment helped to reduce surplus labor and promote separability? We find that separability holds for households in townships with substantial nonagricultural employment, but not for households in villages where nonagricultural employment opportunities exist only within the village and not in the wider township.

These findings indicate that it is not enough for a single village to create nonagricultural employment internally. What is needed is the development of employment opportunities that transcend individual villages, create competitive pressures that influence job allocation within villages, and promote the inter-village movement of resources.

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Table 1: Descriptive Statistics from the Zouping Survey

	Sample Average, 1990-93
household income per capita	1165
share of income from:	
agriculture	0.73
of which: crop cultivation	0.66
non-agriculture	0.26
household size	3.97
share of population that is working-age (18-65)	0.69
share of working-age population that is male	0.51
share of population that is below age 18	0.26
share of population that is above age 65	0.04
average years education of working-age adults	5.44
average age of working-age adults	36.5

<u>Notes</u>:

1. This table gives averages for 258 households over four years, or over 1015 observations. A few households did not remain in the sample for the full four years of the survey. Observations are weighted by the ratio of the village sample size to the village population in order to correct for sampling bias among villages.
2. Income statistics are in constant 1990 yuan. Shares of income from different sources sum to one for individual households, but average shares over all households shown above need not sum to one.
3. The relatively low mean level of education reflects generational differences in schooling.

Table 2: Changes in Household Composition among Sample Households
(258 households, 1015 observations)

Change in:	Number of Households	Number of Observations
household size and/or composition	132 (52%)	180 (18%)
household size	80 (31%)	96 (9%)
fraction of adult males	102 (40%)	131 (13%)
fraction of adult females	113 (44%)	143 (14%)
fraction of children	116 (45%)	152 (15%)
fraction of elderly	36 (14%)	45 (4%)

Notes:
1. If a household reports one or more changes in family size, or in the fraction of adult males or females, children, or elderly in the household, it is counted as having a change in household size and/or composition.
2. Household size is the number of people resident in the same house or residential compound for one or more months during the calendar year.
3. Adults include individuals of age 18 to 65, inclusive. Individuals below age 18 are counted as children and above age 65 as elderly.

Table 3: Land and Labor Used in Cultivation by Sample Households

		Sample Average, 1990-93	Standard Deviation		
			Overall	Between	Within
Total cultivated land area (*mu*)		7.19	3.36	3.13	1.22
Of which:	land "endowment" (*mu*)	6.83	2.66	2.58	0.62
	land transfers (*mu*)	0.44	1.95	1.63	1.06
Share of households transferring land in or out		0.11			
Total labor use (days/year)		442	238	205	121
Of which:	male	210	137	119	69
	female	236	136	115	73
Of which:	family	438	238	205	120
	non-family	4	13	9	10
Share of households using non-family labor		0.19			

Notes:

1. This table gives averages over 258 households over four years, or a total of 1015 observations. A few households did not remain in the sample for the full four years of the survey. Standard deviations give the variation between and within households.
2. Cultivated land includes land "endowments" (land allocated by the village under the responsibility system, private plots, reclaimed land) plus (or minus) additional land transfers between households or between the households and villages (e.g., bid or *toubiao* land). Land "endowments" are so called because households have the right to cultivate this land. Fifteen *mu* equal one hectare; 6.07 *mu* equal one acre.
3. Labor use is measured in standardized 8-hour days.
4. Non-family labor is either hired labor or labor exchanged between households without compensation.

Table 4: Demand for Labor in Cultivation: Base Regression Results
Dependent variable: ln of person days

	Single cross-section	Pooled cross-section	Fixed-effects	Fixed-effects, 2SLS
log cultivated land area	.455*** (.105)	.439*** (.110)	.100 (.075)	.020 (.150)
number of plots	-.012 (.022)	-.011 (.016)	-.014 (.015)	-.010 (.019)
fraction of land that is flat	-.340 (1.290)	-.640 (.477)	-.222 (.350)	-.194 (.412)
fraction of poor land	-.361** (.180)	-.039 (.133)	.002 (.109)	.016 (.130)
fraction of good land	.185* (.102)	.103 (.063)	-.022 (.053)	-.020 (.062)
fraction of land with poor irrigation	.011 (.439)	.018 (.111)	.109 (.151)	.123 (.180)
fraction of land with good irrigation	.027 (.125)	-.135 (.103)	-.027 (.093)	-.024 (.110)
average adult education	-.043*** (.015)	-.019* (.010)	-.037*** (.014)	-.037** (.017)
average adult age	-.001 (.004)	-.001 (.002)	-.005 (.004)	-.005 (.005)
log household size	.498*** (.122)	.494*** (.112)	.492*** (.119)	.543*** (.159)
female adult fraction	-.136 (.199)	.172 (.159)	-.563*** (.189)	-.575** (.223)
elderly fraction	-1.089*** (.250)	-.824*** (.226)	-1.140*** (.244)	-1.132*** (.287)
children fraction	-.692*** (.154)	-.645*** (.104)	-.679*** (.180)	-.679*** (.212)
R-squared (within)	0.72	0.73	0.49	0.45
Test of null hypothesis	F(4,224)=13.57	F(4,257)=28.48	F(4,694)=8.24	F(4,687) = 8.33
Number of observations/ households	253/253	1013/258	1013/258	1007/256

Notes:
1. All regressions include time, village, and time*village dummy variables.
2. Standard errors are in parentheses. *** indicates significance at the 1%, ** at the 5%, and * at the 10% level of confidence.
3. The single cross-section results are estimated using data for 1993. Regressions were also run for the other three years of data, but since the results are similar we do not report them here.
4. Standard errors for the pooled cross-section estimates are calculated using the Huber/White estimator of variance.
5. Instruments used for cultivated land area in the 2SLS regressions are: land endowment, the cotton quota, and the grain quota.

Table 5: Implied Household Composition Elasticities

	Fixed-effects	Pooled cross-section	Male Labor	Female Labor
A. Elasticity of Labor Demand				
Male adult	.322*** (.065)	.227*** (.050)	.606*** (.095)	.054 (.078)
Female adult	.118*** (.050)	.276*** (.045)	.046 (.081)	.255*** (.067)
Elderly	-.010 (.010)	-.008 (.008)	-.022* (.013)	-.007 (.011)
Children	.062* (.036)	-.0004 (.037)	.110** (.055)	.077* (.045)
B. Percentage Change in Labor Demand				
Male adult	.24	.17	.45	.04
Female adult	.09	.20	.03	.18
Elderly	-.05	-.04	-.12	-.04
Children	.06	0	.10	.07
C. Level Change in Labor Demand (person days)				
Male adult	106	75	95	9
Female adult	38	90	7	43
Elderly	-22	-17	-25	-9
Children	25	0	21	16

Notes:

1. Panel A presents elasticities of labor demand with respect to the household composition variables. Panel B gives the percentage change in labor demand in response to an increase of one additional household member in each category. Panel C gives the level change in labor demand (in person days) in response to increasing each category by one person. The formula for the elasticities can be found in footnote 31. All figures are calculated with respect to mean values.

2. Standard errors are in parentheses. *** indicates significance at the 1%, ** at the 5%, and * at the 10% level of confidence.

Table 6: Fixed-effects Estimates of the Alternative Labor Specifications
Dependent variable: ln of labor use

	Efficiency Units of Labor	Imperfect Substitutes		
		All Labor	Male Labor	Female Labor
log cultivated land area	.098 (.074)	.094 (.070)	.036 (.110)	.147 (.090)
number of plots	-.014 (.015)	-.016 (.014)	-.021 (.022)	-.008 (.018)
fraction of land that is flat	-.330 (.346)	-.227 (.325)	-1.313** (.508)	.364** (.416)
fraction of poor land	.0004 (.108)	-.032 (.104)	.089 (.162)	-.187 (.133)
fraction of good land	-.025 (.052)	-.031 (.051)	-.063 (.080)	-.034 (.066)
fraction of land with poor irrigation	.140 (.149)	.107 (.142)	.087 (.222)	.211 (.182)
fraction of land with good irrigation	-.025 (.092)	-.041 (.088)	.186 (.138)	.029 (.113)
average adult education	-.031** (.014)	-.035*** (.014)	-.021 (.021)	-.046 (.017)
average adult age	-.005 (.004)	-.005 (.004)	.008 (.007)	-.018*** (.005)
log household size	.553*** (.118)	.530*** (.115)	.740*** (.180)	.379*** (.147)
female adult fraction	-.781*** (.187)	-.495** (.193)	-1.651*** (.301)	.578** (.247)
elderly fraction	-1.358*** (.242)	-1.224*** (.237)	-2.352*** (.371)	-.348 (.303)
children fraction	-.945*** (.178)	-.667*** (.173)	-1.383*** (.270)	.122 (.221)
R-squared (within)	0.50	0.53	0.39	0.42
Test of null hypothesis	F(4,663)=12.47	F(4, 663) =9.76	F(4, 663)=13.76	F(4, 663)=4.40
Number of observations/ households	1011/257	976/252	976/252	976/252

Notes:
1. All regressions include time, village, and time*village dummy variables.
2. Standard errors are in parentheses. *** indicates significance at the 1%, ** at the 5%, and * at the 10% level of confidence.
3. For the efficiency units specification the dependent variable is the log of weighted person days with α_F=0.79 and α_N=0.5. One household with missing labor composition information has been dropped.
4. For the imperfect substitutes specifications, households that do not use both male and female labor have been dropped so that the regressions reported in columns 2-4 are estimated over the same sample.

Table 7: Fixed-effects Estimates of Labor Demand: By Groups
Dependent variable: ln of person days

	A. Grouped by Land Endowment per Capita	B. Grouped by Development of Township and Village Enterprises
log household size I	.488** (.204)	.418*** (.145)
log household size II	.187 (.213)	1.028*** (.252)
log household size III	.505*** (.171)	.153 (.253)
female adult fraction I	-1.531*** (.359)	-.144 (.247)
female adult fraction II	.136 (.419)	-1.351*** (.390)
female adult fraction III	-.239 (.282)	-1.021** (.473)
elderly fraction I	-.764 (.487)	-.922*** (.295)
elderly fraction II	-.427 (.497)	-2.126*** (.528)
elderly fraction III	-1.282*** (.399)	-1.061 (.837)
children fraction I	-.981*** (.277)	-.454** (.216)
children fraction II	.115 (.379)	-1.712*** (.424)
children fraction III	-.721*** (.259)	-.317 (.384)
R-squared (within)	0.5	0.5
Test of null hypothesis I	F(4, 686) = 6.54	F(4, 686) = 4.41
Test of null hypothesis II	F(4, 686) = 0.95	F(4, 686) = 6.86
Test of null hypothesis III	F(4, 686) = 5.02	F(4, 686) = 1.32
Number of observations/ households	1013/258	1013/258

Notes:
1. To conserve space, only the family structure variables are reported here. All specifications also include the land, land quality, age and education variables, as well as the time and location dummy variables.
2. Standard errors are in parentheses. *** indicates significance at the 1%, ** at the 5%, and * at the 10% level of confidence.
3. Definitions of the groups I, II and III can be found in the text.