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Spatial Poverty Traps?

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Can location make the difference between growth and contraction in living standards for otherwise identical households? Apparently so. Evidence of spatial poverty traps strengthens the case for investing in the geographic capital of poor people.

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Summary findings

Can place of residence make the difference between growth and contraction in living standards for otherwise identical households?

Jalan and Ravallion test for the existence of spatial poverty traps, using a micro model of consumption growth incorporating geographic externalities, whereby neighborhood endowments of physical and human capital influence the productivity of a household's own capital. By allowing for nonstationary but unobserved individual effects on growth rates, they are able to deal with latent heterogeneity (whereby hidden factors entail that seemingly identical households see different consumption gains over time), yet identify the effects of stationary geographic variables.

They estimate the model using farm-household panel data from post-reform rural China.

They find strong evidence of spatial poverty traps. Their results strengthen the case — both for efficiency and equity — for investing in the geographic capital of poor people.

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Spatial Poverty Traps?

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1 Introduction

Consider two households living in different areas but identical otherwise. Suppose that one of the areas is less well endowed with physical, human and social capital–in short geographic capital–than the other. A spatial poverty trap can be said to exist if the household living in the better endowed area sees its standard of living rising over time, while the other does not. Various theoretical models have helped understand how such poverty traps can arise.[2] If borne out by empirical evidence, spatial poverty traps suggest both efficiency and equity arguments for investing in poor areas, such as by developing local infrastructure or by assisting labor export to better endowed areas.

Is it possible to test for spatial poverty traps? There are a number of problems.[3] Aggregate growth empirics can test for divergence, whereby initially poorer areas grow at lower rates (following Barro and Sala-i-Martin, 1992). However, this is neither necessary nor sufficient for a spatial poverty trap, since geographic aggregates do not allow one to separate effects which are external to individuals from purely internal effects (Ravallion and Jalan, 1996). Suppose that one finds lower growth rates in areas with lower average wealth. This may reflect increasing returns to individual wealth, or geographic externalities, whereby living in a poor area lowers returns to individual investments. Aggregate geographic data cannot tell us which it is.

Instead, cross-sectional micro data might be used to test for geographic effects on living

[2] On the theoretical possibilities for a poverty trap (with and without externalities) in a neoclassical one-sector growth model see Azariadis (1996) and references therein.

[3] For a review of the empirical literature on processes creating poor areas see Ravallion (1997).

standards at one point in time.[4] However, to test for spatial poverty traps we need to identify dynamic effects, and to control for latent heterogeneity; that calls for longitudinal observations. Both household-level panel data and geographic data are clearly called for to have any hope of identifying spatial externalities in the growth process.

The problems do not end there. The geographic effects that one might find in household panel data may well be spurious in that they arise solely because geographic variables proxy for omitted non-geographic, but spatially autocorrelated, household characteristics. For example, we might find that the average wealth of an area is positively correlated with growth rates at household level, controlling for individual wealth. But this may be because some household attribute relevant to growth, and positively correlated with average wealth, has been omitted. (Better own education may yield higher growth rates, be correlated with wealth, and be spatially autocorrelated. Then average wealth in the area of residence could just be proxying for individual education.) One might attempt to deal with this by adding variables. But one might reasonably expect considerable latent heterogeneity in any micro data. Nor is it sufficient to allow for latent fixed effects in the levels of consumption (as is common practice). We need an econometric model which allows for individual effects in consumption growth rates.

At this point one might turn to the standard practice in panel data models of treating the latent heterogeneity as a time-invariant fixed effect (albeit a fixed effect in the growth rates, rather than the levels of consumption). However, this immediately wipes out any hope of identifying impacts of the time-invariant geographic variables of interest–of which there are

[4] See, for example, Borjas (1995) on neighborhood effects on schooling and wages in the U.S., and Jalan and Ravallion (1997a) on geographic effects on chronic poverty in rural China.

likely to be many. In that case, the cure to the problem of latent heterogeneity leaves an econometric model which is unable to answer many of the questions we started out with. Nor, for that matter, is it obviously plausible that the heterogeneity in individual effects on growth rates would in fact be time invariant; common macroeconomic and geo-climatic conditions might well entail that the individual effects vary from year to year.

This paper proposes an estimable microeconometric model of consumption growth which can identify underlying (including time-invariant) geographic effects while at the same time allowing for latent heterogeneity in household-level growth rates. We are able to test whether consumption growth rates at the farm-household level vary spatially after controlling for both observed and unobserved heterogeneity at the household level.

Our theoretical model extends the Cass-Koopmans-Ramsey model of optimal consumption growth in a straightforward way to allow geographic effects on the marginal product of own capital, analogous to the role of knowledge externalities in the models of Romer (1986) and Lucas (1988). Our econometric model uses longitudinal observations of growth rates at the micro level collated with other micro and geographic data. The model allows individual effects with nonstationary impacts, following a specification proposed by Holtz-Eakin, Newey and Rosen (1988). Our model allows us to simultaneously deal with latent heterogeneity in growth rates (correlated with both the geographic and non-geographic variables), while still being able to retrieve estimates of the effects of time-invariant geographic capital on subsequent consumption growth at the household level. We believe that the methodology proposed here for micro-growth empirics has potentially wide applications in understanding the processes whereby some individuals do so much better than others over time.

We implement the approach using data for rural areas of southern China over 1985-90. There is a widely held view amongst China scholars and observers that many of the poorer rural areas–typically in more remote inland provinces–have shared rather little in the country's overall economic growth since reforms began,[5] and there is supportive evidence of rising inter-regional inequality and divergence.[6] Anti-poverty policies in China since the mid-1980s have relied heavily on public investment in lagging "poor areas" (Leading Group, 1988; World Bank, 1992; Jalan and Ravallion, 1997b). This is also a setting in which there appears to be very little migration of entire households from one rural area to another; the limited migration that is observed is the export of labor surpluses, primarily to urban areas, and would only rarely entail that the whole household moves.[7] Thus we can abstract from the complications that arise in identifying geographic effects when location is endogenous.

The following section outlines our model of consumption growth. Section 3 describes our data while section 4 presents our results. Section 5 summarizes our conclusions.

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[5] For example: "As China's economic miracle continues to leave millions behind, more and more Chinese are expressing anger over the economic disparities between the flourishing provinces of China's coastal plain and the impoverished inland" (*New York Times*, Dec. 27, 1995, p.1.)

[6] Ravallion and Jalan (1996) provide evidence that counties with lower initial average wealth saw lower subsequent rates of consumption growth. We also find evidence of spatial externalities. However, our estimation method (following standard methods in the literature on cross-country growth empirics) did not exploit the panel nature of our data, did not allow for latent heterogeneity, and did not identify the specific aspects of geographic capital that matter to the divergence.

[7] There are various administrative and other restrictions on migration in China, including registration and residency requirements. For example, it appears to be rare for a rural worker who moves to an urban area to be allowed to enrol his or her children in the urban schools.

2 The micro model of consumption growth

To motivate our empirical work we extend the standard Cass-Koopmans-Ramsey model in a natural way to include production by the farm-household and allow geographic externalities in the production process. We then outline our econometric model and the estimation method.

2.1 Theoretical model

Analogously to the role of firm-specific knowledge and external (economy-wide) knowledge in the Romer (1986) model, we hypothesize that output of the farm household is a concave function of various privately-provided inputs, but that output also depends positively and non-separably on the level of geographic capital, as described by a vector of geographic variables representing physical and social characteristics of the area of residence.[8]

We make the standard assumption that the household maximizes the utility integral:

$$\int_0^\infty \frac{1}{1-\sigma} C(t)^{1-\sigma} e^{-\rho t} dt \qquad (1)$$

where σ is the intertemporal elasticity of substitution, C is consumption (the logarithm of which is denoted c), and ρ is the subjective rate of time preference. The household operates a farm which produces output by combining labor and own capital (which can be interpreted as a composite of land, physical capital and human capital) under constant returns to scale. However, the household's farm output also depends on a vector of geographic variables, G, reflecting

[8] The model outlined here can be extended to allow (inter alia) depreciation of capital and exogenous rates of technological progress and population growth, but it will preserve this feature.

external effects on own-production. Output per worker or person is $F(K, G)$ where K denotes capital per worker. Output can either be consumed or invested:

$$F[K(t), G(t)] = C(t) + K'(t) \quad (2)$$

The derivation of the optimal rate of consumption growth then follows standard methods for dynamic optimization, as outlined in an Addendum available from the authors. It can be shown that the optimal rate of consumption growth satisfies:

$$c'(t) = [F_K(K,G) - \rho]/\sigma \quad (3)$$

The key feature of this model for our purpose is that geographic externalities influence consumption growth rates at the farm-household level, through effects on the marginal product of own capital. The model permits values of G such that the optimal consumption growth rate is negative; given G, output gains from individually optimal investments are not sufficient to cover the discount rate and so consumption falls. Whether that is anything more than a theoretical possibility will be tested in the following sections.

There are other ways in which geographic effects on consumption growth might arise, not captured by the above model. For example, we could also allow geographic variables to influence utility at a given level of consumption, by making the substitution parameter and the discount rate functions of G. Or one might introduce borrowing constraints which differ from one area to another. While our empirical model will allow us to test for geographic effects on consumption growth at the micro level it will not allow us to identify the precise mechanism linking area characteristics to growth.

2.2 *Econometric model*

The theoretical model above motivates an empirical model in which the growth rate of household consumption depends on both its own capital and on geographic capital. To allow for differences in the quality and quantity of family labor (given that labor markets are thin in this setting) we let education and demographics influence the marginal product of own capital; these may also influence the rates of intertemporal substitution and/or time preference.

However, we also allow for aspects of own capital, and other shift parameters in utility and production functions, which one cannot hope to fully capture in the data available. So there is latent heterogeneity in consumption growth rates. Furthermore, it is possible that these omitted variables will be correlated with the geographic variables, leading to biases in OLS estimates of the parameters of interest.

We have a random sample of *N* households observed over *T* dates, where *T* is small and *N* is large. Our empirical specification is interpretable as a linearization of equation (3) giving:

$$\Delta c_{it} = \alpha + \boldsymbol{\beta x}_{it} + \xi z_i + \varepsilon_{it} \quad (i=1,2,..,N;\ t=3,..,T) \tag{4}$$

where Δc_{it} is the growth-rate of consumption of household *i* in time period *t*, x_{it} is a $(k \times 1)$ vector of time-varying explanatory (geographic and household) variables, z_i is a $(p \times 1)$ vector of exogenous time-invariant explanatory (geographic and household) variables, and ε_{it} is the error term. This is taken to include idiosyncratic effects on the marginal product of own capital and the rate of time preference, as well as measurement errors in the consumption growth rates.

In estimating equation (4), we assume that the error term ε_{it} consists of two components: an i.i.d. random component which is orthogonal to the regressors and serially uncorrelated, and a household-specific fixed effect correlated with the regressors. (The fixed effect which may also include unobserved geographic effects). The existence of economy-wide factors (including covariate shocks to agriculture) suggests that the impact of latent heterogeneity on growth rates need not be constant over time. For example, there may be a latent effect such that some farmers are more productive, but this matters more in a bad agricultural years than a good one. Thus we allow for nonstationarity in the impacts of the individual effects (Holtz-Eakin et al., (1988)):

$$\varepsilon_{it} = \theta_t \omega_i + u_{it} \tag{5}$$

where u_{it} is an i.i.d. random variable, orthogonal to the regressors, with mean 0 and variance σ^2_u, and ω_i is a time-invariant household fixed-effect, with mean 0 and variance σ^2_ω, and is not orthogonal to the regressors. This specification allows the latent heterogeneity to influence the fluctuations in average consumption growth rates over time as well as the trend at household level. If $\theta_t = \theta$ for all t, then the model is reduced to the standard fixed effects model. The following assumptions are made about the error structure:

$$E(\omega_i x_{it}) \neq 0,\ E(\omega_i z_i) \neq 0,\ E(\omega_i u_{it}) = 0,\ E(x_{it} u_{it}) = 0,\ E(z_i u_{it}) = 0\ \forall\ i, t \tag{6}$$

The composite error term ε_{it} in (5) is clearly not orthogonal to the regressors. Thus, estimating equation (4) by OLS will give inconsistent parameter estimates.

In standard panel data models, the "nuisance" variable ω_i is eliminated by estimating the model in first differences or by taking time-mean deviations (when there are no lagged dependent variables in the model).[9] However, given the temporal pattern of the effect of ω_i on Δc_{it}, we cannot use these standard transformations to eliminate the fixed effect. We use quasi-differencing techniques, as suggested by Holtz-Eakin et. al. (1988).[10] Lagging equation (4) by one period we get:

$$\Delta c_{it-1} = \alpha + \beta x_{it-1} + \xi z_i + \theta_{t-1}\omega_i + u_{it-1} \tag{7}$$

Define $r_t = \theta_t / \theta_{t-1}$. Premultiplying equation (7) by r_t and subtracting from equation (4) we get:

$$\Delta c_{it} = \alpha(1-r_t) + r_t \Delta c_{it-1} + \beta x_{it} - \beta r_t x_{it-1} + \xi(1-r_t)z_i + u_{it} - r_t u_{it-1} \quad (t=3,..,T) \tag{8}$$

The error term, $u_{it} - r_t u_{it-1}$ is by construction orthogonal to x_{it} and z_i, although it is not orthogonal to Δc_{it-1}. One can however estimate equation (8) by Generalized Method of Moments (GMM) using log consumptions lagged twice (or higher) as instruments for $\Delta c_{i\,t-1}$. Such instruments will be uncorrelated with $u_{it} - r_t u_{it-1}$, given that the u_{it}'s are assumed to be serially uncorrelated. The Appendix provides a more complete exposition of the estimation method.

An important advantage of this approach over the standard fixed effects specification is that the coefficients of the time-invariant regressors ξ are identified by relaxing the cross-equation restrictions that the coefficients on the time-invariant variables must be constant over time. Thus the estimation method simultaneously allows us to control for latent heterogeneity

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[9] An alternative estimation method is the dynamic random effects estimator as suggested by Bhargava and Sargan (1982). However, in this method we have to assume that at least some of the time-varying variables are uncorrelated with the unobserved individual specific effect.

[10] Also see Ahn and Schmidt (1994) for an alternative quasi-differencing transformation.

and to identify impacts of time invariant factors, including many geographic variables. This general specification can be tested against the restriction that $\theta_t = \theta$ for all t.

3 Data

The farm-household level data were obtained from China's Rural Household Survey (RHS) done by the State Statistical Bureau (SSB). A panel of 5,600 farm households over the six-year period 1985-90 was formed for four contiguous provinces in southern China, namely Guangdong, Guangxi, Guizhou, and Yunnan. The latter three provinces form south-west China, widely regarded as one of the poorest regions in the country. Guangdong on the other hand, is a relatively prosperous coastal region (surrounding Hong Kong). In 1990, 37%, 42% and 34% of the populations of Guangxi, Guizhou and Yunnan, respectively, fell below an absolute poverty line which only 5% of the population of Guangdong could not afford (Chen and Ravallion, 1996). Also the south-west appears to have shared little in China's national growth in the 1980s. For the full sample over 1985-90, consumption per person grew at an average rate of only 0.70% per annum; for Guangdong, however, the rate of growth was 3.32% (Table 1). Between 1985 and 1990, 54% of the sampled households saw their consumption per capita increase while the rest experienced decline. If we confine our attention to Guangdong only, then we find that 68% saw rising consumptions over the period.

The data appear to be of good quality. Since 1984 the RHS has been a well-designed and executed survey of a random sample drawn from a sample frame spanning rural China (including small-medium towns), and with unusual effort made to reduce non-sampling errors (Chen and Ravallion, 1996). Sampled households fill in a daily diary on expenditures and are visited on average every two weeks by an interviewer to check the diaries, and collect other data. There is also an elaborate system of cross-checking at the local level. The consumption data from such an intensive survey process are almost certainly more reliable than those obtained by the common cross-sectional surveys in which the consumption data are based on recall at a single interview. For the six year period 1985-90 the survey was also longitudinal, returning to the same households over time. While this was done for administrative convenience (since local SSB offices were set up in each sampled county), the panel can still be formed.[11]

The consumption measure includes imputed values for consumption from own production valued at local market prices, and it an imputed value of the consumption streams from the inventory of consumer durables (Chen and Ravallion, 1996). Poverty lines designed to represent the cost at each year and in each province of a fixed standard of living were used as deflators. These were based on a normative food bundle set by SSB, which assures that average nutritional requirements are met with a diet which is consistent with Chinese tastes; this is valued at province-specific prices. The food component of the poverty line is augmented with an allowance for non-food goods, consistent with the non-food spending of those households whose food spending is no more than adequate to afford the food component of the poverty line.[12]

The household level data were collated with geographic data pertaining to three levels: the village, the county, and the province. At the village level, we have data on topography

[11] Constructing the panel from the annual RHS survey data proved to be more difficult than expected since the identifiers could not be relied upon. Fortunately, virtually ideal matching variables were available in the financial records, which gave both beginning and end of year balances. The relatively few ties by these criteria could easily be broken using demographic data.

[12] For further details on the poverty lines see Chen and Ravallion (1996).

(whether the village is on plains, or in hills or mountains, and whether or not it is in a coastal area), urbanization (whether it is a rural or suburban area), ethnicity (whether it is a minority group village), whether or not it is considered a border area (three of the four provinces are at China's external border), and whether or not the village is in a revolutionary base area (those areas where the Communist Party had firmly established its bases prior to 1949). At the county level we have a much larger data base drawn from China's County Administrative Records, from China's Rural county statistical year books for 1985-90, and from the 1982 Census.[13] These cover agriculture (irrigated area, fertilizer usage, agricultural machinery in use), population density, average education levels, rural non-farm enterprises, road density, health indicators, and schooling indicators. At the province level, we simply include dummy variables for the province. All nominal values are normalized by 1985 prices.

The survey data also allow us to measure a number of household characteristics. A composite measure of household wealth can be constructed, comprising valuations of all fixed productive assets, cash, deposits, housing, grain stock, and consumer durables. We also have data on agricultural inputs used, including landholding, and on the size and demographic compositions of the households, and levels of schooling.

[13] While the county administrative records and the county yearbooks cover rural areas separately, the census county data does not distinguish between the rural and urban areas. However, given that the objective of including the county characteristics is to proxy for the initial level of progress in a particular county relative to another, the aggregate county indicators should be reliable indicators for the differences in socio-economic conditions across the counties.

4 Results

We begin with a simple specification in which the only explanatory variables are initial value of wealth per capita, both at household and county levels. This model is too simple to be believed, but it will help as an expository device for understanding a richer model later.

4.1 A simple expository model

Suppose that the only two variables that matter to the consumption growth rate are initial household wealth per capita (*HW*) and mean wealth per capita in the county of residence (*CW*). The growth model becomes:

$$\Delta c_{it} = \alpha(1-r_t) + r_t \Delta c_{it-1} + \xi^c (1-r_t) \ln CW_t + \xi^h (1-r_t) \ln HW_t + residual_{it} \tag{9}$$

In interpreting this equation, it is useful to re-write it in the form:

$$\Delta c_{it} = r_t \Delta c_{it-1} + (1-r_t) g(HW_t, CW_t) + residual_{it} \tag{10}$$

where

$$g(HW_t, CW_t) \equiv \alpha + \xi^c \ln CW_t + \xi^h \ln HW_t$$

is interpretable as the balanced growth path implicit in (9).

The GMM estimate of this model gives r_t values of 0.293, 0.258, 0.130, and 0.253 for 1987 to 1990 respectively. Using standard errors which are robust to any cross-sectional heteroscedasticity that might be present in the data, the corresponding t-ratios are 7.76, 7.95, 4.31, and 5.59. The estimated equation for the balanced growth rate is (t-ratios in parentheses, also based on robust standard errors):

$$g(HW, CW) = \underset{(5.61)}{-0.143} - \underset{(5.91)}{0.0166} lnHW + \underset{(8.13)}{0.0378} lnCW \qquad (11)$$

which is interpretable as the estimate of equation (3) implied by this specification, where *HW* is interpreted as a measure of *K* and *CW* as a measure of *G*.

Thus we find that consumption growth rates at the farm-household level are a decreasing function of own wealth, and an increasing function of average wealth in the county of residence, controlling for latent heterogeneity. We can interpret equation (11) in terms of the model in section 2.1. The time preference rate and elasticity of substitution are not identified. Nonetheless, given that the substitution parameter is positive, we can infer from equation (11) that the marginal product of own capital is decreasing with respect to own capital, but increasing with respect to geographic capital. However, there are other possible interpretations; for example, credit might well be attracted to richer areas, or discount rates might be lower.

Notice that the sum of the coefficients on *lnCW* and *lnHW* in (11) is positive. Thus, on averaging (11) over all households in a given county, we will find aggregate divergence; counties with higher initial wealth will tend to see higher subsequent average growth rates. However, this is due entirely to geographic externalities, rather than increasing returns to own wealth at the farm-household level.

4.2 A richer model

While the above specification is useful for expository purposes, we now want to extend the model by adding a richer set of both geographic and household level variables. Table 1 gives the descriptive statistics of the explanatory variables to be used in an extended specification.

Table 2 reports our GMM estimates of the extended model for both the sample as a whole and for Guangdong on its own. Again the conventional fixed effects model is firmly rejected in favor of the specification with time-varying coefficients.[14] This also means that we can estimate the impacts of the time-invariant geographic (and non-geographic) variables.

Our model also includes time-varying household variables, and one time-varying geographic (county-level) variable (Table 1). The question arises as to whether to treat these variables as exogenous or endogenous. We estimated a model where both the county and the household variables were assumed to be exogenous (base model). Next we estimated two alternative models: one where we assumed the county variables to be exogenous, but the time-varying household variables to be endogenous, and another where we assumed the time-varying county variable to be endogenous and the household variables to be exogenous. In both cases, we used lagged values as instruments. We then constructed likelihood ratio tests (Hall, 1993; Ogaki, 1993) to test the base model against these two models. The base model was summarily rejected in favor of the model where the time-varying household variables were endogenous, though the base model was accepted when tested against the model where the county variable was endogenous (and the household variables exogenous). Given these test results, Table 2 reports estimates where the time-varying household variables are treated as endogenous and the county variable as exogenous. All the time-invariant variables—county and household—are treated as exogenous. The likelihood ratio test gave similar results when we estimated the model

[14] Wald tests of the null hypothesis that each value of r_t is unity gave Chi-square values of 1245, 662, 1120 and 157 for 1987-1990; the joint test that all four equal unity gave 3888.46

for the households in Guangdong only.

Many of the geographic variables are significant, though not always the same variables for Guangdong as for the sample as a whole. Looking first at the results for the sample as a whole, we find that living in a revolutionary base area entails a higher growth rate than one would have otherwise expected. This suggests favorable treatment to these (historically significant) areas by the center. While living in a coastal area has no significant effect controlling for other factors, living in a village in a mountainous area has a sizable and significant negative effect (a 0.9 percentage point lower annual growth rate), and living on the plains entails a significantly higher growth rate ("hills" is the left out category). These results are consistent with better natural conditions for agriculture in the plains than mountains. Both of the geographic variables which relate to the extent of modernization in agriculture (farm machinery usage per capita and fertilizer usage per acre) have highly significant positive impacts on individual consumption growth rates. However, land under cultivation per capita does not. There is no significant effect of population density. Nor is there any sign that household consumption growth rates tend to be significantly higher in areas with higher proportions of literate adults.[15] The two health-related variables (infant mortality rate and medical personnel per capita) indicate that consumption growth rates at the farm-household level are significantly higher in generally healthier areas. A higher incidence of employment in non-farm commercial enterprises in a geographic area entails a higher growth rate at the household level for those living there. There is a highly significant positive effect of higher road density in an area on

[15] We do not have data on enrollment rates at different schooling levels in the county.

consumption growth. The proportion of population living in urban areas has no effect.

The quantitative magnitudes of these effects are not negligible. For example, a one standard deviation increase in farm machinery usage in an area adds 0.6 percentage points to the annual consumption growth rate holding all else constant; a one standard deviation increase in fertilizer usage adds 1.5 points; a one standard deviation increase in the density of medical personnel adds 0.5 (with presumably an additional impact via lower infant mortality), while a one standard deviation increase in rural road density adds 0.7 points.

The results are broadly similar for Guangdong, although some differences are notable. One expects some variables to become less significant due to the lack of variance within this one province. Unlike the sample as a whole, living in a revolutionary base area in Guangdong has no effect on the rate of consumption growth. Nor does living on the plains. Unlike the full sample, cultivated land per person is significant in Guangdong.[16] Fertilizer usage is not. Population density emerges as a significant factor (possibly through an effect on local demand for non-farm goods and services, although it may also be picking up a tendency for other infrastructure variables to be better endowed in denser areas.) Infant mortality drops out in Guangdong, probably due to the lack of variance. However, access to medical personnel becomes even more significant. Road density also drops out if we confine attention to Guangdong.

Consistent with the simpler model we started with, there is a clear tendency amongst these geographic variables for their effects to be either neutral or "divergent", in that households have higher consumption growth rates in better endowed areas. This suggests that these

[16] While the relatively low inequality in landholding may make it hard to identify this effect in the sample as a whole, it is notable that the variance in landholding is higher in Guangdong (Table 1).

geographic characteristics tend to increase the marginal product of own capital.

This is in marked contrast to the household-level variables. In addition to allowing for latent farm-household level effects on consumption growth, we included a number of household level characteristics related to land and both physical and human capital endowments. These effects tend to be convergent. Again focusing initially on the full-sample results, we find that farm-households with higher expenditure on agricultural inputs per unit land area (an indicator of the capital intensity of agriculture) tended to have lower subsequent growth rates. Fixed productive assets per capita do not, however, emerge as significant; it may well be that the density of agricultural inputs is the better indicator of own-farm capital. Higher land per capita also results in a lower consumption growth rate.

Amongst the other household characteristics, there are a number of significant demographic variables; larger and younger households tend to have higher consumption growth rates. This may reflect the thinness of agricultural labor markets in rural China, so that demographics of the household influence the availability of labor for farm work. There is a life-cycle effect, with growth rates increasing with age of the household head up to 44 years, and decreasing after that. Higher literacy amongst adults does not have a significant effect, although the proportion of children with secondary education has a significantly positive effect, and this may be picking up effects of human capital.

Again there are some differences between results for the full sample and those for Guangdong. Fewer household demographic variables are significant in Guangdong, which suggests better-developed labor markets in rural areas of that province, which is plausible. There is a negative effect of higher incidence of primary school education in Guangdong, although the left out category for this variable is all households with more than primary school education. So, the result should be interpreted as saying that all households with primary school education saw a drop in their consumption growth rates, compared to households with more than primary school education. Besides this variable, the only other household variable which has a significant impact on the consumption growth rate is the proportion of kids in the age-group 6-11 years.

4.3 *Do spatial poverty traps occur within the bounds of the data?*

The above results are consistent with spatial poverty traps. But do such traps actually occur within the bounds of these data? In terms of the theoretical model in section 2.1, while one might find that higher endowments of geographic capital raise the marginal product of own capital at the farm-household level, it may still be the case that no area has so little geographic capital as to entail falling consumption i.e., the marginal product of own capital in "poor areas" may still exceed the discount rate.

To address this issue, consider first our simple expository model in section 4.1. The poverty trap level of county wealth can be defined as CW^* such that $g(HW, CW^*) = 0$ for given HW. The sample mean of $lnHW$ is 6.502 (with a standard deviation of 0.607). Then it is readily verified from equation (11) that $lnCW^* = 6.64$, which is roughly mean log wealth. So if we consider two households with mean personal wealth, one living in a county with slightly above average wealth, the other in one with below average wealth, then our results imply that the former household will see its consumption rising, while it will be falling for the latter. Spatial poverty traps are clearly well within the bounds of these data.

Following the same approach, we can ask the same question for the richer model. We calculate the critical value of each geographic variable at which consumption growth is zero while holding all other (geographic and non-geographic) variables constant at their sample mean values. The critical values implied by our results are given in Table 3. We find, for example, that positive growth in consumption requires that the density of roads exceeds 8.9 square kilometers per 10,000 people (with all other variables evaluated at mean points). In all cases, the critical value at which the spatial poverty trap arises is within one standard deviation of the sample mean for that characteristic.

5 Conclusions

Mapping poverty and its correlates could well be far more than a descriptive tool–it may also hold the key to understanding why poverty persists in some areas, even with robust aggregate growth. That conjecture is the essence of the theoretical idea of a spatial poverty trap. But are such traps of any empirical significance?

Aggregate growth empirics cannot answer that question, since aggregation confounds the external effects that create spatial poverty traps with purely internal effects. And, without controlling for latent heterogeneity in the micro growth process, it is hard to accept any test for spatial poverty traps based on micro panel data. In a regression for consumption growth at the household level, significant coefficients on geographic variables may simply pick up the effects of omitted spatially-autocorrelated household characteristics. Yet the standard treatments for fixed effects in micro panel-data models make it impossible to identify the impacts of the many time-invariant geographic factors that one might readily postulate as leading to spatial poverty traps. Given the potential policy significance of poverty traps, it is worth searching for a convincing method to test for them.

We have offered a test. This involves regressing consumption growth at the household level on geographic variables, allowing for nonstationary individual effects in the growth rates. By relaxing the restriction that the individual effects have the same impacts at all dates, the resulting dynamic panel-data model of consumption growth allows us to identify external effects of fixed or slowly changing geographic variables. The model can be estimated by the Generalized Method of Moments.

On implementing the test on farm-household panel data for rural areas of southern China, we find strong evidence that a number of indicators of geographic capital have divergent impacts on consumption growth at the micro level, controlling for (observed and unobserved) household characteristics. The main interpretation we offer for this finding is that living in a poor area lowers the productivity of a farm-household's own investments, although we note other possible explanations such as geographic differences in access to credit or in preferences.

The geographic effects we find are strong enough to yield spatial poverty traps. Our results suggest that there are areas in this part of rural China which are so poor that the consumptions of some households living in them will be falling even while otherwise identical households living in better off areas enjoy rising consumptions. By interpretation, equilibrium growth paths in poor areas entail that the marginal products of own capital for at least some farm households living there are lower than their discount rates.

What geographic characteristics create such spatial poverty traps? We find that there are publicly provided goods in this setting, such as rural roads, which generate non-negligible gains in living standards. We also find, however, that the aspects of geographic capital relevant to consumption growth embrace both private and publicly provided goods and services. Private investments in agriculture, for example, entail external benefits within an area, as do "mixed" goods (involving both private and public provisioning), such as health care. The prospects for growth in poor areas will then depend on the ability of governments and community organizations to overcome the tendency for under-investment that such geographic externalities are likely to generate.

Appendix: GMM estimation of the micro growth model

The estimation procedure entails stacking the equations in (8) to form a cross-section system, with one equation for each year. For T=6, the system of equations to be estimated is as follows:

$$\begin{aligned} q_3(\Delta c_{i3}, x_{i3}, z_i, b_3) &= \bar{u}_{i3} \\ q_4(\Delta c_{i4}, x_{i4}, z_i, b_4) &= \bar{u}_{i4} \\ q_5(\Delta c_{i5}, x_{i5}, z_i, b_5) &= \bar{u}_{i5} \\ q_6(\Delta c_{i6}, x_{i6}, z_i, b_6) &= \bar{u}_{i6} \end{aligned} \qquad \text{(A1)}$$

In these equations, $\bar{u}_{it}$ (t=3,4,5,6) is the error term u_{it}-$r_t u_{it-1}$, x_{it} is the vector of time-varying explanatory variables, z_i the vector of time invariant variables, and $b_t = [\alpha, \beta, \xi, \gamma, r_t]$ is the parameter vector. Note that not all the ***b***'s vary with time, implying certain cross-equation restrictions on the parameters. It is convenient to write the model in the compact form:

$$q(\Delta c_i, x_i, z_i, b) = \bar{u}_i \qquad \text{(A2)}$$

where $\bar{u}_i = [\bar{u}_{i3}, \bar{u}_{i4}, \bar{u}_{i5}, \bar{u}_{i6}]'$.

The GMM procedure estimates the parameters b_t by minimizing the criterion function:

$$Q_{NT}(b) = g_N(b)' A_N^{-1} g_N(b) \qquad \text{(A3)}$$

where the $(r \times r)$ weighting matrix A_N is positive definite, and where the $(r \times 1)$ vector of sample orthogonality conditions is given by:

$$g_N(b) = [\sum_{i=1}^{N} w_i' q\,(\Delta c_i, x_i, z_i, b)] \tag{A4}$$

where w_i is a *(1 x p)* vector of *p* instruments. Heteroscedasticity is likely to exist across the cross-sections. We use White's approach to correct for this. The optimal weighting matrix is thus the inverse of the asymptotic covariance matrix:

$$A_N = [\sum_{i=1}^{N} w_i \hat{u}_i \hat{u}_i' w_i'] \tag{A5}$$

where $\hat{u}_i$ is the vector of the estimated residuals. These GMM estimates yield parameter estimates that are robust to heteroscedasticity.

The first-order conditions of minimizing equation $Q_{NT}(b)$ imply that $\hat{b}$ is the solution to:

$$G_N(\hat{b})' A_N^{-1} g_N(\hat{b}) = 0 \tag{A6}$$

where $G_N(\hat{b})$ is the *(r x q)* matrix with its *(i, j)*'th element $G_N(\hat{b})_{ij} = \partial g_{ni}(b) / \partial b_j$ and $g_{ni}(b)$ is the *i*'th element of $g_N(b)$. $G_N(\hat{b})$ is assumed to be of full rank. However, given the nonlinearity in the criterion function, equation (A6) does not provide us with an explicit solution. We must use a numerical optimization routine to solve for $\hat{b}$. All the computations can be done using (say) EVIEWS Version 2.0.

References

Azariadis, Costas, 1996, "The Economics of Poverty Traps. Part One: Complete Markets", *Journal of Economic Growth*, 1: 449-486.

Barro, Robert J., and Xavier Sala-i-Martin, 1992, "Convergence", *Journal of Political Economy*, 100: 223-252.

Borjas, George, 1995, "Ethnicity, Neighborhoods, and Human Capital Externalities", *American Economic Review* 85: 365-380.

Chen, Shaohua and Martin Ravallion, 1996, "Data in Transition: Assessing Rural Living Standards in Southern China", *China Economic Review*, 7: 23-56.

Hall, A. (1993), "Some Aspects of Generalized Method of Moments Estimation", in G. S. Maddala, C. R. Rao, and H. D. Vinod (eds) *Handbook of Statistics, Volume 11*, North-Holland.

Holtz-Eakin, D., W. Newey and H. Rosen, 1988, "Estimating Vector Autoregressions with Panel Data", *Econometrica*, 56: 1371-1395.

Jalan, Jyotsna and Martin Ravallion, 1997a, "Transient and Chronic Poverty in Rural China: A Semiparametric Estimation", mimeo, Development Research Group, World Bank.

__________ and ____________, 1997b, "Are There Dynamic Gains from a Poor-Area Development Program?", *Journal of Public Economics*, in press.

Leading Group, 1988, *Outlines of Economic Development in China's Poor Areas*, Office of the Leading Group of Economic Development in Poor Areas Under the State Council, Agricultural Publishing House, Beijing.

Lucas, Robert E. (1988), "On the Mechanics of Economic Development", *Journal of Monetary*

Economics, 12, 3-42.

Ogaki, M. (1993), "Generalized Method of Moments: Econometric Applications", in G. S. Maddala, C. R. Rao, and H. D. Vinod (eds) *Handbook of Statistics, Volume 11*, North-Holland.

Ravallion, Martin, 1997, "Poor Areas", in Giles, David and Aman Ullah (eds) *Handbook of Applied Economic Statistics*, New York: Marcel Dekkar (in press).

Ravallion, Martin and Jyotsna Jalan, 1996, "Growth Divergence due to Spatial Externalities", *Economics Letters*, 53(2): 227-232.

Romer, Paul M., 1986, "Increasing Returns and Long-Run Growth", *Journal of Political Economy,* 94: 1002-1037.

World Bank, 1992, *China: Strategies for Reducing Poverty in the 1990s*, World Bank, Washington DC.

Table 1: Descriptive statistics

Variable	Full sample		Guangdong	
	Mean	Standard deviation	Mean	Standard deviation
Dependent variable				
Average % growth rate of consumption, 1986-90	0.7004	28.5290	3.3235	27.9164
Geographic variables				
Proportion of sample in Guangdong	0.2286	0.4199	-	-
Proportion of sample in Guizhou	0.2442	0.4296	-	-
Proportion of sample in Yunnan	0.2029	0.4021	-	-
Proportion of sample living in a revolutionary base area (see text)	0.0259	0.1587	0.0946	0.2926
Proportion of counties which shares a border with a foreign country	0.1547	0.3616	-	-
Proportion of villages which are located on the coast	0.0307	0.1724	0.1318	0.3383
Proportion of villages in which there is a concentration of ethnic minorities	0.2562	0.4365	-	-
Proportion of villages which have a mountainous terrain	0.4415	0.4966	0.2326	0.4225
Proportion of villages which are located in the plains	0.2171	0.4122	0.3163	0.4651
Fertilizers used per cultiv. area (tonnes per sq.km)	11.8959	6.4937	19.0845	6.4849
Farm machinery used per capita (horsepower)*	158.5453	151.2195	198.9797	239.2853
Cultivated area per 10,000 persons (sq km)	13.0603	3.2622	12.6063	4.6081
Population density (log)	8.2264	0.3786	8.5090	0.4704
Proportion of illiterates in the 15^+ population (%)	34.8417	15.8343	23.1204	9.6244
Infant mortality rate (per 1,000 live births)	40.4600	23.3683	18.5147	8.5448
Medical personnel per 10,000 persons	8.0576	5.0205	11.3310	5.3009
Pop. employed in commercial (non-farm) enterprises (per 10,000 persons)	117.8102	68.8162	191.4500	96.8070
Square kilometers of roads per 10,000 persons	14.1900	10.4020	11.0930	6.0409
Proportion of population living in the urban areas	0.1018	0.0810	0.1430	0.0517

Variable	Full sample		Guangdong	
	Mean	Standard deviation	Mean	Standard deviation
Household level variables				
Expenditure on agricultural inputs (fertilizers & pesticides) per cultivated area (yuan per mu)*	30.4597	80.5274	60.8067	154.4674
Fixed productive assets per capita (yuan per capita)*	132.1354	217.5793	125.0693	256.0311
Cultivated land per capita (mu per capita)*	1.2294	1.1011	0.9882	0.6476
Household size (log)*	1.6894	0.3461	1.7027	0.3350
Age of the household head	42.1315	11.4225	43.6147	11.0557
Age^2 of the household head	1,905.5300	1,024.7320	2,024.4600	1,018.8200
Proportion of adults in the household who are illiterate	0.3230	0.2898	0.2163	0.2353
Proportion of adults in the household with primary school education	0.3819	0.3063	0.4210	0.2970
Proportion of kids in the household between ages 6-11 years	0.1173	0.1408	0.1101	0.1426
Proportion of kids in the household between ages 12-14 years	0.0836	0.1066	0.0763	0.1051
Proportion of kids in the household between ages 15-17 years	0.0698	0.1004	0.0740	0.1018
Proportion of kids with primary school education	0.2672	0.3642	0.2500	0.3581
Proportion of kids with secondary school education	0.0507	0.1757	0.0747	0.2227
Proportion of a household members working in the state sector	0.0436	0.2042	0.0558	0.2296
Proportion of 60^+ household members	0.0637	0.1218	0.0601	0.1055

Notes: * indicates that the variable is time-varying in the GMM model. 1 mu = 0.000667 km^2

Table 2: Estimates of the consumption growth model

	Full sample		Guangdong	
	Coeff. estimate	t-ratio	Coeff. estimate	t-ratio
Constant	-0.2820	-3.1625*	-1.3575	-5.8606*
Time-varying fixed effects				
r_{87}	0.0399	1.4653	0.1239	2.8878*
r_{88}	0.2269	7.5543*	0.1231	2.4650*
r_{89}	0.0981	3.6426*	0.2969	4.5375*
r_{90}	0.4871	11.8983*	0.2979	4.2699*
Geographic variables				
Guangdong (dummy)	0.0040	0.7323	-	-
Guizhou (dummy)	0.0226	4.2838*	-	-
Yunnan (dummy)	-0.0035	-0.5749	-	-
Revolutionary base area (dummy)	0.0256	2.7725*	-0.0118	-1.1250
Border area (dummy)	-0.0015	-0.3318	-	-
Coastal area (dummy)	-0.0132	-1.5117	0.0024	0.2771
Minority area (dummy)	-0.0034	-0.9705	-	-
Mountainous area (dummy)	-0.0090	-2.5859*	-0.0204	-2.6576*
Plains (dummy)	0.0105	2.7136*	-0.0079	-1.1120
Farm machinery usage per capita (x1000)	0.0420	3.4328*	0.0597	3.9327*
Cultivated area per 10,000 persons	0.0013	1.5013	0.0109	4.8882*
Fertilizer used per cultivated area	0.0023	4.5678*	0.0002	0.2615
Population density (log)	0.0160	1.6949	0.1308	5.8433*
Proportion of illiterates in 15^{+} population (x100)	0.0159	0.9000	0.0467	1.2352
Infant mortality rate (x100)	-0.0313	-2.5295*	-0.0422	-0.8071
Medical personnel per capita	0.0011	3.6882*	0.0054	8.2851*
Prop. of pop. empl. nonfarm commerce (x100)	0.0067	2.1156*	0.0130	2.4340*
Square kilometers of roads per capita (x100)	0.0741	4.3033*	0.0849	1.3341
Prop. of population living in the urban areas	-0.0228	-1.0254	-0.3080	-3.3753*

	Full sample		Guangdong	
	Coeff. estimate	t-ratio	Coeff. estimate	t-ratio
Household level variables				
Expenditure on agricultural inputs per cultivated area (x100)	-0.1193	-5.6113*	-0.0171	-1.6459
Fixed productive assets per capita (x 1000)	0.0042	0.3048	0.0324	1.4772
Cultivated land per capita	-0.0151	-2.6279*	-0.0149	-1.4027
Household size (log)	0.0473	6.9675*	0.0334	2.6298*
Age of the household head (x 100)	0.2324	2.8321*	0.0357	0.2121
Age^2 of the household head (x 100)	-0.0026	-2.9200*	-0.0001	-0.0629
Proportion of adults in the household who are illiterate	0.0079	1.2696	-0.0069	-0.5126
Prop. of adults in the h'hold with primary school education	-0.0040	-0.7948	-0.0207	-2.2251*
Prop. of kids in the household between ages 6-11 years	0.0330	3.4658*	0.0450	2.4429*
Prop. of kids in the h'hold between ages 12-14 years	0.0421	3.1405*	0.0458	1.8187
Prop. of kids in the h'hold between ages 15-17 years	0.0096	0.6185	0.0136	0.4990
Proportion of kids with primary school education (x 100)	-0.4348	-1.0644	-0.0041	-0.0047
Proportion of kids with secondary school education	0.0209	2.4275*	0.0090	0.6972
Whether a household member works in the state sector (dummy)	-0.0132	-1.8790	-0.0150	-1.3721
Proportion of 60^+ household members	0.0189	1.5487	-0.0205	-0. 6738

Notes: *: indicates significant at 5% level or better

Table 3: Critical values for a spatial poverty trap

Geographic variables	Full sample: Critical values to avoid spatial poverty traps	Full sample: Sample mean (standard deviation in parentheses)	Guangdong: Critical values to avoid spatial poverty traps	Guangdong: Sample mean (standard deviation in parentheses)
Cultivated area per 10,000 persons (sq km.)	-	-	12.3861	12.606 (4.608)
Fertilizers used per cultivated area (tonnes per sq km)	10.1650	11.896 (6.494)	-	-
Farm machinery used per capita (horsepower)	65.6550	158.545 (151.220)	158.6500	198.980 (239.285)
Population density (log)	-	-	8.4906	8.509 (0.470)
Infant mortality rate (per 1,000 live births)	52.9245*	40.460 (23.368)	-	-
Medical personnel per 10,000 persons	4.4783	8.058 (5.020)	10.8852	11.331 (5.301)
Population employed in commercial (non-farm) enterprises (per 10,000 persons)	59.3186	117.810 (68.816)	172.9294	191.450 (96.807)
Square kilometers of roads per 10,000 persons	8.9250	14.190 (10.402)	-	-
Proportion of population living in urban areas	-	-	0.1508*	0.143 (0.052)

Notes: A spatial poverty trap will exist if the observed value for any county is less than the critical values given above; for those marked * the observed value cannot exceed the critical value if a poverty trap is to be avoided. Critical values are only reported if the relevant coefficient from Table 2 is significantly different from zero. All the critical values reported above are significantly different from zero (based on a Wald-type test) at the 5% level or better.

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