Sectoral Growth Linkages and the Role of Infrastructure Development: Revisiting the sources of nonfarm development in the rural Philippines

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Sectoral Growth Linkages and the Role of Infrastructure Development: Revisiting the sources of nonfarm development in the rural Philippines*

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Abstract:

This paper analyzes the sources of rural non-farm sector growth in the Philippines, which has become the main driver of rural poverty reduction. We find that agricultural growth has significantly positive effects on service sector growth (with elasticity of about 0.20) but little effects on manufacturing growth, suggesting that rural labor force is sufficiently mobile or capital is relatively immobile across provinces. We also identify different roles played by national road networks, on the one hand, and local roads, on the other. We find that local road facilitates rural service sector development while national road facilitates agricultural growth.

Key words: sectoral linkages; nonfarm growth; agricultural development; road infrastructure; Philippines

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1. Introduction

The main aim of this paper is to analyze the sources of rural non-farm sector growth, which has been recognized as a main driver of rural poverty reduction in the Philippines as well as in other parts of Asia. In particular, we revisit the issue of linkage effects between agricultural and non-farm growth and the role of infrastructure in rural development.

It has been well recognized that 'structural transformation' is a key to rapid poverty reduction in rural areas in Asia (e.g., Timmer and Akkus, 2008). In the Philippines, the structural transformation progressed in the past few decades with increasing diversification in rural economies. The share of agricultural GDP declined from 30% in 1970 down to 14% in 2006 while that of services increased from 39% to 54%. An increasing number of micro-level studies (based on household-level panel data) on poverty dynamics in the rural Philippines argue that non-agricultural growth has increasingly played a crucial role in reducing rural poverty, in part due to the increase in the relative returns to human capital vis-à-vis agricultural land over the past few decades (e.g., Hayami and Kikuchi 2000; Hossain, Gascon and Marciano 2000; Estudillo, Sawada and Otsuka 2007; Fuwa 2007). How non-farm development can be facilitated, however, is not fully understood and potentially debatable. This paper focuses on the potential sources of rural non-farm development in the Philippines. In analyzing the potential sources of non-farm growth, we take into account both direct effects through investments in infrastructure development and in human capital and indirect linkage effects through agricultural growth.

In the course of our analysis, there are two conventional wisdoms that we intend to revisit. One is the positive growth linkages between agricultural growth and non-agricultural sector growth, *a la* Jonston and Mellor (1961). While this view has been widely accepted for quite some time now, relatively more recent theoretical work has raised the possibility that the relationship between agricultural and non-agricultural growth could potentially be either positive (complementary) or negative (substitutive). The theoretical model developed by Matsuyama (1992), for example, demonstrated how the positive effects of agricultural productivity growth on industrialization depend on the assumption of a closed economy (while the opposite results are possible under an open economy assumption). The theoretical model developed by Foster and Rosenzweig (2008) similarly demonstrates that, at sub-national levels, much of how incomes of different sectors evolve (or, how growth in one sector affects growth in another) is ambiguous, depending on the tradability of the goods produced by each sector, the degree of mobility in factors of production—especially labor and capital—across sectors and across geographical locations, and the extent of income transfers between rural and urban households. The theoretical work thus suggests that the question of whether agricultural sector growth and non-farm income growth are "complements" (meaning, positively related) or "substitutes" (negatively related) is largely an empirical issue that needs to be carefully examined in individual country contexts. An empirical analysis by Foster and Rosenzweig (2004) finds, for example, that the productivity growth in agriculture and nonagricultural income growth were "substitutes," rather than "complements," in rural India over the period between 1971 and 1990. In other empirical studies, the importance of rural infrastructure (Balisacan and Fuwa 2004, Hazell and Haggblade 1990) as well as certain spatial characteristics (Deichman et al. 2008) is also emphasized in enhancing growth linkages.

Another conventional wisdom is thus that infrastructure development positively affects rural non-farm development. While this appears to be a reasonable proposition in general, in the case of road infrastructure, it appears to us that more careful analysis is required. Policy makers with limited budget, for example, need to allocate resources efficiently between national road networks, on the one hand, and local roads on the other. Furthermore, investing in road networks may potentially have both positive (through better access to markets for locally produced goods) and negative (through competition with imported goods and better access to urban migration) effects on rural non-farm and farm growth, and their net effects are not obvious. It is possible, for example, that the role of national road networks and local roads (connecting rural communities to national roads) may have differential roles to play. This paper makes an attempt for such disaggregated analysis of the impact of road infrastructure on rural non-farm development in the Philippine context.

The rest of the paper is organized as follows. Section 2 describes the dataset used and the econometric specification employed in this study. Section 3 presents the main empirical results, followed by, in Section 4, some additional robustness checks based on alternative econometric specifications. The final section concludes.

2. Data and Empirical Specifications

Our main data source comes from the Family Income and Expenditure Surveys (FIES) conducted in every three years. FIES contains both total household incomes by sources as well as total household consumption expenditures. In order to analyze poverty dynamics covering the entire country, in the analysis that follows, household level data are aggregated into the provincial level (73 provinces, excluding Metro Manila) to form a panel with observation points in every three years (i.e., 1991, 1994, 1997, 2000, 2003 and 2006). [2] For each household, reported incomes from different sources are aggregated into agricultural and non-agricultural incomes. Those incomes from agricultural and non-agricultural sources are then aggregated into provincial averages, which constitute the unit of analysis. Provincial income and consumption expenditure data are then deflated using provincial cost of living indexes.[3]

Table 1 classifies the 73 provinces in terms of the change in poverty incidence and of the change in the share of agricultural incomes between 1991 and 2006. During this period, poverty incidence declined in 62 out of 73 provinces. In most (58) of the 62 provinces where poverty incidence fell, non-agricultural incomes grew faster than did agricultural

[2] While FIES data are, in fact, available in every 3 years starting 1985, due to the substantially smaller sample sizes prior to the 1991 FIES, the 1985 and 1988 rounds of FIES were excluded from this analysis.

[3] One difficulty in using the FIES income data to obtain sectoral incomes is that the existence of the unearned income category (including domestic and foreign transfers, rents, etc.) makes the interpretation of sectoral incomes somewhat ambiguous. Ideally, the unearned incomes should be assigned to the sectors where they originate (e.g., the rental income from land comes from the agricultural sector), but FIES data do not provide sufficient information for such classification. As a result, we had to categorize unearned incomes as non-agricultural income sources. One consequence of this would be that, when the total household income is disaggregated between the agricultural and non-agricultural incomes (including unearned incomes), the share of agricultural income is likely to be underestimated (since this calculation implicitly assumes that all the unearned incomes come from either secondary or tertiary sectors). Since our panel analyses mainly rely on variations within provinces overtime, rather than the levels of sectoral incomes, the existence of a systematic underestimation of the level of agricultural income would not appear to suggest particular directions of bias. If there is a tendency for the share of agricultural sector incomes to decline within the category of unearned incomes, however, then arguably our methodology may overestimate the growth rate of agricultural income.

incomes. In addition, instead of using the long-term growth episode during 1991-2006, the 3 year intervals of the FIES survey data can be used to examine the set of 3 year episodes across 73 provinces during 1991 and 2006, and lead us to similar (though somewhat less dramatic) conclusions (Table 2). The headcount poverty ratio declined in a majority of the provincial 3-year growth spells (221 out of 365 province-growth spells), but it increased in 152 provincial growth spells. The growth rate in the non-agricultural income was higher in 235 out of 365 province-growth spells while that of the agricultural income was higher in 130 province-growth spells. The most common pattern, again, is the growth spell with poverty reduction and with faster growth in non-agricultural (than agricultural) incomes. The ratio of the frequency of non-agricultural-growth led poverty reduction to that of agricultural-growth led poverty reduction is now roughly two to one, rather than 58 to 4 as in Table 1. Our main focus is now to analyze the sources of the non-agricultural development in the Philippines using the same provincial panel dataset.

Model specification

Our empirical specification follows the empirical analysis of India by Foster and Rosenzweig (2004) who applied fixed-effects regression analyses to a village-level panel dataset by regressing the level of (the natural log of) non-agricultural income on the level of agricultural productivity, except that our unit of observation is at the level of province, rather than village, and also that the maximum yield of high yielding varieties (HYV) used as the measure of agricultural productivity in Foster and Rosenzweig is replaced by per capita agricultural income in our analysis.

The inclusion of provincial fixed effects (η_i below) can control for unobservable and time invariant factors determining the level of non-farm incomes and is robust to possible correlation between any such unobservables and the other right hand side variables (unlike the random effects model). Our inference on agricultural vs. non-agricultural linkages is thus robust to at least time invariant province effects (such as all the physical characteristics, geographical and natural environments, fixed cultural practices, preferences, fixed institutions) possibly affecting (simultaneously) both agricultural productivity and non-agricultural income.[4] In a later section, additional attempts will be made to estimate alternative specifications to examine the robustness of the main findings.

The econometric specification that we estimate is as follows:

$$Y_{it} = \beta_0 + \beta_1 AG_{it} + \sum_k \gamma_k Z_{kit} + \eta_i + \sum_t D_t + \varepsilon_{it} \qquad (1)$$

where

Y_{it}	measure of rural non-farm sector activities
AG_{it}	measure of rural agricultural sector activities (or productivity)
Z_{kit}	other k control variables including infrastructure
i	unit of observation – province
η_i	province specific fixed effects
D_t	time (year) dummies

The nature of the linkage between agricultural growth and non-farm growth as specified in (1) can be identified using the following hypothesis:

$\beta_1 < 0$, substitutes
$\beta_1 > 0$, complements

In the original Foster and Rosenzweig (2004) study, their village-level analysis includes the following as Z_{kit} variables: population (natural log), number of secondary schools, electrification, distance from nearest 'organized market', and average household wealth. In our empirical analysis below, our Z_{kit} variables consist of: population (in log), the share of households with access to piped water, the share of households with access to toilet, the share of households with access to electricity, road density and the average schooling level (measured by the provincial average proportion of actual to potential years of schooling among all members of the household).

[4] On the other hand, however, this specification cannot rule out the possibility of unobserved, province specific and *time varying* shocks, such as terms of trade or other price shocks, weather shocks, random measurement errors affecting both agricultural and non-agricultural incomes, which might lead both agricultural and non-agricultural incomes to move together.

In our empirical analysis, rural non-farm sector growth is measured by the log of non-agricultural income (consisting of the income from industrial and service sectors but excluding unearned incomes) per capita in rural areas (aggregated at the provincial level), but, in addition, we further disaggregate the non-agricultural income by subsectors (industry and service sector incomes separately).

3. Empirical Results

Linkage between agricultural growth and rural non-agricultural growth

As reported in Table 3 column (1), we find that (the log of) non-agricultural income is positively associated with log of agricultural income, although the level of significance is somewhat lower than the conventional level (12%). The study's inference becomes sharper when non-agricultural income is further disaggregated into industrial and service sectors. We find a complementary (i.e., positive) relationship between service sector income and agricultural income with the elasticity of 0.24, and the relationship is statistically significantly different from zero [Table 3, column (2)]. The relationship between rural industrial sector income and agricultural income, on the other hand, is qualitatively similar to the relationship between service sector income and agricultural income, but the relationship is not statistically significant (Table 3, column (3)).

In order to further explore whether the extent of the positive relationship between agricultural and non-farm growth differs across provinces due to various natural and socioeconomic conditions, the regression equation (1) was re-estimated with additional interaction terms. Drawing on APPC (2008), we focus on two aspects of such conditions: comparative advantage in agricultural production and extent of urbanization. They found that the extent to which the rural poor benefit from income growth was partly dependent on the degree of comparative advantage in agricultural production and on access to urban areas. Table 4 reports the results with the additional interaction terms.

For each province, we measured the degree of urbanization by the percentage of urban population and the degree of comparative advantage in agricultural production by the proportion of municipalities with slope of land between zero and 18 degrees. A larger number of the latter measure indicates that the provincial landscape is relatively flat, thus presumed to be better suited for agricultural production. The coefficients of the interaction terms between per capita agricultural income and the proportion of 0-18 slope are all statistically significant in all equations, i.e., non-agricultural income, service sector income, and industrial income as dependent variables. These results suggest that the extent of positive relationship between agricultural and non-agricultural (service sector or industrial sector) incomes is relatively stronger when the landscape is relatively flatter, thus better suited for agricultural production. On the other hand, the coefficients of the interaction term between per capita agricultural income and the urbanization variable were not statistically significant in any of the specifications.

The positive linkage effects found between agricultural and service sector growth is consistent with the theoretical model developed by Foster and Rosenzweig (2004) and their empirical evidence from India. The main difference of our results with the Indian case is the absence of the negative (i.e., substitutive) relationship between industrial (i.e., producing tradable goods) and agricultural sector growth. The main theoretical conditions leading to the negative relationship in the Foster and Rosenzweig model are: (1) immobility of rural labor force (thereby creating regional wage differentials) and (2) mobile capital (in search of locations with cheaper labor). The absence of the negative relationship in the rural Philippines appears to imply that either (or both) of these conditions does not apply in the case of the Philippines.

Impact of Infrastructure on Rural Non-farm Growth and Agriculture vs. Non-agriculture Linkages

While the discussion has so far focused on the estimated coefficients on (the log of) agricultural income per capita, the estimated models include additional control variables (somewhat similar to the set of control variables included in Foster and Rosenzweig's empirical analysis). In particular, we find a positive and consistent impact of some key infrastructure on rural non-farm sector growth, especially on the non-tradable service sector. As Tables 3 and 4 show, rural service sector growth is positively associated with household access to toilet (sanitation), level of education (measured by the provincial average proportion of actual to potential years of schooling among all household members), and road density. The same right hand variables are generally positively correlated with rural non-farm sector growth (aggregating both industrial and service sector incomes); however, the positive correlation with rural industrial sector income is much weaker.

While there is positive association between access to toilet (sanitation) and rural non-farm growth, the correlation between household access to water and rural non-farm growth is not statistically significant. Even though toilet access and water access are positively correlated, the correlation coefficient is only moderately high (0.64). It is not immediately clear why only the effects of "toilet" access is significant but not "water" access although both are likely to contribute to sanitation and health.

Investigating further the impact of infrastructure development on rural non-farm sector growth, we also examined whether road infrastructure affects the impact of agricultural growth on rural non-farm growth. This was done by adding an interaction term between agricultural income and road density in the right hand side of the regression models. As reported in Table 5, however, it was found that once the interaction term is added, the coefficients of both the level of road density and the interaction terms tend to be estimated imprecisely and the coefficients tend to be both statistically insignificant. We thus failed to find evidence, given the dataset, of the existence of linkage effects of agricultural sector growth on rural non-farm (especially services sector) growth due to road infrastructure development.

An Extended Analysis of the Effects of Infrastructure: Reduced Form Estimation of the Determinants of Provincial Income by Sector

In our analysis reported in Table 3, the variable 'road density' is measured by the ratio of the 'quality adjusted' *local* concrete and asphalt road length to arable and disposable land area in each province. The distinction between national road and local road reveals an intriguing pattern. For instance, local road density is positively and significantly associated with rural non-farm growth (non-farm income as a whole, as well as service sector incomes separately) but the effects of national road density are mostly statistically insignificant, with the signs of correlation being mostly negative. When the aggregated measure of road density (by adding local and national road densities) is used instead, the correlation mostly remains positive but the magnitude is smaller than that of local road density and sometimes the correlation is not statistically significant.[5] This pattern of empirical results suggests that it is the development of local roads (rather than national highways) that mainly contributes to rural non-farm sector growth. National road, on the other hand, is likely to have offsetting (as well as facilitating) effects on rural non-farm sector, for example, by making it easier to migrate to urban areas or to import goods or services.

Finally, we also estimated ‘reduced form’ specifications [excluding the measure of agricultural productivity on the right hand side of equation (1)] of the determinants of provincial incomes with an extended set of infrastructure variables. Table 6 summarizes the results. As before, we find that population growth is negatively associated with income growth (from all sectors); that improving sanitation (equipping with toilets) is positively associated with both agricultural and services sector growth (but not industrial income); and that schooling is positively associated with services sector income growth but not with industrial income growth.

While these results are not dramatically different from those of earlier specifications, a few intriguing differences are observed among the relationships between some infrastructure variables and incomes from different sectors. Investing in local (rather than national) road is positively associated with services sector and industrial sector incomes (though the latter case is not statistically significant), while it is significantly and negatively associated with agricultural income growth. In contrast, investing in national road is significantly and positively associated with agricultural income growth but negatively associated with industry income. The reduced form estimation results on the differential effects of local and national roads confirm our earlier observation on the possibly complex interactions between either local or national road investments and income growth from different sectors. That is, road improvements could potentially hamper, or enhance, rural non-farm (as well as farm) development. In the case of a tradable sector, road improvement can facilitate either export (positive growth effects) or import (negative growth effects) of such goods from other regions. It could also slow growth in a particular sector in rural areas

[5] Detailed regression results are not reproduced here for brevity, but are available upon request.

by making labor migration easier. Our empirical results suggest that investment in local roads facilitates local non-farm sector growth, particularly services sector growth, which is a non-traded sector. The marginally significant negative effects of national road on industrial income growth could reflect the effects of increased imports from other parts of the country (or abroad) of tradable industrial goods, as well as the effects of increased labor (out) migration. Our data suggest that in the case of the Philippines, national road network may possibly lead to concentration (rather than dispersion) of industrial production and rural industrialization.

In contrast, in the case of agricultural sector growth, a tradable sector, the positive effects of national road development (for example, by allowing longer distance trade of agricultural produce) appear to dominate the (weak and marginally significant) negative effects of local road.[6]

The number of airports is significantly and positively associated with income from both non-farm sectors (services and industry). Given that only 53 out of 73 provinces have an airport and that airports are purposefully constructed (presumably) in locations with higher growth potentials, interpreting the positive correlations as the causality running from the location of airports to growth may not be warranted. Moreover, the number of seaports (interacted with the dummy variable indicating coastal provinces) is significantly and negatively associated with agricultural income growth.[7] In light of the earlier finding on the positive effects of national road network on agricultural growth, this result is rather puzzling.

The number of cellular phone sites (per area) is significantly and positively associated with services sector income; however, the inclusion of cell phone sites as a

[6] Our reduced form inferences on the effects of infrastructure development on non-farm (as well as agricultural) growth are robust to time invariant province effects (such as all the physical and geographical and time-invariant institutional factors attracting infrastructure investments and, at the same time, inducing non-farm development). We cannot rule out, however, the possibility that the positive correlation between electricity and road could be mainly due to province specific common trends. The same is true regarding the possibility of unobserved, province specific and time varying (without trend) shocks affecting both government decisions of infrastructure placement and non-farm development.

[7] An alternative attempt was made with specifications where the number of seaports is interacted with the dummy for both coastal and island provinces. The resulting coefficients are not statistically significant.

variable resulted in the coefficients on road becoming insignificant.[8] Notably, irrigation investments are not significantly correlated with income growth of any sector, including the agricultural sector.

Alternative Specifications: System GMM estimation

One of the main foci of this paper has been the growth linkages between agricultural and rural non-farm sectors. Our results so far suggests that agricultural sector growth is positively and significantly related to rural service sector growth, while similar linkages between agricultural and industrial sector growth are either weak or nonexistent. In this section, additional attempts are made to examine the robustness of this finding by re-estimating the growth linkages with alternative specifications. More specifically, the alternative specifications introduce dynamics explicitly as follows:

$$lnY_{it} = \beta_0 + \beta_1 lnY_{it-1} + \beta_2 lnAG_{it} + \sum_k \gamma_k Z_{kit} + \eta_i + \sum_t D_t + \varepsilon_{it} \qquad (1b)$$

where

Y_{it}	rural non-farm sector activities, as measured by (a) non-agricultural income per capita, (b) service sector income percapita, or (c) industrial income per capita.
AG_{it}	rural agricultural income per capita
Z_{kit}	other k control variables including infrastructure
i	unit of observation – province
η_i	province specific fixed effects
D_t	time (year) dummies

As before, the nature of the linkage between agricultural growth and non-farm growth can be identified using the following hypothesis:

$\beta_1 < 0$, substitutes
$\beta_1 > 0$, complements

[8] The correlation coefficient between cell phone sites and local (national) road density is not alarmingly high, i.e., 0.6 (0.33); these results are somewhat puzzling.

As has become standard in the empirical literature, the above specification is estimated by the system GMM (generalized method of moments) estimation technique developed by Arellano and Bover (1995) and Blundell and Bond (1998).[9] Implementation of the system GMM estimation could potentially entails a number of specification choices, including: the number of lags to be included in the right hand side of the equation as the lagged dependent variables ($\Sigma^{P}{}_{p=1} lnY_{it-p}$); the number of the maximum lagged values of Y_{it} to be included as the instrumental variables to control for the endogeneity of the lagged dependent variable(s); the lag structure of AG_{it} and the treatment of AG_{it} (as well as Z_{kit}, potentially) as either purely exogenous, predetermined or endogenous (and, in the latter two cases, the maximum number of lagged variables to be used as instruments); and so on. After some initial specification searches, the provisional results reported below are based on the following specification choices:

- Only a single lagged dependent variable lnY_{it-1} and the contemporaneous agricultural income AG_{it} are retained on the right hand side.
- Agricultural income, AG_{it}, is treated as endogenous.
- Following Roodman (2009), the parameter estimates are obtained by the two-step estimator and with robust standard errors (which is arguably "modestly superior to robust one-step"), and the lagged variables used as instruments are kept to minimum in order to avoid over-fitting of endogenous variables.

Figure 1 below collects scatter diagrams depicting the relationship between non-agricultural income and agricultural income, with three alternative measures of non-farm sector income (i.e., (A) total non-agricultural income, (B) service income, (C) industry income), after controlling for province dummies, year dummies as well as other control variables Z in equation (1) above. The observation of Eastern Samar 1988, as well as, possibly, Bataan 1988, would appear to be potential candidates for outlier observations. While some initial experimentation suggests that exclusion of some potential outliers does not appear to change the qualitative results dramatically, those observations are excluded in the results reported below.

[9] The estimation results that follow are obtained by the "xtdpdsys" command in STATA.

Standard tests, including the Arellano-Bond test for serial correlation in first-differenced errors and the Sargan test of overidentifying restrictions, are conducted; we find that, in all the specifications reported below, the null hypotheses of both zero autocorrelation in first-differenced errors of order two and of the overidentifying instruments being valid are not rejected at the conventional level of significance. Table 7 summarizes the estimation results of some select specifications of our system GMM models as specified in equation (1b). The qualitative results are more or less in line with our earlier (and based on more naïve specifications) results in the sense that there is a positive and significant (though, marginally) linkage effects from agricultural income growth to service sector growth, while similarly significant relationships are not observed in the case of industrial income growth or of total non-agricultural income growth. Furthermore, the point estimates of the elasticity of service sector growth with respect to agricultural growth are confined to the range between 0.2 and 0.25, and those estimates closely match the elasticity estimate based on the static model as reported in Table 3. Despite the relatively stable point estimates obtained across different specifications, however, the level of statistical significance tends to hover around the neighborhood of 10 percent (slightly below or above, depending on the specification).[10] We could conclude, therefore, that agricultural growth in rural areas has positive linkage effects on rural service sector growth (but not on rural industrial growth) with the estimated elasticity of 0.2 to 0.25, and that such estimates tend to be robust to alternative specifications including the endogeneity of agricultural income.

Apart from the sectoral growth linkages, our estimation results based on system GMM specificaiton also suggest that, also as consistent with our earlier results, the infrastructure variables, i.e., local road and electricity, have significantly (though not all specifications) positive effects on service sector growth.

[10] The results reported here are based on rather conservative estimates, in the sense that the results obtained by the (arguably ‘modestly inforior’, according to Roodman 2009,) one step estimator, the estimated coefficients on agricultural income are statistically significantly different from zero at 10% or below in (almost) all the alternative specifications.

4. Conclusions

The empirical findings in this paper can be summarized as follows. Consistent with the existing theoretical literature (e. g., Eswaran and Kotwal 2002, Foster and Rosenzweig, 2004), we find evidence of positive growth linkages from agricultural growth to (non-tradable) service sector growth. Based on various econometric specifications, the estimated elasticity of the linkage effects appears to be in the range of between 0.20 and 0.25. In contrast, significant relationship, either positive or negative, is not found between agricultural and (tradable) industrial sector growth. Based on the theoretical model by Foster and Rosenzweig (2004), the absence of significant negative relationship between agricultural and tradable nonfarm sector growth could suggest that rural labor force is sufficiently mobile across provinces and/or that capital is relatively immobile across provinces. We additionally find that the elasticity of growth linkages between agricultural and service sector growth tends to be larger in the areas where land topography is consistent with comparative advantage in agricultural production (i.e., higher irrigation potentials). The extent of urbanization, on the other hand, does not appear to affect the size of the elasticity.

We find that expansion of *local* road network is positively and significantly associated with service sector growth (and positively and insignificantly with industrial growth) and negatively and significantly associated with agricultural growth. In contrast, expansion of *national highways* is positively and significantly associated with agricultural growth and negatively (and marginally significantly) associated with industrial sector growth. Our results suggest that it is mainly local roads that facilitate non-tradable rural nonfarm sector growth while investing in national road networks may possibly lead to further concentration of tradable nonfarm sectors. Agricultural sector (which is a tradable sector) growth in rural provinces, on the other hand, could be facilitated by expanding in national road.

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Table 1. Changes in Poverty Incidence and growth of ag. versus non-ag income among 73 provinces, 1991-2006

		Ag. vs. non-ag income growth rate during 1991-2006	
		Δag.income > Δnon-ag income	Δag.income < Δnon-ag income
Δpoverty incidence during 1991-2006	increase	3	8
	decrease	4	58

Table 2. Number of Province-Growth Spells by Change in Poverty Incidence and by Income Growth by Sector: FIES provincial panel 1991-2006 (every 3 years)

	Number of province-growth spells	
	Δ ag income>Δ non-ag income 1991-2006	Δ ag income<Δ non-ag income 1991-2006
Poverty reduction	72 (2000.0)*	149 (1998.8)
Poverty increase	58 (2002.7)	86 (2000.2)

*Year average across growth spells

Table 3. Rural Agriculture to Non-farm Growth Linkages (fixed effects estimation)

Variable	Dependent variable (natural log)					
	Non-agricultural income per capita		Service sector income per capita		Industrial sector income per capita	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
lrpcag[*]	0.193	1.57	0.242	2.20	0.14	0.69
lyrice						
lpopfies	-0.529	-3.13	-0.48	-3.23	-0.498	-1.78
water	-0.005	-0.02	-0.012	-0.06	0.648	1.43
toilet	0.343	1.78	0.423	2.06	0.167	0.33
electsh	0.791	2.7	0.669	0.85	1.153	2.45
educat	2.509	2.25	3.443	2.17	-0.292	-0.12
road4loc	0.75	2.57	0.718	3.14	0.888	1.64
_Iyear_1988			0	2.72	0	.
_Iyear_1991	0.222	3.94	0.185	.	0.349	3.15
_Iyear_1994	0.175	2.55	0.167	2.72	0.096	0.61
_Iyear_1997	0.417	5.71	0.38	2.15	0.582	4.68
_Iyear_2000	0.289	3.18	0.298	4.81	0.322	2.17
_Iyear_2003	0.364	3.89	0.388	3.01	0.316	1.89
_Iyear_2006	0.137	1.06	0.122	3.81	0.212	0.92
_cons	11.354	5.12	9.473	4.62	10.956	2.76
N	*510*		*510*		*506*	
r2	*0.48*		*0.51*		*0.192*	
r2_a	*0.466*		*0.497*		*0.17*	

[*]variable definitions can be found in the appendix table.

Table 4. Examining agricultural vs. non-agricultural linkages with additional interaction terms (without national road)

Variable	nonag. income				service income				industry income			
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
Lrpcag	-0.640	-2.470	0.193	1.570	-0.486	-1.980	0.242	2.200	-1.018	-1.890	0.140	0.690
lrpcag* urbanization	0.006	0.120			0.013	0.270			-0.039	-0.380		
lrpcag* slope0 ° -18°	1.688	3.080			1.468	3.250			2.361	2.040		
Lpopfies	-0.400	-2.160	-0.529	-3.130	-0.347	-1.970	-0.480	-3.230	-0.452	-1.280	-0.498	-1.780
Water	-0.023	-0.110	-0.005	-0.020	-0.025	-0.110	-0.012	-0.060	0.601	1.320	0.648	1.430
Toilet	0.350	1.800	0.343	1.780	0.425	2.030	0.423	2.060	0.220	0.410	0.167	0.330
Electsh	0.682	2.510	0.791	2.700	0.578	1.920	0.669	2.170	0.965	2.340	1.153	2.450
Educat	2.698	2.820	2.509	2.250	3.597	3.680	3.443	3.140	0.113	0.050	-0.292	-0.120
road4loc	0.724	2.420	0.750	2.570	0.688	2.570	0.718	2.720	0.876	1.630	0.888	1.640
_Iyear_1991	0.215	3.310	0.222	3.940	0.172	2.200	0.185	2.720	0.374	3.120	0.349	3.150
_Iyear_1994	0.164	2.060	0.175	2.550	0.150	1.690	0.167	2.150	0.125	0.720	0.096	0.610
_Iyear_1997	0.392	4.580	0.417	5.710	0.351	3.780	0.380	4.810	0.591	3.750	0.582	4.680
_Iyear_2000	0.289	2.780	0.289	3.180	0.291	2.570	0.298	3.010	0.368	2.010	0.322	2.170
_Iyear_2003	0.360	3.650	0.364	3.890	0.378	3.480	0.388	3.810	0.345	1.910	0.316	1.890
_Iyear_2006	0.126	0.890	0.137	1.060	0.104	0.680	0.122	0.850	0.233	0.900	0.212	0.920
_cons	9.508	3.370	11.354	5.120	7.613	2.880	9.473	4.620	10.031	2.010	10.956	2.760
N	*510.000*		*510.000*		*510.000*		*510.000*		*506.000*		*506.000*	
r2	*0.530*		*0.480*		*0.543*		*0.510*		*0.230*		*0.192*	
r2_a	*0.516*		*0.466*		*0.529*		*0.497*		*0.206*		*0.170*	

*Year dummies are also included but coefficient estimates are omitted for brevity. variable definitions can be found in the appendix table.
**D. denotes first difference operator: D.$y_t \equiv y_t - y_{t-1}$; L. denotes lag operate L.$y_t \equiv y_{t-1}$ (i.e., initial condition).

Table 5. Adding an interaction term between agricultural income and road infrastructure as a determinant of rural non-farm development (t ratios in parentheses)

Variable	Dependent variable =					
	Rural non-ag. income		Rural service sector income		Rural Industry income	
	log(lrpcnag) (log on log)	D.log(lrpcnag) (diff in diff)	log(lrpcserv) (log on log)	D.log(lrpcserv) (diff in diff)	log(lrpcind) (log on log)	D.log(lrpcind) (diff in diff)
Lrpcag	0.143		0.221		0.059	
	(1.08)		(1.68)		(0.29)	
D.lrpcag[**]		0.194		0.211		0.315
		(1.58)		(1.60)		(1.08)
lrpcag*	0.288		0.047		0.623	
	(0.68)		(0.12)		(0.95)	
D.lrpcag*		-0.052		0.106		-0.428
		(-0.11)		(0.22)		(-0.44)
Lpopfies	-0.492		-0.466		-0.43	
	(-3.26)		(-3.30)		(-1.61)	
D.lpopfies		-0.263		-0.195		-0.026
		(-2.03)		(-1.16)		(-0.08)
Water	-0.034		-0.032		0.616	
	(-0.15)		(-0.14)		(1.35)	
D.water		0.392		0.473		0.61
		(1.54)		(1.57)		(1.35)
Toilet	0.537		0.668		0.184	
	(2.41)		(2.91)		(0.38)	
D.toilet		0.482		0.617		-0.164
		(1.90)		(1.88)		(-0.27)
Electsh	0.981		0.921		1.147	
	(3.38)		(2.95)		(2.70)	
D.electsh		0.79		0.835		0.683
		(2.22)		(2.13)		(0.76)
road4loc	-1.515		0.404		-4.109	
	(-0.44)		(0.12)		(-0.78)	
D.road4loc		0.397		-0.717		3.202
		(0.10)		(-0.18)		(0.40)
_cons	12.564	0.065	11.21	0.078	10.882	-0.114
	(5.63)	(1.48)	(5.12)	(1.75)	(2.89)	(-1.07)
N	*510*	*437*	*510*	*437*	*506*	*430*
r2	*0.468*	*0.224*	*0.488*	*0.171*	*0.194*	*0.125*
r2_a	*0.454*	*0.202*	*0.475*	*0.148*	*0.173*	*0.1*

*Year dummies are also included but coefficient estimates are omitted for brevity.; variable definitions can be found in the appendix table.

**D. denotes first difference operator: $D.y_t \equiv y_t - y_{t-1}$; L. denotes lag operate $L.y_t \equiv y_{t-1}$ (i.e., initial condition).

Table 6. Impact of infrastructure on rural income determination, reduced form (t ratios in parentheses)

RHS variable	Dependent variable: non. Ag. income		ag. income		service income		industrial income	
Lpopfies	-0.552***	-0.67***	-0.455***	-0.607***	-0.44**	-0.654***	-0.792**	-0.611*
	(-2.82)	(-3.20)	(-3.73)	(-6.39)	(-2.22)	(-3.52)	(-2.56)	(-1.81)
Water	0.194	-0.058	-0.328**	-0.397**	0.084	-0.082	1.102**	0.633
	(0.91)	(-0.28)	(-2.07)	(-2.07)	(0.38)	(-0.38)	(2.36)	(1.48)
Toilet	0.17	0.403*	0.278	0.617***	0.255	0.507**	-0.285	0.093
	(0.88)	(1.98)	(1.38)	(3.36)	(1.19)	(2.43)	(-0.48)	(0.17)
Electsh	0.779**	0.707**	-0.625***	-0.708***	0.554	0.560*	1.16**	1.251**
	(2.29)	(2.32)	(-2.66)	(-2.80)	(1.46)	(1.81)	(2.03)	(2.31)
Educat	2.878***	2.411**	0.008	-0.911	3.701***	3.302***	2.066	-0.15
	(2.80)	(2.46)	(0.01)	(-0.93)	(3.37)	(3.52)	(0.88)	(-0.07)
road4loc	-0.02	0.732**	-0.392*	-0.325*	-0.078	0.684**	0.003	0.866
	(-0.07)	(2.56)	(-1.93)	(-1.79)	(-0.26)	(2.56)	(0.01)	(1.62)
road4nat	0.671	-0.147	2.667***	2.58***	1.073	-0.111	-0.94	-2.132
	(0.58)	(-0.24)	(3.00)	(4.81)	(0.88)	(-0.18)	(-0.49)	(-1.61)
Airport	0.271***	0.35***	0.024	0.029	0.247***	0.379***	0.33**	0.315**
	(2.91)	(3.81)	(0.31)	(0.34)	(2.80)	(3.49)	(2.03)	(2.59)
seaport* coastal	0.103	0.085*	-0.093**	-0.098**	0.085	0.074	0.139	0.089
	(1.58)	(1.70)	(-2.06)	(-2.06)	(1.35)	(1.28)	(1.49)	(1.18)
cellsite	271.243		-0.347		288.398		251.533	
	(2.04)		(0.00)		(2.91)		(1.07)	
Irrig	-0.078		0.042		0.126		-0.059	
	(-0.37)		(0.38)		(0.52)		(-0.17)	
Urban	0.214		0.488**		0.488		-0.487	
	(0.46)		(2.17)		(1.03)		(-0.59)	
_Iyear_1991	0.241	0.253***	0.007	0.159***	0.200	0.224***	0.304	0.397***
	(1.59)	(4.26)	(0.06)	(3.67)	(1.18)	(3.32)	(1.35)	(3.33)
_Iyear_1994	0.182	0.197***	0.072	0.214***	0.195	0.199***	0.114	0.13
	(1.33)	(2.76)	(0.74)	(3.99)	(1.24)	(2.70)	(0.46)	(0.81)
_Iyear_1997	0.401***	0.453***	0.083	0.248***	0.381***	0.428***	0.544***	0.647***
	(3.35	(5.58)	(1.14)	(3.61)	(2.87)	(5.38)	(2.74)	(4.71)
_Iyear_2000	0.301***	0.311***	0.023	0.194**	0.326***	0.331***	0.319*	0.393**
	(3.27	(3.12)	(0.38)	(2.15)	(3.51)	(3.26)	(1.78)	(2.43)
_Iyear_2003	0.337***	0.377***	-0.04	0.12	0.373***	0.41***	0.304*	0.404**
	(4.29	(3.70)	(-0.78)	(1.34)	(4.59)	(3.84)	(1.84)	(2.44)
_Iyear_2006	--	0.149	--	0.209	--	0.148	--	0.291
	--	(1.12)	--	(1.53)	--	(1.05)	--	(1.21)
_cons	12.517***	14.367***	14.626***	17.035***	10.253***	13.346***	14.266***	13.161***
	(4.37	(5.78)	(8.59)	(14.65)	(3.47)	(5.92)	(3.10)	(3.10)
N	420	510	420	510	420	510	418	506
r2	0.386	0.482	0.384	0.361	0.419	0.507	0.164	0.2
r2_a	0.360	0.466	0.358	0.342	0.394	0.492	0.129	0.176

*Year dummies are also included but coefficient estimates are omitted for brevity.; variable definitions can be found in the appendix table.

**D. denotes first difference operator: $D.y_t \equiv y_t - y_{t-1}$; L. denotes lag operate $L.y_t \equiv y_{t-1}$ (i.e., initial condition).

Table 7. Rural Agriculture to Non-farm Growth Linkages (System GMM estimation)

(A) dependent variable: non-agricultural income

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Lrpcnag						
L1.	0.495***	0.325	0.471	0.353***	0.491	0.389
	[5.12]	[0.22]	[0.33]	[3.29]	[0.33]	[0.41]
lrpcag	0.139	0.206	0.151	0.188	0.172	0.199
	[0.91]	[0.54]	[0.20]	[1.45]	[0.37]	[0.25]
road4loc		0.195	0.984	0.585	0.637	0.353
		[0.12]	[0.46]	[1.26]	[0.12]	[0.15]
educat		0.912		0.72	2.243	0.236
		[0.34]		[0.56]	[0.31]	[0.08]
lpopfies		-0.176		-0.09		-0.11
		[-1.48]		[-0.91]		[-0.70]
toilet		0.236		0.087		0.468
		[0.63]		[0.22]		[0.87]
electsh		0.982		1.027**		0.804
		[0.64]		[2.38]		[0.59]
_Iyear_1994	-0.082	-0.128	-0.104	-0.141**	-0.136	-0.112
	[-1.21]	[-0.21]	[-0.21]	[-2.53]	[-0.19]	[-0.23]
_Iyear_1997	0.12	0.023	0.116	0.054	0.066	0.079
	[1.39]	[0.05]	[0.22]	[0.85]	[0.10]	[0.19]
_Iyear_2000	0.019	-0.088	-0.081	-0.137*	-0.138	-0.086
	[0.24]	[-0.10]	[-0.12]	[-1.71]	[-0.19]	[-0.14]
_Iyear_2003	0.115	-0.025	0.064	-0.023	-0.016	0.016
	[1.09]	[-0.05]	[0.10]	[-0.31]	[-0.02]	[0.05]
_Iyear_2006	0.034	-0.22	-0.046	-0.238**	-0.253	-0.171
	[0.36]	[-0.40]	[-0.06]	[-2.46]	[-0.20]	[-0.21]
_cons	3.278**	5.219	3.298	4.150**	1.68	4.18
	[2.24]	[0.37]	[0.18]	[2.28]	[0.08]	[0.27]
N	435	435	435	435	435	435
endogenous variables	lrpcag	lrpcag,	lrpcag, road4loc	lrpcag, road4loc	lrpcag, road4loc educat	lrpcag, road4loc educat
number of instruments	37	32	39	43	59	53

* variable definitions can be found in the appendix table.

** L. denotes lag operate $L.y_t \equiv y_{t-1}$ (i.e., initial condition).

(B) dependent variable: log(service sector income)

Variable	(1)	(2)	(3)	(4)	(5)	(6)
lrpcserv						
L1.	0.298***	0.193*	0.299	0.202**	0.325***	0.229***
	[3.57]	[1.91]	[0.23]	[2.17]	[4.98]	[2.88]
lrpcag	0.221*	0.257	0.206	0.253*	0.218	0.228*
	[1.67]	[1.48]	[0.32]	[1.75]	[1.61]	[1.65]
road4loc		0.066	1.123***	0.626*	0.820***	0.452
		[0.19]	[3.52]	[1.85]	[2.66]	[1.37]
educat		0.53		1.105	1.562	0.203
		[0.43]		[0.95]	[1.29]	[0.21]
lpopfies		-0.141		-0.078		-0.166**
		[-1.10]		[-0.83]		[-2.33]
toilet		0.285		0.185		0.425
		[0.70]		[0.46]		[1.29]
electsh		1.035**		0.830*		0.844**
		[2.24]		[1.93]		[2.22]
_Iyear_1994	-0.013	-0.033	-0.048	-0.049	-0.058	-0.04
	[-0.18]	[-0.49]	[-0.09]	[-0.77]	[-0.82]	[-0.66]
_Iyear_1997	0.197**	0.106	0.174	0.137*	0.135	0.144**
	[2.26]	[1.27]	[0.29]	[1.77]	[1.64]	[2.03]
_Iyear_2000	0.229**	0.086	0.07	0.039	0.032	0.055
	[2.50]	[0.83]	[0.07]	[0.42]	[0.34]	[0.62]
_Iyear_2003	0.296***	0.135	0.202	0.149*	0.141*	0.169**
	[2.81]	[1.24]	[0.23]	[1.83]	[1.76]	[2.22]
_Iyear_2006	0.262**	-0.005	0.13	-0.036	-0.015	0.021
	[2.41]	[-0.03]	[0.13]	[-0.31]	[-0.10]	[0.20]
_cons	3.95***	5.293**	3.999	4.211**	2.800*	5.732***
	[2.91]	[2.19]	[0.25]	[2.25]	[1.93]	[3.43]
N	435	435	435	435	435	435
endogenous variables	lrpcag	lrpcag,	lrpcag, road4loc	lrpcag, road4loc	lrpcag, road4loc educat	lrpcag, road4loc educat
number of instruments	37	32	39	43	59	53

* variable definitions can be found in the appendix table.

** L. denotes lag operate $L.y_t \equiv y_{t-1}$ (i.e., initial condition).

(C) dependent variable: log(industrial sector income)

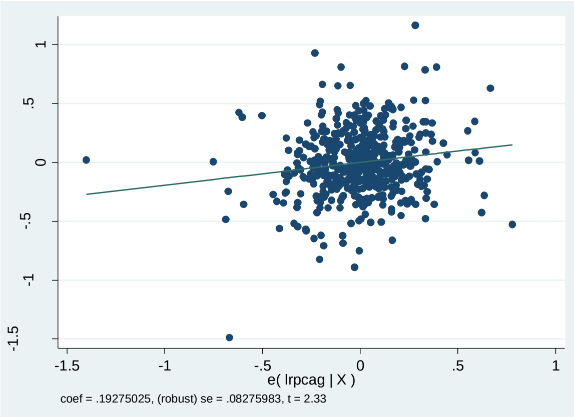
Variable	(1)	(2)	(3)	(4)	(5)	(6)
lrpcind						
L1.	0.302***	0.235**	0.322***	0.294***	0.280***	0.298***
	[3.46]	[2.52]	[3.28]	[3.29	[4.67]	[3.86]
lrpcag	0.265	0.298	0.143	0.369	0.254	0.357
	[1.22]	[1.33]	[0.65]	[1.63]	[1.02]	[1.55]
road4loc		0.626	2.065***	1.446**	1.209**	1.355**
		[0.94]	[3.31]	[2.28]	[2.42]	[1.96]
educat		-2.338		-0.22	8.261**	1.25
		[-1.07]		[-0.09]	[2.39]	[0.47]
lpopfies		-0.01		-0.03		0.027
		[-0.05]		[-0.14]		[0.12]
toilet		0.363		0.165		0.19
		[0.60]		[0.23]		[0.29]
electsh		1.912***		1.877***		1.571***
		[2.71]		[2.79]		[2.62]
_Iyear_1994	-0.104	-0.195*	-0.197**	-0.306***	-0.255**	-0.295***
	[-1.14]	[-1.65]	[-2.00]	[-3.63]	[-2.15]	[-2.82]
_Iyear_1997	0.167	0.025	0.085	-0.058	-0.039	-0.038
	[1.41]	[0.15]	[0.71]	[-0.49]	[-0.33]	[-0.29]
_Iyear_2000	0.00	-0.286	-0.289**	-0.492***	-0.481***	-0.499***
	[0.00]	[-1.17]	[-2.12]	[-3.53]	[-3.44]	[-3.69]
_Iyear_2003	0.053	-0.217	-0.166	-0.454***	-0.381**	-0.449***
	[0.54]	[-0.88]	[-1.34]	[-3.31]	[-2.51]	[-2.80]
_Iyear_2006	-0.051	-0.328	-0.277**	-0.671***	-1.023***	-0.761***
	[-0.45]	[-0.85]	[-2.02]	[-2.91]	[-2.79]	[-3.06]
_cons	2.878	3.322	3.673	1.463	-1.713	0.094
	[1.36]	[0.63]	[1.63]	[0.32]	[-0.54]	[0.02]
N	428	428	428	428	428	428
endogenous variables	lrpcag	lrpcag,	lrpcag, road4loc	lrpcag, road4loc	lrpcag, road4loc educat	lrpcag, road4loc educat
number of instruments	37	32	39	43	59	53

* variable definitions can be found in the appendix table.

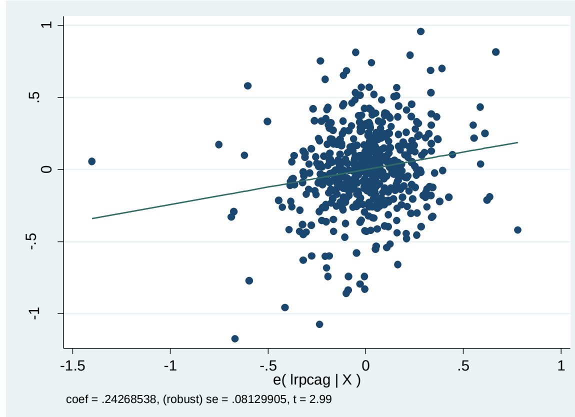
** L. denotes lag operate $L.y_t \equiv y_{t-1}$ (i.e., initial condition).

Figure 1

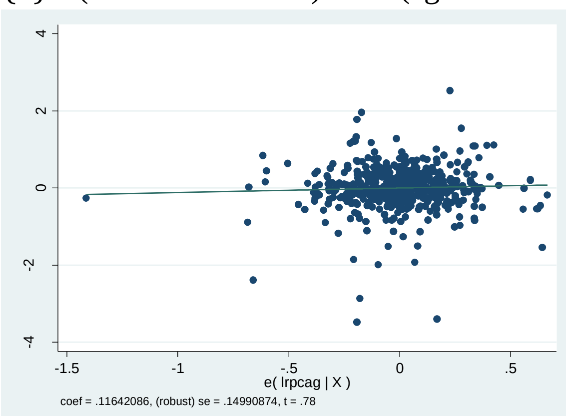
(A) ln(non-ag income) vs. ln(agricultural income)



(B) ln(service income) vs. ln(agricultural income)



(C) ln(industrial income) vs. ln(agricultural income)



Variable Definitions

Variables	Variable Name	Years Available
Lrpcag	Natural log of real Per capita agriculture income in rural areas	1988, 1991, 1994, 1997, 2000, 2003 and 2006
Lrpcserv	Natural log of real Per capita service income in rural areas	1988, 1991, 1994, 1997, 2000, 2003 and 2006
Lrpcind	Natural log of real Per capita industry income in rural areas	1988, 1991, 1994, 1997, 2000, 2003 and 2006
YIELD_CORN	Corn yield per hectare (in MT)	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
YIELD_PALAY	Palay yield per hectare (in MT)	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
POP_FIES	Population projection	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
EDUCAT	Proportion of actual to potential years of schooling, all members of HH	1988, 1991, 1994, 1997, 2000, 2003 and 2006
WATER	Proportion of households with access to potable water(types 1-4)	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
TOILET	Proportion of households with access to sanitary toilet facility (type 1)	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
SLOPE1	Percentage of municipality with slope 0-18 degrees	
URBAN	Share of Urban population	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
ROAD4_NAT	National Road Density; concrete and asphalt	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2013
ROAD4_LOC	Local Road Density; concrete and asphalt	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2014
ROAD4_TOT	Total Road Density; concrete and asphalt	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2015
TELE	Number of installed telephone lines	1994, 1997, 2000, 2003, 2006
CELLSITE	Number of cell stations	1988, 1991, 1994, 1997, 2000, 2003 and 2006
ELECT_SHARE	Proportion of households with access to electricity	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
IRRIG	Proportion of irrigated area to total irrigable area	1991, 1994, 1997, 2000, 2003 and 2006
AIRPORT	Number of Airports	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006
SEAPORT	Seaport	1985, 1988, 1991, 1994, 1997, 2000, 2003 and 2006