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# The Effect of Infrastructure Access and Quality on Non-Farm Enterprises in Rural Indonesia

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**Abstract**

There is growing interest in the rural non-farm sector in developing countries as a contributor to economic growth, employment generation, livelihood diversification and poverty reduction. Access to infrastructure is identified in some studies as a factor that affects non-farm rural employment and income but less attention has been paid to the constraints imposed by poor quality infrastructure. In this paper we use data from 4000 households in rural Indonesia to show that the quality of two key types of infrastructure – roads and electricity – affects both employment in and income from non-farm enterprises. It appears that there would be gains from development strategies that improve both the access to and the quality of rural infrastructure.

**Keywords**
infrastructure
non-farm rural economy
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**JEL Classification**
H54, O17

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## I. Introduction

The rural non-farm economy (RNFE) is emerging as a key contributor to economic growth, employment generation, livelihood diversification and poverty reduction in developing countries. The combination of off-farm wage work, rural non-farm self-employment and remittances contributes 30-50% of rural household income in sub-Saharan Africa (Reardon, 1997) and about one-third of income in Asia (Haggblade, Hazell and Reardon, 2007). This growing importance of the RNFE is reflected in several recent studies of the determinants of non-farm rural employment and income (Lanjouw, 1999; Berdegué, Ramirez, Reardon, and Escobar, 2001; Corral and Reardon, 2001; Escobal, 2001; Lanjouw, 2001; Isgut, 2004; Zhu and Luo, 2006).

But policy makers who seek guidance from this literature may detect ambivalence about at least one key intervention -- improving rural infrastructure (Reardon, Berdegué, and Escobar, 2001). Investments in roads, electricity and telecommunications are often cited as interventions that can assist the rural non-farm economy by reducing transactions costs (Zhu and Luo, 2006; Reardon, Stamoulis and Pingali, 2007). Yet these same investments might also harm the non-farm rural economy, as Start (2001, p.502) points out:

> 'The irony of the RNFE is that the same infrastructure that will open up rural areas and speed their development will also allow urban goods to compete away the RNFE, as the protection of their non-tradability is eroded'.

For example, Berdegué et al. (2001) find rural Chilean households served by the worst type of dirt roads earn higher income from non-farm self-employment than households with access to better paved roads, partly due to the protection against efficient urban competitors given by the bad roads.

In view of this ambivalence we reexamine the relationship between rural infrastructure and non-farm self-employment and income. At least three features distinguish the current study from much of the rapidly growing literature on the RNFE. First, we concentrate on an Asian developing country, Indonesia, while prior studies are mostly from Africa and Latin America. Relative to those regions, more of non-farm employment in rural Asia is in manufacturing and services (Haggblade et al. 2007). In addition, the higher population density in Asia may make infrastructural constraints bind differently than in other regions.

Second, we consider both the *accessibility* and the *quality* of rural infrastructure. This distinction makes sense from a policy point of view because there may be tradeoffs between building new infrastructure to improve accessibility, and upgrading the quality of existing infrastructure.[1] Accounting for quality differences also makes sense from an econometric point of view because the estimated effect of infrastructure access on the RNFE may be biased if relevant quality attributes are ignored. Heterogeneous infrastructure quality implies

that simply measuring quantities, such as spending on roads or the length of roads, may not be sufficient. For example, in China a one Yuan investment in the lowest level rural roads raises non-farm rural GDP by five Yuan, but a similar investment in expressways has no significant effect (Fan and Chan-Kang, 2005) so ignoring this heterogeneity could bias estimates of the effect of infrastructure spending.

Third, we corroborate the cross-sectional results with a limited panel analysis of the effect that changes in infrastructure over time have on participation in rural non-farm self-employment. This panel analysis may mitigate two econometric problems affecting cross-sectional estimates: *reverse causation* and *omission of unobserved productive factors*. Reverse causation occurs if richer areas with more non-farm activity attract more infrastructure investment, so that the correlation between infrastructure and the level of RNFE is not a causal relationship (Gibson and Rozelle, 2003). Omitted variables bias may occur if rural infrastructure is systematically located in places with higher unobserved (to the econometrician) productivity (Jacoby, 2000). A solution to these problems is to use panel data so that time-invariant unobserved productivity can be controlled for by estimating the relationship between changes in infrastructure and changes in the RNFE. Such analysis is somewhat limited compared with panel studies in other areas (e.g. labor economics) because most infrastructure changes only slowly over time. For this reason, and to maintain comparability with the literature, we mainly concentrate on the cross-sectional results.

Our analysis is based on 4000 rural households in the Indonesia Family Life Survey (IFLS). The cross-section is from wave 3, which took place in mid-2000, and the panel compares with wave 1 (1993). Three measures from the IFLS are used to indicate the importance of the RNFE: the share of household income from the net revenue of non-farm enterprises, whether any household member worked in a self- or family-owned non-farm enterprise within the previous 12 months, and the total number of non-farm enterprises operated by the household. We prefer these measures to others such as off-farm wage work because they clearly relate to *local* non-farm economic activity which can then be related to information on the accessibility and quality of local infrastructure. While there have been previous studies of both income shares and participation decisions, the number of enterprises that households operate has been less commonly studied. However, it is plausible that the more enterprises the household is engaged in, the greater the diversification of their income.[2]

## II. The Non-farm Economy and Infrastructure in Rural Indonesia

Rapid economic growth prior to the 1997 financial crisis created many opportunities for rural Indonesian households to be involved in a range of non-farm sales and service activities, particularly in Java (Effendi and Manning, 1994: 233-236).[3] But only limited attention was paid to rural non-farm employment because the high growth rate obtained via outward-looking industrialization allowed urban enterprises to absorb much of the excess labor

(Kristiansen, 2003). But since the financial crisis, RNFE activities have received renewed attention, due to their potential to stabilize incomes of the rural poor (Tambunan, 2000) and because small-scale rural enterprises performed better during the crisis than larger scale enterprises (Hill, 2001).

Over one-third of rural employment in Indonesia is outside of the primary sector (Table 1). The major non-farm sectors are manufacturing, trade and services. The non-farm sector may be even more important as an income source; according to the data in the second part of Table 1, over two-thirds of rural income in Java may come from non-farm sources,[4] although the share of non-farm income is likely to be lower in the outer islands. The major non-farm income sources are wage income and self-employment income. It is also notable that the average share of non-farm income is lower than the contribution of these income sources to aggregate income, reflecting a somewhat skewed contribution from these income sources.

**Table 1. The Importance of Rural Non-Farm Economy in Indonesia**

| | *Total (000)* | *Share* |
|---|---|---|
| *Employment by sector* | | |
| Agriculture, Forestry and Fishery | 36,088 | 63.90% |
| Manufacturing industry | 4,549 | 8.10% |
| Wholesale/Retail Trade, Restaurants, Hotels | 7,345 | 13.00% |
| Public Services | 3,159 | 5.60% |
| Others | 5,322 | 9.40% |
| All Non-Farm | 20,375 | 36.10% |
| *Composition of rural income (Java, 1999)* | *Rupiah per household per year* | *Average share of household income* |
| Farm income | 127,834.9 | 26.64% |
| Non Farm Income | | |
| - Self employment income | 111,606.3 | 18.87% |
| - Wage income | 147,076.9 | 28.46% |
| - Remittances and transfers | 39,442.68 | 8.60% |
| - Rent/interest/pension income | 58,212.25 | 12.43% |
| - Other income | 35,792.02 | 4.9% |

*Source:* World Bank (2006) (derived from SAKERNAS 2004) and authors' calculation based on SUSENAS 1999.

One drawback of the evidence presented in Table 1 is that it does not indicate the sectors where non-farm self-employment is concentrated. Since the average size of enterprises differs by sector, employee numbers may not be a good proxy for enterprise numbers. To provide more focused evidence, Table 2 reports on the range of non-farm activities the rural population is engaged in. Nearly 60% of rural non-farm enterprises are engaged in trade (both food and non-food sales). The remaining activities are largely in manufacturing and service sectors.

In addition to rapid economic growth creating non-farm opportunities, improvements in infrastructure in rural Indonesia also likely contributed to the rise of the non-farm economy. The percentage of the rural population using electricity increased from below 10% in 1980 to

above 80% by 2001. The main electricity company, PLN (Pelayanan Listrik Negara) reached 82% of rural households in the IFLS-3 survey. However, quality of electricity varies considerably, with outer regions suffering regular black-outs (Reuters, 2008 and World Bank, 2008). Indonesia's roads system also expanded rapidly, with the official road network increasing in length by 19.5% since 2000. As with electricity, however, there is considerable variation across regions in both the *extent of access* and the *quality* of infrastructure. Densely populated Java, with only 6.8% of Indonesia's land area but 61.9% of its population, accounts for 26.8% of the classified road network (World Bank, 2006). Only about 50% of district roads are paved with asphalt and about 40% are classified as either damaged or seriously damaged (Table 3).

**Table 2. Sector of non-farm enterprises for rural households in Indonesia**

| Sector | % of rural non-farm enterprises | |
|---|---|---|
| Agriculture, Forestry and Fishery | | **3.85** |
| Mining and Quarrying | | **1.04** |
| Electricity, Gas and Water | | **0.30** |
| Construction | | **1.93** |
| Transportation and Communication | | **2.96** |
| Finance, Insurance, Real Estate | | **0.49** |
| - Restaurant, food sales | 35.08 | |
| - Sales: non food | 22.97 | |
| Trade | | **58.05** |
| - Food Processing | 7.02 | |
| - Clothing | 1.93 | |
| - Other Industry | 8.55 | |
| Manufacturing | | **17.49** |
| Services | | **13.78** |

*Source:* Authors' calculations from IFLS3 data.

**Table 3. Condition and Surface Type of District Road Network in 2003**

| | Sumatra | Java | Bali & Nusatenggara | Kalimantan | Sulawesi | Maluku & Papua | Total | |
|---|---|---|---|---|---|---|---|---|
| | Km | km | Km | Km | km | km | km | % |
| | | | | *Surface Type* | | | | |
| Asphalt | 41,814 | 61,948 | 12,389 | 9,537 | 23,718 | 3,703 | 153,109 | 52.30 |
| Gravel/Stone | 15,580 | 10,409 | 4,128 | 4,417 | 7,275 | 927 | 42,736 | 14.60 |
| Earth | 25,875 | 10,099 | 8,142 | 9,925 | 9,411 | 8,917 | 72,369 | 24.72 |
| Other | 6,963 | 1,487 | 1,041 | 4,357 | 4,202 | 6,510 | 24,560 | 8.39 |
| | | | | *Condition* | | | | |
| Good | 29,779 | 36,183 | 9,217 | 7,183 | 18,357 | 5,179 | 105,898 | 36.17 |
| Moderate | 22,215 | 22,433 | 5,456 | 5,684 | 9,557 | 12,386 | 77,731 | 26.55 |
| Damaged | 21,815 | 18,283 | 7,295 | 8,818 | 6,939 | 903 | 64,053 | 21.88 |
| Seriously damaged | 16,423 | 7,044 | 3,732 | 6,551 | 9,753 | 1,589 | 45,092 | 15.40 |

*Source*: Parikesit (2006).

## III. Data and Methods

The data we use come mainly from the third wave of the Indonesian Family Life Survey, conducted in mid-2000 (Strauss et al., 2004). The first wave of this survey (in 1993) originally interviewed 7,200 households from 130 rural villages and 180 census enumeration areas in urban locations. The sample had grown to 10,400 households by wave 3, because the IFLS tracks and interviews households who split off from the original sampled households. However, the detailed questions on rural infrastructure are only collected in the original IFLS villages so our analysis is restricted to 3,951 households in the original 130 rural villages.

For the IFLS sample of rural households, the share of total income from non-farm enterprises (NFE) is 3.5% (8.4% amongst those households with an enterprise), with 40% households having at least one member involved in a NFE and a mean of 1.22 NFEs per household (Table 4). Households that have non-farm enterprises are larger, and more likely to be headed by a younger male who is married, and is Islamic, and have higher income. In terms of locational and infrastructure characteristics, the data shows that households with NFEs tend to live in communities in which a higher percentage of households have electricity.

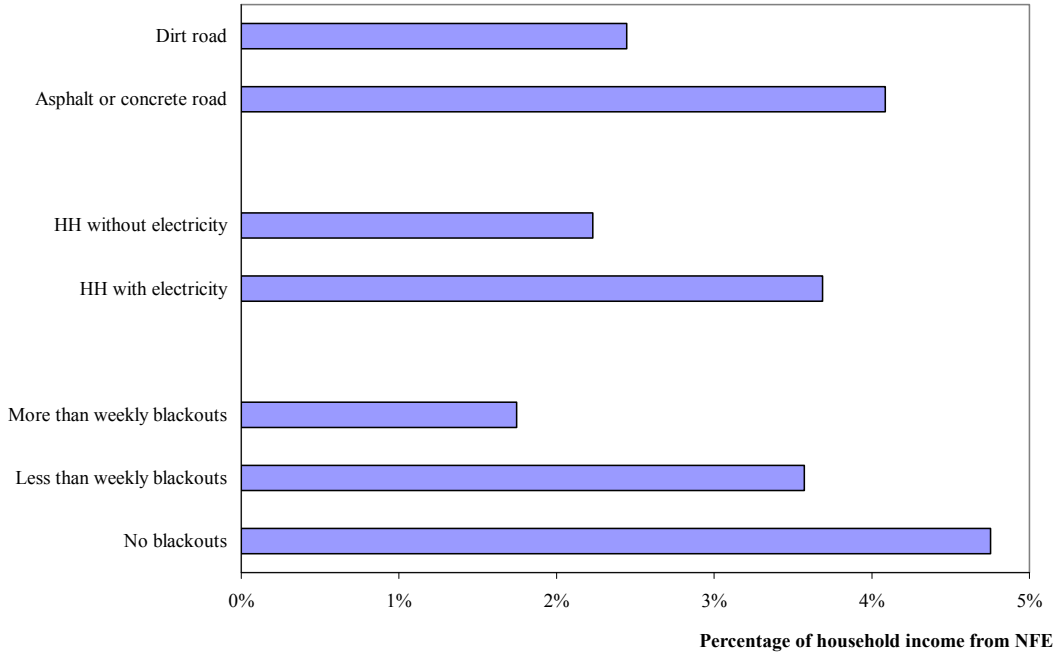
**Table 4. Comparison of Mean Characteristics of Participant and Non-participant Households**

| | All Households | | Households without non-farm enterprises | | Households with non-farm enterprises | | *F*-stat for significant |
|---|---|---|---|---|---|---|---|
| Variable | Mean | Std.Dev. | Mean | Std.Dev. | Mean | Std. Dev. | difference |
| *Importance of NFE* | | | | | | | |
| Share of HH income from NFE | 0.03 | 0.11 | n.a. | n.a. | 0.08 | 0.165 | n.a. |
| # of non-farm enterprises (NFE) | 0.50 | 0.68 | n.a. | n.a. | 1.22 | 0.49 | n.a. |
| Has NFE (=1 if yes, else 0) | 0.40 | 0.49 | n.a. | n.a. | 1.00 | 0.00 | n.a. |
| *Household Characteristics* | | | | | | | |
| Household size | 4.17 | 1.90 | 4.02 | 1.91 | 4.37 | 1.89 | 64.49** |
| Female HH head | 0.17 | 0.37 | 0.18 | 0.39 | 0.15 | 0.35 | 11.20* |
| Age of HH head | 48.81 | 26.18 | 49.91 | 31.92 | 47.16 | 13.49 | 3.84+ |
| Married HH head | 0.83 | 0.37 | 0.82 | 0.39 | 0.86 | 0.35 | 27.20** |
| % kids 0 – 6 yrs | 0.08 | 0.13 | 0.08 | 0.14 | 0.08 | 0.13 | 0.01 |
| % kids 7 – 14 yrs | 0.12 | 0.15 | 0.11 | 0.15 | 0.13 | 0.16 | 22.89** |
| % adults 15 – 49 yrs | 0.57 | 0.23 | 0.55 | 0.24 | 0.59 | 0.22 | 4.77* |
| Primary < Gr 6 | 0.07 | 0.25 | 0.07 | 0.25 | 0.07 | 0.25 | 0.00 |
| Completed primary | 0.26 | 0.44 | 0.26 | 0.44 | 0.26 | 0.44 | 0.02 |
| Secondary & above | 0.13 | 0.33 | 0.12 | 0.32 | 0.15 | 0.34 | 2.38 |
| Per capita farm size (ha) | 1.35 | 14.74 | 1.53 | 16.40 | 1.09 | 11.90 | 0.46 |
| Islamic HH | 0.88 | 0.32 | 0.86 | 0.35 | 0.92 | 0.27 | 6.97** |
| HH speaks Chinese | 0.06 | 0.24 | 0.06 | 0.24 | 0.06 | 0.24 | 0.33 |
| Total income (Rp 000 per HH) | 6,842 | 27,800 | 4,881 | 10,700 | 9,778 | 25,800 | 33.41** |
| *Location and infrastructure characteristics* | | | | | | | |
| Log distance to Prov capital[a] | 4.69 | 0.92 | 4.71 | 0.92 | 4.65 | 0.92 | 0.59 |
| Log average road speed[b] | 3.56 | 0.62 | 3.56 | 0.63 | 3.58 | 0.60 | 0.37 |
| Dirt road (=1, 0 otherwise) | 0.36 | 0.48 | 0.39 | 0.49 | 0.33 | 0.47 | 2.7 |
| % of HH with electricity | 0.82 | 0.38 | 0.78 | 0.41 | 0.87 | 0.32 | 25.43** |
| Village never has blackouts | 0.20 | 0.40 | 0.18 | 0.38 | 0.23 | 0.42 | 2.45 |
| Total observation | 3,951 | | 2,369 | | 1,582 | | |

Notes: + denotes significant at 10% level, * at 5% level; ** at 1% level; a = kilometer, b = kilometre/hour.

In addition to these differences between households with and without NFEs, there also appear to be relationships between infrastructure quality and the share of household income from non-farm enterprises. For the IFLS rural sample, NFE income shares are higher for households that are connected to the public electricity network relative to households without access to electricity and for those in a village with asphalt or concrete roads rather than dirt roads (Figure 1). Similarly, blackouts occurring at least once a week are associated with a 60% lower NFE income share compared with living in villages with no blackouts.

**Figure 1. Infrastructure and the Extent of NFE Activities in Indonesia**




*Empirical Methods*

We first model the determinants of how much rural household income comes from the net revenue of non-farm enterprises. Since many households do not report any income from non-farm enterprises we use the Tobit regression model:

$$\begin{aligned} y_i^* &= \mathbf{x}_i\boldsymbol{\beta}+u_i \quad \text{if } \mathbf{x}_i\boldsymbol{\beta}+u_i > 0 \\ &= 0 \quad\quad\;\; \text{if } \mathbf{x}_i\boldsymbol{\beta}+u_i \le 0 \quad i = 1,2,...,N \end{aligned} \tag{1}$$

where $N$ is the number of observations, $y_i^*$ is the dependent variable, which is a latent variable only observed for income shares above a threshold $(u_i > -X_i\beta)$ and is otherwise zero, $\mathbf{x}_i$ is a vector of independent variables which includes attributes of the household and the household head, and community and infrastructure characteristics, $\boldsymbol{\beta}$ is a vector of unknown coefficients, and $u_i$ is an independently distributed error term assumed to be normal with zero mean and constant variance $\sigma^2$.

To model participation of household members in their non-farm enterprise we use a Probit model, which takes the following form:

$$\Pr(p_i = 1|\mathbf{x}_i) = \Phi(\mathbf{x}_i\beta) \tag{2}$$

where $p_i$ is the outcome of the 0-1 variable for the $i$th observation, $\Phi$ is the standard cumulative normal, $\mathbf{x}_i$ is the vector of explanatory variables for observation $i$ and $\beta$ is the vector of coefficients to be estimated. These probit coefficients are not directly interpretable, but marginal effects for continuous variables can be calculated (at the mean) as:

$$\left.\frac{\partial\Phi(\mathbf{xb})}{\partial x_i}\right|_{\mathbf{x}=\bar{\mathbf{x}}} = \phi(\bar{\mathbf{x}}\mathbf{b})b_i \tag{3}$$

where **b** is the vector of estimated coefficients and $\phi$ is the normal density. For dummy variables, the discrete change in probability when the dummy variable switches from zero to one is calculated as $\Phi(\bar{\mathbf{x}}_1\mathbf{b}) - \Phi(\bar{\mathbf{x}}_0\mathbf{b})$ where $\bar{\mathbf{x}}_1 = \bar{\mathbf{x}}_0 = \bar{\mathbf{x}}$ except that the $i$th elements of $\bar{\mathbf{x}}_1$ and $\bar{\mathbf{x}}_0$ are set to one and zero, respectively.

The model of the number of non-farm enterprises that the household operates is estimated with a Poisson regression model, where the observed count for each household, $y_i$ is assumed to be drawn from a Poisson distribution with mean $\mu_i$, where $\mu_i$ is estimated from observed characteristics:

$$\mu_i = E(y_i|\mathbf{x}_i) = \exp(\mathbf{x}_i\beta). \tag{4}$$

The exponential of $\mathbf{x}_i\beta$ is taken to ensure that $\mu_i$ is positive, which is needed since counts can only be zero or positive. The vector of characteristics in $\mathbf{x}_i$ includes attributes of the household and the household head, and community and infrastructure characteristics.

## IV. Cross-Sectional Results

Table 5 contains results of Tobit regressions for the share of rural household's total income that comes from the net revenue of their non-farm enterprises. The explanatory variables are divided into three groups: characteristics of the household, including demographics, main language spoken, religion and land ownership; characteristics of the household head, including age, gender and education; and characteristics of their community, including province fixed effects, distance of the community from the provincial capital and local infrastructure.

Rural households appear to have higher income shares from non-farm enterprises when older children and (less conclusively) prime age adults are a bigger share of the household population. The income shares are also higher for Islamic households and lower when the household mainly speaks Chinese. The only characteristic of the household head that appears to matter is whether they have education at a secondary school level or above.

**Table 5. Determinants of Rural Household's Share of Total Income from Nonfarm Enterprises**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Household characteristics* | | | | | |
| Household size | 0.008 | 0.008 | 0.007 | 0.009 | 0.009 |
| | (0.95) | (1.04) | (0.85) | (1.04) | (1.08) |
| % kids 0-6 yrs | 0.017 | 0.028 | 0.023 | 0.012 | 0.023 |
| | (0.18) | (0.28) | (0.23) | (0.12) | (0.23) |
| % kids 7-14 yrs | 0.186 | 0.193 | 0.190 | 0.192 | 0.197 |
| | (1.89)+ | (2.01)* | (1.93)+ | (1.98)* | (2.05)* |
| % adults 15-49 yrs | 0.105 | 0.126 | 0.098 | 0.097 | 0.115 |
| | (1.64) | (1.95)+ | (1.52) | (1.43) | (1.71)+ |
| Per capita land area | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.71) | (0.82) | (0.74) | (0.76) | (0.87) |
| Islamic HH | 0.253 | 0.233 | 0.252 | 0.262 | 0.248 |
| | (2.20)* | (2.07)* | (2.19)* | (2.30)* | (2.14)* |
| HH mainly speaks Chinese | -0.208 | -0.320 | -0.211 | -0.251 | -0.334 |
| | (2.01)* | (2.61)** | (2.05)* | (2.57)* | (2.87)** |
| *Characteristics of the household head* | | | | | |
| Age of HH head | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.36) | (0.54) | (0.37) | (0.58) | (0.70) |
| Female HH head | 0.032 | 0.028 | 0.033 | 0.023 | 0.020 |
| | (0.84) | (0.73) | (0.88) | (0.60) | (0.54) |
| Incomplete primary school | 0.030 | 0.041 | 0.031 | 0.036 | 0.046 |
| | (0.55) | (0.76) | (0.58) | (0.67) | (0.86) |
| Completed primary school | -0.000 | -0.014 | -0.003 | -0.005 | -0.015 |
| | (0.01) | (0.40) | (0.08) | (0.15) | (0.42) |
| Has secondary schooling | 0.082 | 0.078 | 0.074 | 0.070 | 0.067 |
| | (1.84)+ | (1.75)+ | (1.66)+ | (1.57) | (1.52) |
| *Location and infrastructure characteristics* | | | | | |
| Log distance to Prov capital | -0.098 | -0.127 | -0.096 | -0.110 | -0.121 |
| | (3.46)** | (4.37)** | (3.42)** | (4.43)** | (4.42)** |
| Log average road speed | | 0.088 | | | 0.044 |
| | | (2.10)* | | | (1.03) |
| Dirt road (=1, 0 otherwise) | | -0.106 | | | -0.106 |
| | | (1.71)+ | | | (1.80)+ |
| HH connected to electricity | | | 0.078 | 0.070 | 0.061 |
| | | | (1.51) | (1.37) | (1.33) |
| Village never has blackouts | | | | 0.269 | 0.249 |
| | | | | (3.36)** | (3.32)** |
| Constant | -0.421 | -0.488 | -0.482 | -0.453 | -0.439 |
| | (2.27)* | (2.68)** | (2.49)* | (2.39)* | (2.24)* |
| Province fixed effects | Yes | Yes | Yes | Yes | Yes |
| $\chi^2$ test all slopes=0 | 232.8** | 232.7** | 224.1** | 233.4** | 246.5** |
| $\chi^2$ test access variables=0[a] | 11.9** | 19.1** | 13.4** | 20.7** | 20.1** |
| $\chi^2$ test quality variables=0[b] | n.a. | 7.6* | n.a. | 11.3** | 18.5** |

*Note:* Coefficients are robust Tobit estimates from IFLS in year 2000, for *N*=3913 rural households. The dependent variable is the share of total household income in the form of net revenue from non-farm businesses, with 451 uncensored observations and 3462 left censored observations. Robust *z*-statistics in ( ) are adjusted for clustering by community. + significant at 10%; *at 5%; **at 1%.

[a] Access variables are log distance to provincial capital and whether the household is connected to electricity.

[b] Quality variables are the log average road speed, whether mainly a dirt road and prevalence of blackouts.

The further a community is from the provincial capital, the lower the share of household income from NFE. Even after controlling for this effect of remoteness, two indicators of the quality of road infrastructure are associated with variations in the household reliance on the NFE (column 2). The first indicator is the (log) average speed of travel between the village and the provincial capital (which averages 52 km/hr).[5] The better the quality of roads (relative to the traffic load), the faster the average speed of travel and according to the regression results the greater the importance of NFE for households. The final indicator of road quality concerns the predominant type of road within the village: when this is not asphalt or cement (denoted 'dirt roads' in the table) there is a significantly lower share of total income coming from NFE.

If a household has electricity it opens up a wider range of activities (e.g., minor construction or assembly tasks requiring electrical equipment, food stalls where refrigeration is required). However, to the extent that the electricity supply is unreliable, with frequent blackouts, a rural household may be less willing to engage in an electricity-dependent enterprise, since they may then either face the capital cost of buying their own generator or put up with the disruptions caused by blackouts. To look at both of these effects, the share of rural household income from non-farm enterprises is regressed on indicators for whether the household is connected to electricity and for the quality of supply – proxied here by a dummy variable for whether the village never has blackouts (column 4).

The regression also controls for the (log) distance from the provincial capital because otherwise the electrification variables may simply be acting as a proxy for overall remoteness. The results show that the presence of electricity is positive but is not statistically significant. However, quality of electricity supply has a considerable impact in affecting households to engage in NFE. Column 4 of Table 5 shows that the share of rural income from NFE is 26.9 percentage points higher for households in villages that never suffer blackouts. The last column of Table 5 shows that even after controlling for access to infrastructure and distance from the provincial capital, the better the quality of roads and electricity the higher the income share from NFE for rural households.

**Table 6. Determinants of Participation in Nonfarm Enterprises for Rural Households**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Household characteristics* | | | | | |
| Household size | 0.020 | 0.021 | 0.019 | 0.019 | 0.020 |
| | (4.14)** | (4.20)** | (3.78)** | (3.93)** | (3.98)** |
| % kids 0-6 yrs | -0.086 | -0.082 | -0.069 | -0.070 | -0.068 |
| | (1.18) | (1.10) | (0.95) | (0.91) | (0.87) |
| % kids 7-14 yrs | 0.128 | 0.136 | 0.136 | 0.132 | 0.138 |
| | (1.92)+ | (1.98)* | (2.00)* | (1.92)+ | (1.96)+ |
| % adults 15-49 yrs | 0.161 | 0.171 | 0.150 | 0.148 | 0.157 |
| | (3.66)** | (3.76)** | (3.34)** | (3.15)** | (3.26)** |
| Per capita land area | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.63) | (0.75) | (0.70) | (0.80) | (0.89) |
| Islamic HH | 0.203 | 0.200 | 0.197 | 0.199 | 0.197 |
| | (3.86)** | (3.58)** | (3.77)** | (3.35)** | (3.15)** |
| HH mainly speaks Chinese | 0.208 | 0.174 | 0.187 | 0.151 | 0.127 |
| | (1.27) | (1.03) | (1.16) | (0.94) | (0.77) |
| *Characteristics of the household head* | | | | | |
| Age of HH head | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 |
| | (1.46) | (1.47) | (1.46) | (1.39) | (1.42) |
| Female HH head | -0.003 | -0.007 | -0.002 | -0.005 | -0.008 |
| | (0.14) | (0.28) | (0.10) | (0.21) | (0.32) |
| Incomplete primary school | -0.003 | 0.002 | 0.002 | 0.002 | 0.005 |
| | (0.09) | (0.05) | (0.05) | (0.06) | (0.16) |
| Completed primary school | 0.006 | -0.002 | 0.000 | -0.001 | -0.006 |
| | (0.26) | (0.08) | (0.02) | (0.04) | (0.30) |
| Has secondary schooling | 0.082 | 0.075 | 0.067 | 0.061 | 0.057 |
| | (2.76)** | (2.57)* | (2.31)* | (2.05)* | (1.93)+ |
| *Location and infrastructure characteristics* | | | | | |
| Log distance to Prov capital | -0.020 | -0.032 | -0.017 | -0.021 | -0.027 |
| | (1.00) | (1.47) | (0.85) | (1.07) | (1.30) |
| Log average road speed | | 0.040 | | | 0.024 |
| | | (1.42) | | | (0.89) |
| Dirt road (=1, 0 otherwise) | | -0.066 | | | -0.059 |
| | | (1.74)+ | | | (1.54) |
| HH connected to electricity | | | 0.135 | 0.133 | 0.127 |
| | | | (4.54)** | (4.63)** | (4.41)** |
| Village never has blackouts | | | | 0.113 | 0.104 |
| | | | | (1.99)* | (1.88)+ |
| Province fixed effects | Yes | Yes | Yes | Yes | Yes |
| Pseudo R-squared | 0.034 | 0.038 | 0.041 | 0.045 | 0.048 |
| $\chi^2$ test all slopes=0 | 177.8** | 187.9** | 192.6** | 172.0** | 179.4** |
| $\chi^2$ test access variables=0 | 1.0 | 2.2 | 21.7** | 23.0** | 21.2** |
| $\chi^2$ test quality variables=0 | n.a. | 5.3+ | n.a. | 4.0* | 7.4+ |

*Note:* Robust probit estimates from IFLS in year 2000, for *N*=3951 rural households. The dependent variable equals one if any household member was employed or self-employed in a non-farm enterprise in the past year (*N*=1582) and otherwise equals zero (*N*=2369). Coefficients show the change in probability from a unit change in the explanatory variable.
All other notes are as reported in Table 5.

Table 6 contains a parallel set of analyses to those in Table 5, except this time the results are from a Probit model of whether household members worked in their non-farm enterprise. The results are largely the same as for the income shares. The probability of participating is higher for households with a larger proportion of youths aged 7 – 14 years, and a greater proportion of adults in the household. Muslim households and those where the household head has secondary education and above also have a higher probability of participation. In terms of location and infrastructure characteristics, the results are largely the same as for the income shares, with one exception.

After controlling for the quality of supply, a dummy variable for whether the particular household uses electricity remains statistically significant (column 4). According to the coefficient on this dummy variable, the participation rate in NFE goes up by 13.3 percentage points when the household utilizes electricity. Hence, when a household connects to the electricity network, it expands the range of activities that household members can participate in. However, for both NFE participation and NFE income shares, the quality of electricity supply matters even after controlling for access to electricity.

Table 7 contains the results of Poisson regressions for the number of nonfarm enterprises operated by each rural household. Household size, the percentage of children aged 7 – 14 and of adults in the household, being a Muslim household and having a household head with secondary education or above are statistically significant in determining the number of nonfarm enterprises. Controlling for location and road quality (as proxied by average speed of travel), there is a further negative effect of having a predominantly dirt road in the village which decreases the expected number of NFEs operated by rural households by 0.78 (this is the exponential of -0.25). Since 37% of the rural population is in villages with dirt roads, there is considerable scope for upgrading local road quality and thereby increasing the average number of NFEs. Access to electricity also seems to play an important role – having an electricity connection raises the expected number of NFEs operated by each household by 1.5 (the exponential of 0.42). The quality of electricity supply also matters, with households in villages which never suffer blackouts having an average of 1.3 more NFEs, even when controlling for access to electricity.

A consistent pattern in the results for NFE income shares, participation in NFE and the number of NFEs operated, is that infrastructure quality matters even after controlling for infrastructure access. This is shown formally by the chi-squared values at the foot of Tables 5, 6, and 7 which are for tests of the hypothesis that the infrastructure quality variables have no effect, once access to infrastructure, community location and household and household head characteristics are controlled for. In all cases, the hypothesis that infrastructure quality does not matter is rejected.

**Table 7. Determinants of the Number of Nonfarm Enterprises Operated by Rural Households**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Household characteristics* | | | | | |
| Household size | 0.065 | 0.065 | 0.060 | 0.062 | 0.062 |
| | (4.92)** | (4.99)** | (4.57)** | (4.74)** | (4.83)** |
| % kids 0-6 yrs | -0.268 | -0.265 | -0.226 | -0.239 | -0.240 |
| | (1.11) | (1.09) | (0.94) | (0.97) | (0.98) |
| % kids 7-14 yrs | 0.426 | 0.441 | 0.439 | 0.425 | 0.432 |
| | (2.12)* | (2.16)* | (2.15)* | (2.11)* | (2.13)* |
| % adults 15-49 yrs | 0.506 | 0.530 | 0.476 | 0.466 | 0.488 |
| | (3.41)** | (3.49)** | (3.20)** | (3.04)** | (3.15)** |
| Per capita land area | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.05) | (0.14) | (0.11) | (0.18) | (0.25) |
| Islamic HH | 0.591 | 0.576 | 0.573 | 0.581 | 0.572 |
| | (3.07)** | (2.81)** | (3.03)** | (2.88)** | (2.66)** |
| HH mainly speaks Chinese | 0.448 | 0.341 | 0.382 | 0.293 | 0.207 |
| | (1.27) | (0.91) | (1.12) | (0.85) | (0.57) |
| *Characteristics of the household head* | | | | | |
| Age of HH head | -0.003 | -0.004 | -0.004 | -0.004 | -0.004 |
| | (1.55) | (1.74)+ | (1.61) | (1.69)+ | (1.86)+ |
| Female HH head | -0.098 | -0.108 | -0.096 | -0.104 | -0.113 |
| | (1.34) | (1.49) | (1.32) | (1.44) | (1.56) |
| Incomplete primary school | -0.006 | 0.012 | 0.007 | 0.010 | 0.025 |
| | (0.07) | (0.14) | (0.09) | (0.12) | (0.30) |
| Completed primary school | 0.048 | 0.024 | 0.033 | 0.032 | 0.012 |
| | (0.82) | (0.42) | (0.56) | (0.54) | (0.22) |
| Has secondary schooling | 0.211 | 0.189 | 0.172 | 0.160 | 0.143 |
| | (2.83)** | (2.59)** | (2.36)* | (2.15)* | (2.00)* |
| *Location and infrastructure characteristics* | | | | | |
| Log distance to Prov capital | -0.067 | -0.094 | -0.059 | -0.071 | -0.082 |
| | (1.18) | (1.64) | (1.00) | (1.27) | (1.48) |
| Log average road speed | | 0.096 | | | 0.053 |
| | | (1.59) | | | (0.90) |
| Dirt road (=1, 0 otherwise) | | -0.250 | | | -0.229 |
| | | (2.31)* | | | (2.12)* |
| HH connected to electricity | | | 0.431 | 0.421 | 0.387 |
| | | | (4.47)** | (4.51)** | (4.20)** |
| Village never has blackouts | | | | 0.291 | 0.274 |
| | | | | (2.10)* | (2.16)* |
| Constant | -2.005 | -2.020 | -1.397 | -2.188 | -2.110 |
| | (4.01)** | (3.75)** | (3.91)** | (4.15)** | (3.77)** |
| Province fixed effects | Yes | Yes | Yes | Yes | Yes |
| $\chi^2$ test all slopes=0 | 187.3** | 192.6** | 193.1** | 181.5** | 186.8** |
| $\chi^2$ test access variables=0 | 1.4 | 2.7 | 21.2** | 22.4** | 19.3** |
| $\chi^2$ test quality variables=0 | n.a. | 8.1* | n.a. | 4.4* | 11.2** |

*Note:* Poisson regression estimates from IFLS in year 2000, for *N*=3951 rural households. The dependent variable is the number of non-farm enterprises operated by the household in the past year (expected value=0.48). Exponential of coefficients shows the change in expected number from a unit change in the explanatory variable. All other notes are as reported in Table 5.

## V. Do Improvements in Infrastructure Affect Participation in Non-Farm Enterprises?

The cross-sectional relationships reported above are subject to various interpretation problems which can weaken inferences drawn from the results for the infrastructure variables. It is possible that more productive areas (due to environmental and other factors) have both more infrastructure and more NFE activity. Alternatively, NFE activity may drive demand for infrastructure, rather than the reverse.

Because IFLS is a panel survey it is possible to at least partially deal with this problem. If infrastructure is endogenously placed, then the communities with the most favorable attributes should receive infrastructural investment before less well-endowed communities. Hence, information on access to infrastructure for the same community in a previous period can help to control for some of this unmeasured productivity attributes. Similarly, there are characteristics of households (such as education, attitudes to risk and entrepreneurship etc) which are likely to affect their current participation in NFE activities, irrespective of the infrastructural constraints that they face. So a regression of current NFE participation on previous participation in NFE may control for the other household-level characteristics affecting choice of economic activities.

Therefore the strategy in this section of the paper is to estimate probit models of whether any household member worked in a non-farm enterprise within the previous 12 months (that is, for the 1999 year, given that the data were collected in mid-2000), conditioning upon the participation of the same household in non-farm enterprises in 1993. We also control for infrastructure access in 1993. The key explanatory variables are the *change* in infrastructure availability at the village level between 1993 and 2000. Once we have conditioned on previous household behavior (did they participate in NFE or not?) and previous infrastructure access, the coefficients on the change in infrastructure should have a stronger causal interpretation for the effects of infrastructure on the importance of NFE than is possible in cross-sectional analysis. Note also that it would be possible to do this analysis in another way, by looking at changes in NFE income shares between 1993 and 2000 but changes in the structure of the income module between the 1993 and 2000 waves of the survey would make this analysis less clear than one based on the simpler participation questions.

The results in column (1) of Table 8 suggest that improvements in village infrastructure, in the form of upgrading from dirt roads and connecting to an electricity network, raise the likelihood of households having a NFE, even after conditioning on previous infrastructure and previous household participation. Improvements in village access to electricity and in the predominant type of local road are positively correlated ($p<0.001$) so the results in columns (2) and (3) separate out the effects of roads and electricity in case multicollinearity is affecting the coefficients. In both cases the results are largely the same.

**Table 8. Relationship Between Changes in Village Infrastructure and Whether Anyone in the Household Participates in Non-Farm Business**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| HH participated in NFE in 1993? | 0.376 | 0.380 | 0.378 | 0.376 |
| | (20.28)** | (20.61)** | (20.42)** | (20.07)** |
| Village had dirt road in 1993 | -0.022 | -0.039 | | |
| | (0.98) | (1.85)+ | | |
| Village road improved since 1993 | 0.042 | 0.046 | | |
| | (2.04)* | (2.41)* | | |
| Village had electricity in 1993 | 0.154 | | 0.163 | |
| | (2.95)** | | (3.23)** | |
| Village gained electricity since 1993 | 0.134 | | 0.130 | |
| | (2.47)* | | (2.41)* | |
| % of HH with electricity in 1993 | | | | 0.190 |
| | | | | (5.59)** |
| Change in % of HH with electricity | | | | 0.087 |
| | | | | (2.17)* |
| Observations | 4244 | 4274 | 4244 | 4162 |

*Source:* Authors' calculations from IFLS3 and IFLS1 data, for rural households.
Robust z-statistics in parentheses. * significant at 5%; ** significant at 1%; + significant at 10%
The estimates are from a probit model for whether anyone in the household participated in non-farm business in the previous 12 months. The coefficients reported are marginal effects.

Conditional on previous infrastructure and whether the household previously engaged in a NFE, upgrading the local road increases the likelihood of a household being engaged in an NFE by just over four percentage points (equivalent to one-tenth of the mean participation rate). Connecting the village to the electricity network raises the likelihood of NFE participation by 13 percentage points, which is an increase equivalent to about one-third of the mean. In the final column in Table 8 an alternative measure of improvements in electrification – the change in the share of households within the village who use electricity – is used. Once again, the results suggest that improvements in infrastructure are associated with higher participation rates in NFE, even after controlling for previous infrastructure availability.

## VI. Conclusions

The results in this paper suggest that both lack of access to infrastructure and poor quality of infrastructure constrain the non-farm enterprises of rural households in Indonesia. Households are less likely to have a non-farm enterprise and also have a lower income share from NFE if they live in a location that is more remote, has lower quality roads, lacks access to electricity, and suffers from frequent electricity blackouts. Moreover, it appears that improvements in village-level infrastructure between 1993 and 2000 are associated with increases in the share of households that have non-farm enterprises.

While there is some ambivalence in the literature about whether improvements in rural infrastructure aid or harm the rural non-farm economy, the results reported here favor the view that poor infrastructure constrains rural non-farm enterprises. Moreover, there is a

negative effect of poor quality infrastructure on top of previously examined effects of poor access to infrastructure. Therefore, gains can be expected from improving the quality of existing infrastructure and not just from building new infrastructure to improve access.

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## Notes

[1] For example, in the Lao PDR, roads investment between 1997-98 and 2002-03 helped to bring dry weather roads up to a wet weather standard and contributed to the poverty reduction that occurred over the period (Warr, 2005). Another way to reduce poverty might have been to allocate road investment so that those areas with no road access (containing 32% of rural households) got to at least a wet weather standard.

[2] Evidence from Papua New Guinea shows a significant decline in the number of income-earning activities that household members participate in for every one-hour increase in traveling time to the nearest road (Gibson and Rozelle, 2003).

[3] These included activities such as selling snacks and gasoline, working as minibus and truck drivers and kenek (assistants), and engaging in TV/radio and motorcycle repair activities. Those involved in these 'new' service activities tended to be better educated than those engaged in traditional areas of non-farm work, such as traditional healers and masseurs (*dukun* and *tukang pijit*), tailors and trishaw drivers.

[4] Although these results refer to 1999, the same patterns are likely to hold in other years because of the trend for non-farm income to increase faster than farm income. According to Booth (2002), the growth of off-farm income of agricultural households was 24 percent faster than the growth of income from agricultural holdings between the 1983 and 1993 Agricultural Censuses.

[5] This is derived from two questions on the distance to the capital city and the time taken for a one-way trip.