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Transformation of Rural Bangladesh: Role of Infrastructure and Financial Institutions

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Abstract

This paper reviews the process of structural transformation and its consequences on the welfare of rural households in Bangladesh. We argue that public investments in roads, electricity, and financial institutions trigger structural transformation, which increases and diversifies rural incomes, raises consumption expenditures, reduces poverty, and increases educational achievements. Data analysis suggests that the average household income goes up by 10 percent and consumption expenditure by 4.7 percent as a result of one additional microfinance institution branch in a village. Grid connectivity and road investment also increase incomes and expenditures, and lower poverty. Analysis also shows that incomes increase more for non-farm sources than for farm sources as a result of infrastructure investments. These developments point to a structural transformation at play in rural Bangladesh.

Keywords: infrastructure investments, electrification benefits, road impacts, microfinance impacts, Bangladesh

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1. Introduction

The term “structural transformation” refers to a large scale transfer of resources from some sectors to others in a system, caused by fundamental changes in policies and objectives. Structural transformation accommodates long-term changes in the structure of demand, production, and employment, which in turn allow for the transformation of a traditional, low productivity, and mostly agricultural economy into a modern economic system with industrial, manufacturing, and service sectors, where productivity is higher and the pace of technological growth is fast (Chenery 1979; Johnston and Kilby 1975; Szirmai 2005). According to Timmer (2007), structural transformation is characterized by four changes: (i) reduced share of agriculture in economic output and employment; (ii) increased share of urban economic activity and modern services, (iii) increased rural-to-urban migration of workers, and (iv), increased population growth before a new equilibrium is reached. Timmer (2007) also considers structural transformation the main pathway out of poverty for all societies.

Structural transformation needs a trigger, which may develop within the society, or may be the result of some external intervention. One of the major triggers can be infrastructure. The term “infrastructure” in this context implies “economic infrastructure” which may also be referred to as “public infrastructure” since it is usually funded by the government. Broadly speaking, economic infrastructure can be categorized as public utilities that involve power, telecommunications, a piped water supply, sanitation and sewerage, solid waste collection and disposal, or piped gas; public works that contain roads, bridges, or major dam and canal works for irrigation and drainage; or other transport sectors that include urban and interurban railways, urban transport, ports and waterways, or airports. A bridge construction project in rural areas can change the surrounding rural community and may gradually push the entire area towards modernization. Thus,

infrastructure investment can be one of the prominent catalysts of the structural transformation. In fact, the adequacy of infrastructure determines a country's success in diversifying production, expanding trade, coping with population progression, abating poverty, and improving environmental sustainability (World Bank 1994). There are of course other types of infrastructure such as financial institutions, educational institutions, market outlets, and communication networks.

Another major trigger for structural transformation, besides infrastructure, is the improvement in agricultural productivity, as suggested by Golin, Parente and Rogerson (2002). Using a one-sector neoclassical growth model, this study hypothesizes that starting at a certain point in agricultural growth, any incremental labor starts flowing out of agriculture regardless of the state of the non-agricultural sector. Since worker output in the non-agricultural sector is much higher than that in the agricultural sector in most developing countries, the movement of labor from the agricultural to non-agricultural sector increases productivity. In this paper, however, we will consider the role of infrastructure and the financial sector, rather than agricultural growth, in the structural transformation of rural Bangladesh.

We hypothesize that an investment in infrastructure facilitates economic activity, and enhances productivity and efficiency in production, consumption, and distribution. Increased productivity in turn improves income levels and bolsters the technology for economic development. Hence, the economy "structurally" modernizes. . This paper provides an empirical framework to determine the nature and extent of productivity growth caused by structural transformation induced by an investment in infrastructure in Bangladesh.

Bangladesh's growth and development have been steady over the last 25 years. They have been especially impressive during the 2000-2010 decade when GDP grew at about 6 percent per year and poverty dropped by 1.7 percentage points per year (World Bank 2013).

Throughout this period, health outcomes and living conditions improved for the poor, infant mortality decreased, and literacy improved. There has also been significant job growth in the industry and service sectors, accompanied by a gradual decline in the size of the agricultural sector, and a movement from wage and self-employment to salaried employment. This paper discusses the contribution of infrastructure (mostly roads and electrification) and financial interventions (both formal finance and microfinance) in improving the rural welfare of Bangladesh.

2. Role of infrastructure: Cross-country evidence

During the 1990s, developing countries invested US$200 billion a year in new infrastructure, which was 4 percent of their GDP and one-fifth of their total investment. This resulted in a dramatic increase in infrastructure services including transportation, power, water, sanitation, telecommunication, and irrigation. Table 1 shows the extent of various infrastructure services across countries in 1990 and 2010. The positive correlation between infrastructure and economic development is obvious from the table. The data also reveals that the differences in infrastructure development between high and low income countries has declined over time.

It is also important to note that the composition of various infrastructure services varies by income level. As Figure 1 shows, low-income countries spend most of their resources on irrigation, whereas high income countries invest more in power generation. Roads are an important investment for all countries, but high-income countries invest slightly more. Infrastructure investment in water is higher for the low-income group, indicating the recent success of low-income countries in providing their people with access to water. To sum up, low-income countries invest in infrastructure mainly to meet their basic needs such as access to water and food (indicated by irrigation), while high-income ones

concentrate more on the quality of life, investing more in the sanitation, telecommunication, and power sectors.

The role of public infrastructure investment did not attract much attention from the economists until the late-1980s, when the downturn in U.S. productivity growth was attributed to the decline in investments in infrastructure (Aschauer 1989; Gramlich 1994). The empirical results of these studies show that non-military public expenditures in infrastructure are more important in determining productivity growth, and that physical infrastructure such as roads and transportation, sewer and water systems, etc. are the best predictors of productivity. But other studies show that while a relationship between infrastructure and productivity cannot be ruled out, it is difficult to ascertain the benefits of infrastructure from aggregate data, mostly because of attribution problems (Evans and Karras 1994; Holtz-Eakin and Swartz 1994; Gramlich 1994). As Bougheas, Demetriades and Mamuneas (2000) discuss, several other attempts to isolate the contribution of public expenditures from that of private expenditures in economic growth were not very successful (Day and Zou 1994; Easterly 1993; Ferreira and Issler 1995; Holtz-Eakin and Schwartz 1994).

However, as a World Bank study observes, during the 1990s, a one percent increase in the stock of infrastructure relates to a one percent increase in gross domestic product (GDP) across all countries (World Bank 1994). Easterly and Rebelo (1993) conducted a comprehensive survey across all countries and found the share of public investment in transportation and communication to be strongly correlated with growth. A number of recent studies explored infrastructure investments and their effects using long panel data. Berechman, Ozmen, and Ozbay (2006), analyzing longitudinal state-, county-, and municipal-level data from 1990 to 2000, show that transportation investments have strong spillover effects, however results get weaker when models are refined using space and time lags. Another study, using panel data from Spanish regions from 1965 to 1995, shows that

10 percent growth in the transportation sector increases private sector benefits by up to 0.42 percent (Cantos, Gumbau, and Maudos 2005). The same study also finds that when analysis is disaggregated by transportation type (roads, ports, airports, and railways), growth in the road sector is seen to have the highest impacts. Another study, also conducted in the Spanish provinces, reveals that while returns on investments in local infrastructure are higher than those on national investments in transportation and communication infrastructure, the latter has spillover effects in regions beyond where they are located (Moreno and López-Bazo 2007). In a study of German cities, authors implementing a political economy model for the allocation of public infrastructure investment grants and using a panel for the years 1980, 1986, and 1988 find that cities ruled by a council sharing the state ("Bundesland") government's current political affiliation were particularly successful in attracting infrastructure investment grants, and such investments were a significant factor in private growth (Kemmerling and Stephan 2002). Cross-section analysis also consistently showed the government's budget surplus correlated with growth and private investment. However, other fiscal investment variables somewhat weakly relate to growth due to high collinearity (Easterly and Rebelo 1993). Finally, using a meta-regression analysis of 68 studies from countries all over the world from 1983-2008, Bom and Ligthart (2014) find a short-term output elasticity of 0.083 and a long-term elasticity of 0.122 for public per capita investment.

In short, there is a clear association between infrastructure investment and economic growth, while causality with aggregate data analysis remains questionable. Later in the chapter, we will demonstrate the impacts of infrastructure projects, implemented at community and household levels, where the causality or attribution issue has been dealt with convincingly.

3. Macro evidence of infrastructure growth in Bangladesh

Despite experiencing natural calamities and political instability, Bangladesh has achieved spectacular progress in infrastructure development. Table 2 shows the dynamics of key infrastructure services in Bangladesh during 1981-2010. Over this period, there was substantial progress in public access to water and sanitation. Education and domestic credit also achieved a respectable growth. However, the telecommunication sector experienced exponential growth during the last decade. We also present the breakdown of energy consumption in Figure 2, which shows that Bangladesh has significantly benefitted from the consumption of natural gas during the 1990s.

There are other important institutions in Bangladesh which enhanced this growth. For example, microfinance institutions (MFIs) have reached remote corners of the country, providing credit to the poorest people, who are otherwise non-bankable. Besides providing credit, microfinance programs now offer other financial services such as savings, insurance, and money transfers. Many MFIs support health and education services as well as environmental and social awareness programs that are positively contributing to society's welfare. Figure 3 shows the growth in membership in the microcredit market. The average growth rate was 11 percent each year over a period of 14 years. During the high growth period, institutions also became more self-sufficient as the savings to loans outstanding ratio grew by three percent each year during 1996-2010. Figure 4 shows the growth of savings as a percentage of loans outstanding. It is obvious that microcredit members have been saving more and more, compared to the amount they are borrowing.

4. Impact of infrastructural investment: An analytical framework

Our aim in this paper is to determine the mechanisms through which a range of infrastructure and credit policies have contributed to growth across different sectors, and whether these policies have also reduced poverty significantly. Using household- and village-level panel data, we examine the linkages between these initiatives and local area endowments and household consumption and income growth. We also examine household income growth from farm and non-farm sources, as well as the wage and non-wage sources of farm and non-farm income. We examine the effects of such policies on intermediate markets (including input costs across different sectors) to better understand the mechanisms by which infrastructure and credit expansion affect households.

There are complex interactions, however, between household incomes and expenditure growth, intermediate markets, policies, and local area endowments (Figure 5). Infrastructural and credit-related investments are not random. In fact, given the rural context of the sample, these investments are directly influenced by agroclimatic and other local area endowments, which also affect the agricultural and non-agricultural opportunities of a given village. Better-endowed areas are likely targets in some instances (for example, public investments in roads may seek areas with better terrain and earning potential), whereas other investments such as microfinance may target poorly endowed areas. Moreover, local agroclimatic characteristics are likely to be highly correlated with other potentially unobserved community features that affect program placement, such as local political influence (Binswanger, Khandker, and Rosenzweig 1993).

Infrastructure investments can be expressed as:

$$I_{jt} = \alpha_0 + \alpha_1 \varphi_j + \alpha_2 \varpi_j + \alpha_3 R_{jt} + \varepsilon_{jt} \qquad (1)$$

where, φ_j and ϖ_j are agroclimatic (measured) and locational (unmeasured) factors, respectively. Given the rural context of these areas, such characteristics can include soil quality, flood potential, temperature, sunshine, and other related factors affecting the earnings opportunities and growth potential of the locality.[1] Other region and time-specific characteristics, R_{jt}, including variations in annual rainfall, population density can also affect investments I_{jt}. ε_{jt} is a time-specific error term.

Household outcome y_{it}, which is household per capita income and expenditures, as well as a range of intermediate outcomes such as transportation costs, wages, labor days in agricultural and non-agricultural activities, and agricultural output, is also affected by agroclimatic endowments and resulting policies. Such interactions make it difficult to identify the precise role of infrastructure and other policy initiatives on income, productivity, poverty, and human capital investment. Observed and unobserved community endowments as well as income earning opportunities jointly determine both household and policy interventions, and hence, household income levels and poverty rates. Unobserved heterogeneity at the community and household level may therefore affect both the outcomes of interest and program placement. Taking into account all these factors, household outcome can be expressed as:

$$y_{it} = \delta_0 + \delta_1 H_{it} + \delta_2 I_{jt} + \delta_3 R_{jt} + \delta_4 \varphi_j + \delta_5 \varpi_j + \delta_6 \mu_i + \upsilon_{it} \qquad (2)$$

where, H_{it} represents a range of time-varying household characteristics, μ_i represents a vector of unobserved household characteristics, and υ_{it} is an error term uncorrelated with the explanatory variables in the estimation. The mean relationship over time for household *i* is:

[1] Agroclimatic data were obtained from the Bangladesh Agricultural Research Council's website. http://www.barc.gov.bd/Data_Stat.htm.

$$\bar{y}_i = \delta_0 + \delta_1 \bar{H}_i + \delta_2 \bar{I}_j + \delta_3 \bar{R}_j + \delta_4 \varphi_j + \delta_5 \varpi_j + \delta_6 \mu_i + \bar{\upsilon}_i \qquad (3)$$

Taking the difference of (2) and (3) yields a panel fixed-effects model that can be estimated by OLS:

$$(y_{it} - \bar{y}_i) = \delta_1 (H_{it} - \bar{H}_i) + \delta_2 (I_{jt} - \bar{I}_j) + \delta_3 (R_{jt} - \bar{R}_j) + (\upsilon_{it} - \bar{\upsilon}_i) \qquad (4)$$

Regarding the specific question of how to treat program placement, one problem with estimating equation (4) is that the direct impact of the agroclimatic variables φ_j and ϖ_j cannot be determined. We could estimate these effects if the policy investments I_{jt} were not a function of the unobserved agroclimatic variables ϖ_j . This would be the case if the observed set of agroclimatic variables φ_j completely represented the set of local area endowments affecting placement of infrastructure and credit programs, and thus if ϖ_j could be treated as random. In this case, a random-effects estimation of equation (3) is valid. However, our results suggest that, using Hausman-Wu specification tests, the fixed-effects is more appropriate than the random-effects model.

5. Welfare gains from household participation in an infrastructure intervention

In this section, we attempt to estimate the welfare gains realized directly by households from some of the infrastructural interventions. For example, microcredit program placement in a village can affect a household who participates in the program and the induced effect of such an intervention can be estimated, thereby revealing the direct effect of microcredit program placement. However, households who are not direct beneficiaries of microcredit program placement may benefit through induced changes in local output-input markets affected by program placement. The next section will attempt to capture the aggregate effect of program intervention encompassing both direct and indirect effects. In contrast, this

section estimates the direct effect of program intervention, such as household connection to grid and non-grid electrification as well as microfinance participation.

Impact of grid electrification

The benefits of electricity are well recognized by development practitioners and in the literature (Dinkelman 2011; Khandker et al. 2014; Khandker, Barnes, and Samad 2012, 2013; UNEP 2013; Barkat 2003; Barkat et al. 2002). Electricity is the most efficient and modern form of energy that enhances household working hours and productivity, thereby advancing the overall quality of life through diverse channels. For instance, Nieuwenhout et al. (1998) found that electricity improves household lighting, thereby increasing study hours (Barkat et al. 2002; World Bank 2002a) and providing more active hours for all members in the household for household chores as well as income generating activities (World Bank 2002b). It also imparts a sense of security in the community, which is an indirect benefit of electrification. Both traditional energy sources (e.g., kerosene, fuel wood, candles, or batteries) and devices (e.g., battery powered radios, three stone stoves) are relatively inefficient and costly. Thus, electricity allows people to afford more light (O'Sullivan and Barnes, 2006). Hence, switching from more efficient devices causes significant time-save and efficiency gains (Meier et al. 2007). The saved time can be employed to productive purpose for income growth (Blackden and Wodon 2006).

Inside households, electricity can also facilitate better cooking and storage, while providing access to information and business knowledge outside households. Dinkelman (2011) found that women's employment grew by 13.5 percent in South Africa due to rural electrification. In Bangladesh rural electrification is credited with providing 3 million direct jobs (Barkat 2005). Thus, electricity plays dual positive roles in consumption and production, making a precise estimation of its impact difficult. Mere findings of increased

incomes among households with electricity do not prove that electrification has contributed to income growth. Moreover, there might be endogeneity in program placements. Controlling for endogeneity, Khandker, Barnes, and Samad (2012) analyzed a 2005 cross-sectional survey of 20,900 households in rural Bangladesh. They focus on the total gain of electrification regardless of individual pathways.

According to Khandker, Barnes, and Samad (2012), household per capita expenditures increases by 11.3 percent and overall total income rises by 21.2 percent due to electrification.[2] Examining the components of income, it appears that having electricity improves both farm and non-farm income (Table 3). In addition, the impact of household electrification on educational outcomes is positive, increasing completed years of schooling and study hours for both boys and girls. For example, grid electrification improves boys' completed years of schooling by 0.233 grades and girls' years of schooling by 0.157 grades. Boys' study time also increases by nearly 22 minutes a day and girls' by 12 minutes a day as a result of electrification.

Since a household's consumption level and poverty are closely linked, Khandker, Barnes, and Samad (2012) also analyzed the impacts of electrification on poverty. According to the reported FE-IV estimates, a household's poverty level may decrease by 13.3 percentage points as a result of electrification (Table 4). Alternately, household poverty reduction due to electrification can be calculated from the FE-IV estimation of impact on per capita expenditures reported in Table 3. The poverty impact estimated in this way (13 percentage points) is close to the result from the direct FE-IV estimate (13.3 percentage points). Thus, the poverty estimation results are quite robust. Another study also finds that access to electricity significantly influences household shifts from poor to non-poor status (Barkat 2004). Since households in rural Bangladesh had had electricity for an average

[2] Barkat et al. (2002), in a pioneering study, finds that about 16 percent of the income growth can be attributed to household electrification. This finding is not far off from the 21 percent income growth reported in Khandker, Barnes, and Samad (2012).

nine years, poverty reduction due to grid electrification is some 1.5 percentage points per year (Khandker, Barnes, and Samad 2012). The link between the duration of electricity use and poverty reduction has also been identified by Barkat et al. (2002). These benefits of electrification are impressive given the relatively low connectivity in Bangladesh, and disparities in connectivity between urban and rural homes, and between rich and poor.[3]

Impact of microfinance participation

Next, we discuss the welfare impacts of microfinance participation at the household level. An examination of the benefits of household participation in microcredit could reveal the direct benefits of microfinance institutions. The best known series of studies on the benefits of microcredit participation involved repeated examinations of the same set of rural households in Bangladesh over a period of 20 years (1991-2010). Here we discuss the findings of the most recent study of the series, which is based on the long panel covering 1991/92, 1998/99 and 2010/11.[4] Khandker and Samad (2013) used a household fixed-effects model on the long panel data, which controls for various household- and village-level exogenous characteristics including the lagged dependent variables. Their findings are reported in Table 5.

Microcredit participation by females has wider ranging effects on household welfare than does male participation. For example, while female participation improves

[3] Barkat (2008) finds that 20 percent of the total population are urban households enjoying an 80 percent connectivity, while 80 percent of total population are rural with only 20 percent connectivity. The same study finds that in electrified villages, on average, connectivity is 35 percent, with a high of 95 percent for the rich, a low of 24 percent for the poor and a very low 16 percent for the poorest households.

[4] These studies were carried out by the World Bank in partnership with Bangladesh Institute of Development Studies (BIDS) (in 1991/92 and 1998/99) and the Institute of Microfinance (InM) (in 2010/11). The first study in 1991/92 covered 1,769 households from 87 villages in Bangladesh, the second one in 1998/99 tracked 1,638 of the previously surveyed households, and finally, the third one included 1,509 households from previously covered households. All three studies demonstrated the wide-ranging benefits of microcredit participation (Khandker 1998; Pitt and Khandker 1998; Khandker 2005; Khandker and Samad 2013).

household total income, non-farm income, total expenditures, and non-food expenditures, and lowers poverty, male participation enhances only non-farm income. Female participation increases the total income by 15.8 percent, non-farm income by 22.6 percent, and total expenditures by 4.5 percent, thereby lowering moderate poverty by 5.1 percentage points. On the other hand, male participation increases non-farm income by 42 percent. Obviously, household income from the non-farm sector benefits more from microcredit participation than does the income from the farm sector. These findings are along the same line as those we observed in the case of MFI expansion at the village level.

As discussed in this section, as a result of electrification in rural Bangladesh, household income and expenditures increase, poverty decreases, children spend more time in studies and their grade attainment goes up. Like electrification, microfinance participation, in particular by women, raises household income and expenditures, and lowers poverty.

6. Welfare gains from village-level infrastructure growth

This section discusses the aggregate impact of community-level infrastructure and financial institutions on household income and poverty. Compared to the earlier findings that demonstrated the direct effects of infrastructure on household-level outcomes such as income and poverty, this section summarizes the combined direct and indirect effects of village-level infrastructural growth. In this context, we summarize the findings of a study done by Khandker and Koolwal (2010) exploring how infrastructure and financial institutions affect rural growth and poverty. Using a pooled dataset of three household panels over a period of 10 years (1991-2001), they found the expansion of irrigation, paved roads, electricity, and access to formal and informal credit led to higher rural farm and non-

farm incomes. During the process, they accounted for exogenous local agroclimatic endowments that explain a considerable part of the variation in the growth of infrastructure and credit programs.

During the period of 1991-2001, there were several significant infrastructure interventions such as the electrification and irrigation of villages, expansion of paved roads, and the formation of commercial banks and microfinance institutions that aimed to raise income and consumption for the rural poor in Bangladesh. Interestingly, these interventions were not randomly distributed but were heavily determined by exogenous local agroclimatic endowments across villages. Infrastructural and credit-related investments are influenced by agricultural activities and patterns, initial endowments, the environment, political influence, transportation facilities, etc. (e.g., Khandker and Koolwal 2010).

Table 6 presents household fixed-effects estimates of the effects of various policy-level interventions on household income and expenditures. There are three interesting findings. First, there is a clear distinction in the sources of income on which policies have affected households. Aside from microfinance expansion, all policies have impacts only on either farm or non-farm income. Second, the policy impacts on total farm and non-farm income are often not as pronounced as on the different categories of income within these sectors (namely, agricultural self-employment, agricultural wage, non-farm enterprise, or non-agricultural wage earnings). This highlights the importance of considering the specific farm and non-farm mechanisms through which policies have affected households. Furthermore, where policies have enhanced farm or non-farm incomes, it has primarily been through self-employment activities in these sectors; wage income (and, in particular, earnings from agriculture) have not been affected as significantly.

Table 6 reveals that a one percent increase in households with electricity in the village has led to a 0.8 percent increase in total per capita income, largely through a 1.3 percent increase in the per capita self-employed farm income. Commercial banks have also

done well for households primarily through an improvement in farm incomes, and in particular, self-employment earnings. Access to a paved road, on the other hand, has led to a 33 percent increase in total per capita income through a roughly 70 percent increase in the total non-agricultural income over time.

Interestingly, non-agricultural incomes (and in particular, non-farm enterprise income) rises concavely with an increase in the village land irrigated, while irrigation leads to no significant impact on farm income. The effect of greater village-level irrigation on non-farm enterprise income and total non-farm income is therefore increasing at a decreasing rate, and is ultimately negative for higher levels of village irrigation. There can be multiple mechanisms underlying this trend. For example, improved irrigation may initially generate better efficiency and productivity in agriculture, thereby raising agricultural incomes. This can in turn lead to greater spending in the local non-farm sector, for example in non-leisure activities, leading to higher non-farm incomes as well. However, spending on non-farm goods from other areas or markets may also increase further with higher agricultural incomes, leading to little or an even negative impact ultimately on the local non-farm sector. Both of these mechanisms may be at work here (see Hymer and Resnick 1969).

The number of microfinance institutions serving the village has had a significant impact on both farm and non-farm incomes, albeit a larger impact on the latter. An additional MFI in the village increases non-farm enterprise income by about 63 percent, compared to 20 percent for self-employed farm income. This is expected given that members of MFIs in rural Bangladesh have often used funds to embark on small-scale non-farm enterprise activities (Khandker 1998; Sen, Mujeri, and Shahabuddin 2007). Similar to per capita income, average per capita expenditures have responded positively over the period to electrification, paved roads, and MFIs. Access to paved roads raises average per capita expenditures by about 10 percent, which is similar to the findings from Bangladesh

on the impact of rural road development (Khandker, Bakht, and Koolwal 2009). An additional MFI in the village also increases per capita expenditures by 3.7 percent, while a 10 percent increase in the number of households with electricity in the village leads to a 2.7 percent increase in per capita expenditures.

It's also important to consider the effects of policies on factor market outcomes in each sector, as the distinctions in policy impacts are difficult to interpret without such considerations. Given the complex interactions of policy with agricultural and non-agricultural factor and output markets in these areas, and observed/unobserved local conditions (such as agroclimatic factors) that jointly affect program placement and different sources of income, knowing a priori how credit and infrastructure initiatives will affect household income and costs across sectors is difficult (see Lanjouw and Lanjouw 2001 for a related discussion). Spillovers across the farm and non-farm sectors are also likely, as households along the expenditure distribution also diversified their incomes across farm and non-farm earnings.

Table 7 shows panel fixed-effects estimates of the policy impacts on a range of intermediate outcomes for households across the farm and non-farm sectors. These include household agricultural production and prices, agricultural transport costs, wages and labor days worked in the past month for men in agricultural and non-agricultural activities, and wage costs for household non-farm enterprises. As Table 7 shows, while irrigation has led to a rise in agricultural output, it has not led to a corresponding rise in agricultural output prices; this has depressed the price per unit of output. Agricultural transport costs have also fallen as a result of village electrification and commercial bank expansion. Electrification has also led to higher agricultural output prices over the period; although the positive effect we find is weakly significant (at the 10 percent level), greater electrification can raise productivity in agriculture, thereby improving both the volume and quality or composition output, the latter through greater investments in pumps, tractors, and farm animals

(Binswanger, Khandker, and Rosenzweig 1993). Access to paved roads has also improved the diversification of income and the non-agricultural labor supply, which may be expected given that paved roads allow families to migrate for additional income opportunities (van de Walle and Mu, 2008; Khandker, Bakht and Koolwal 2009).

Improved credit through MFIs and commercial bank expansion has improved agricultural wages relative to non-agricultural wages. This might be because more households are working in the non-farm sector as technology and credit improve. Table 7 shows that non-agricultural wage labor has increased due to MFI expansion, leading to lower wage rates in the non-farm sector. The effect of microfinance on diversifying economic activity towards the non-farm sector has also been discussed in Khandker (1998). Correspondingly, as labor shifts out of agriculture, agricultural wages rise. Again, however, as mentioned earlier, multiple mechanisms may be at work. If links between farm and non-farm sectors exist in the rural economy, improved access to credit can raise demand for agricultural products as well as non-farm incomes. Table 7 also shows, for example, that MFIs serving the village has led to a modest increase in agricultural output. This can raise demand for agricultural labor as well, helping lift wages in this sector.

This section discusses community-level benefits of various infrastructure investments. The availability of electricity, paved roads, banks, and microfinance institutions in the village increase household incomes, and with the exception of banks, all of them increase household expenditures as well. Village electrification lowers agricultural transport costs but raises agricultural output prices. Paved roads, on the other hand, increase non-agricultural labor supply. Finally, MFI expansion increases non-agricultural labor, and also agricultural wages.

7. Distributional effects of infrastructure intervention

While the estimates reported in Table 7 show the impacts of various community level policy variables on household incomes and expenditures, they do not spell out which households benefit the most. Khandker and Koolwal (2010) used a quantile regression technique to estimate differential impacts across quintiles. More specifically, their findings are reported on village-level infrastructure interventions on household income and expenditure quantiles (Table 8).

Among the policy variables, electrification and paved road have differential impacts on total income by quintile. However, we do not see any trends in such impacts as we go from lower to higher quintiles. We do observe a diminishing effect of commercial banking on farm incomes. On the other hand, proximity to paved roads has an increasing impact as we move into higher quintiles of per capita expenditures. Overall, it seems that households in higher expenditure quantiles benefit more from infrastructure than do those in lower expenditure quantiles, while no trends are observed for infrastructure effects on income levels.[5]

While all policies contributed to an increase in per capita expenditures for households in the 20th percentile, this has not translated into noticeable reductions in moderate poverty. Table 9 does show, however, that predicted reductions in extreme poverty for the poorest households have occurred for the most part through increases in irrigation, microcredit participation, and electrification in the village. A probable reason is that poorer households are involved to a greater extent in agriculture, and these initiatives have all appeared to enhance agricultural incomes through

[5] One possible explanation of the variation in quantile effects between income and expenditure could be that expenditure effects of infrastructure capture income effects as well as the price (of food and non-food items) effects induced by infrastructure investment. Because of the transportation linkages with market centers, the consumption basket is different for rural households. Hence, the income effects reported in the quantile regression are smaller or insignificant across quantiles compared to those for the expenditure effects.

improvements in output and output prices, daily agricultural wages, and reductions in agricultural transport costs (Khandker and Koolwal 2010). Other initiatives such as banks and paved roads, on the other hand, have not had the same impacts on agricultural output and prices.

Most of the predicted reductions in poverty from the examined policies have accrued at higher percentiles of the distribution. Households in the 40th percentile of the distribution have incurred the largest actual reductions in extreme poverty, compared to greater reductions in moderate poverty for households in the 60th and 80th percentiles (see Table 9). Although the predicted and actual data are not directly comparable, the findings provide some additional insights into other factors (for example, inequality and the extent to which households in different percentiles are clustered around the poverty line) that may be at work. The 20th percentile of households appears to be involved less in own-farm income as compared to those at the higher end of the distribution. The poorest might be less likely to capitalize on productivity-enhancing improvements stemming from lower transport costs and better agricultural production opportunities. For example, in a study from rural India, Foster and Rosenzweig (2008) discuss how fixed costs associated with digging wells make it difficult for the poor to benefit from irrigated land and improvements in agricultural productivity. Shortfalls in education and land ownership can also hamper the ability of the rural poor to participate in non-farm income growth, particularly skilled non-farm work (Ravallion and Datt, 2002). A related point is that the policy initiatives examined had a greater impact on enhancing self-employment incomes, compared to wage incomes in both the agricultural and non-agricultural sectors; the poorest households are much more likely to rely on wage earnings, and thus do not derive as much benefit from these initiatives.

Among the different policies, Khandker and Koolwal (2010) found that access to microfinance provided a disproportionate benefit to the poorest households relative to the rest of the distribution. Microfinance institutions encourage non-farm activities among the participants (Khandker 1998), and as workers move into non-farm employment, higher wage rates in agriculture can result. The rise in agricultural wages, in particular, is likely to benefit poorer households as the bottom 20th percentile of households are concentrated in agricultural wage activities, whereas households in the 40th and 60th percentiles were more likely to engage in non-farm self-employment over the 1990s. Knowledge of the sectors and sources of income in which households are involved is therefore vital to understanding how they benefit from better access to finance and infrastructure.

8. Conclusion

Drawing on the available literature, this paper discusses the welfare impacts of infrastructure growth in the context of rural Bangladesh. Available studies on cross country evidence at the macro level suggest that there is doubtless a positive correlation between infrastructure growth and the economic development of the country, although establishing causality between infrastructure growth and development is difficult. This paper shows, using both community- and household-level infrastructure interventions in rural Bangladesh, that infrastructure development can enhance household welfare, in particular, income and expenditures, thereby reducing the incidence of poverty.

However welfare growth by itself does not necessarily lead to structural transformation. Key to structural transformation is a sustained change in demand, production, and employment, in particular, from low productivity activities such as agriculture to high return activities such as non-farm enterprises and services. This may

happen through the diversification of income, energy consumption, and access to financial sources. So the key research question is whether the infrastructure investment in Bangladesh has led to (or has been leading to) sustained growth and the diversification of income to promote structural transformation. Based on the discussion of infrastructure impacts covered in this paper, there are grounds to assert that infrastructure development has triggered a transformation in the rural economy.

First and foremost, infrastructure interventions at both the village and household levels have increased and diversified household incomes, raised consumption expenditures, and reduced poverty. For example, the expansion of microfinance institutions in rural areas has increased total incomes, self-employed farm and non-farm incomes, and consumption expenditures. Household incomes increase by 10 percent and consumption expenditures by 4.7 percent as a result of one additional MFI in the village. Similarly, grid connectivity at the household level increases incomes (total, farm and non-farm) and expenditures, and lowers poverty. Second, while income levels from various sources go up as a result of infrastructure investment, they increase more for non-farm sources than for farm sources. Going back to the example of MFI expansion, an increase in MFI activity in the rural areas increases self-employed farm income by about 20 percent and non-farm enterprise incomes by almost 63 percent. Also household grid connectivity increases non-farm more than farm incomes. At the household level, female participation in microcredit programs raises household non-farm income by almost 23 percent without having any impacts on farm income.

So, the growth effects of infrastructure investment, its consistency for various infrastructure types, and the difference in the nature of such effects (effects are higher for non-farm income than farm income), all point to a transformation in the rural economy.

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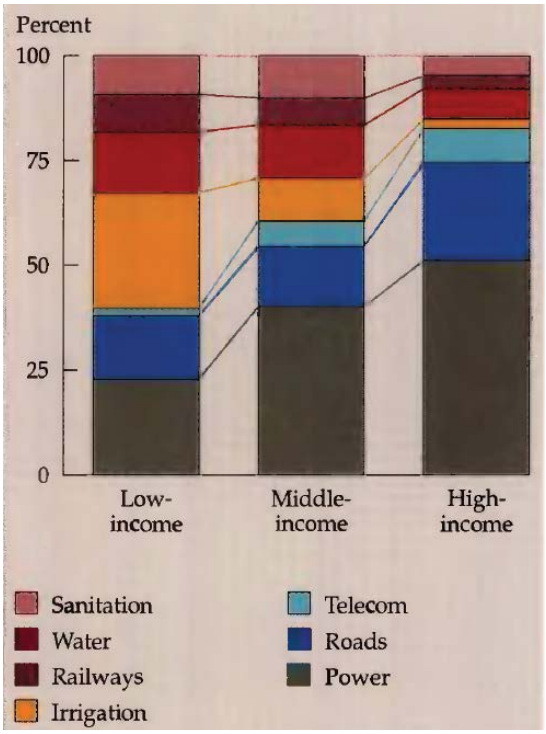
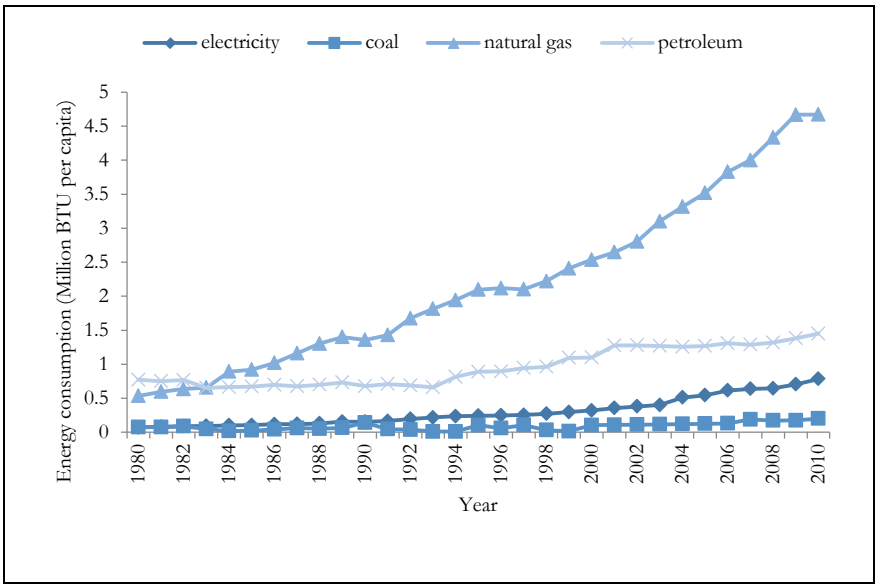
Figures



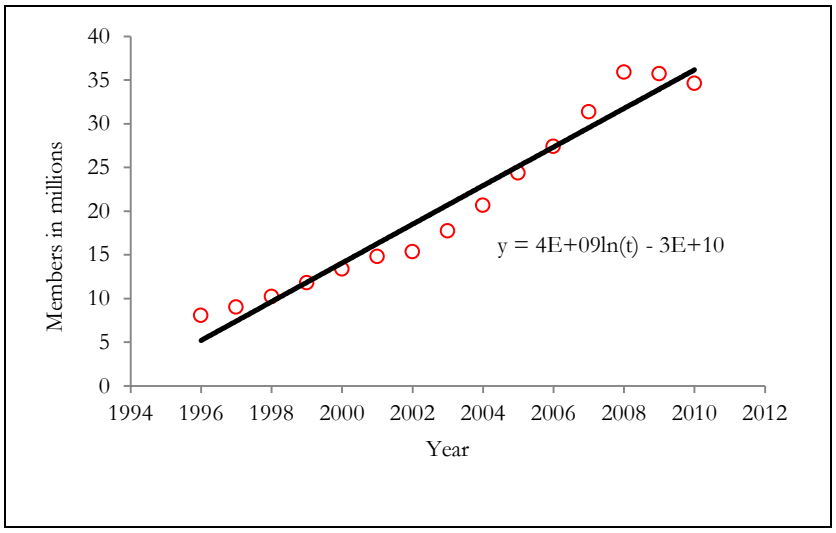
Source: World Bank (1994)

Figure 1. The composition of infrastructure changes with country income level



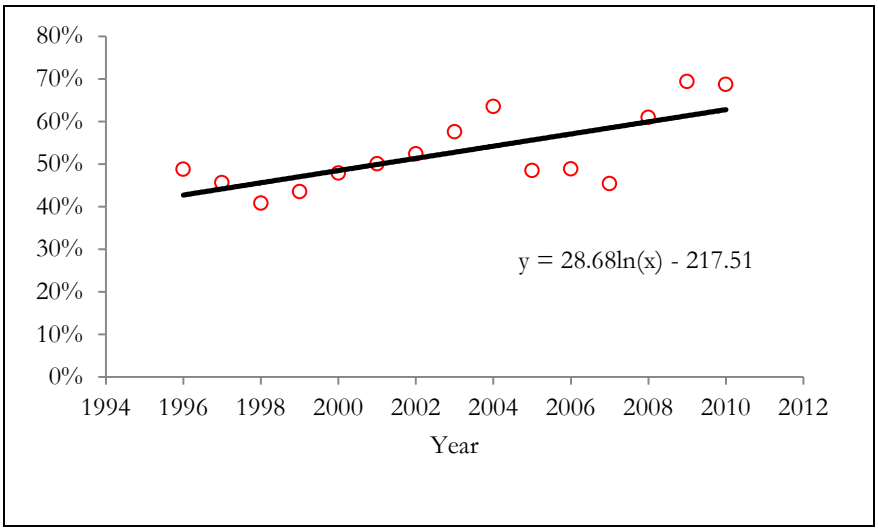
Source: EIA (2014)

Figure 2. Dynamics of energy consumption in Bangladesh (1980-2010)



Source: Bangladesh Microfinance Statistics (1996-2011)

Figure 3. Membership growth in Bangladeshi microcredit market (1996-2010)



Source: Bangladesh Microfinance Statistics (1996-2010)

Figure 4. Savings as % of loans outstanding in Bangladeshi MFIs (1996-2010)

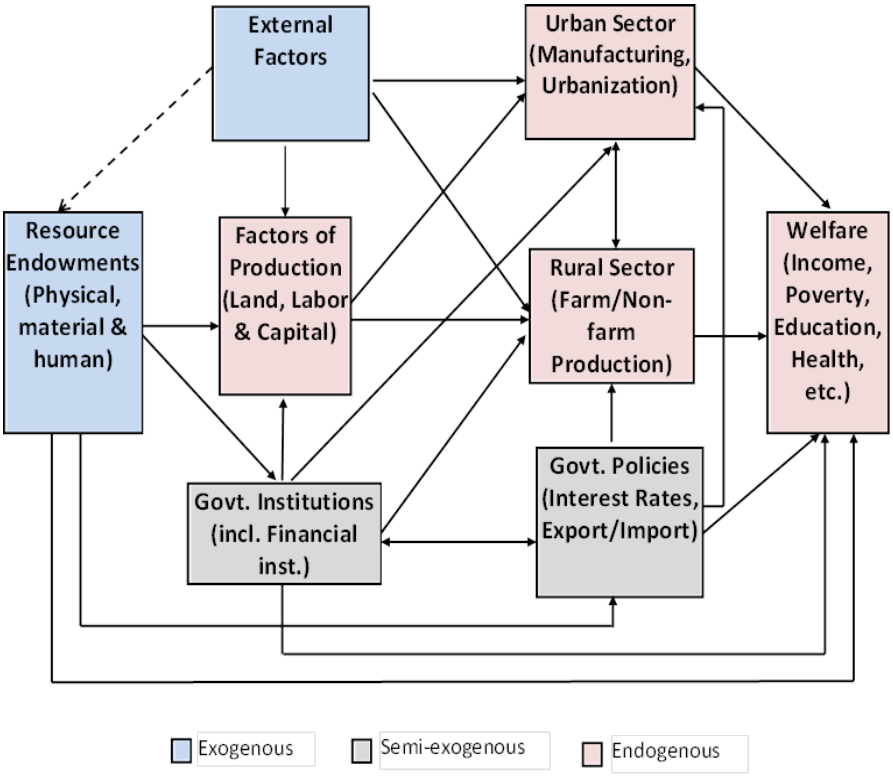


Figure 5. An economic framework for development

Tables

Table 1. Changes in infrastructure services indicators (1990 and 2010)

	Countries in 1990				Countries in 2010			
Infrastructure service indicator	**High-income**	**Upper middle income**	**Lower middle income**	**Low-income**	**High-income**	**Upper middle income**	**Lower middle income**	**Low-income**
Share of electricity in total energy consumption (%)	11	8	9	9	14	12	13	12
Share of paved road in total roads (%)	71	48	40	24	75	63	48	24
Net primary enrollment (%)	94	91	76	49	95	93	88	78
Cellphone subscription rate (%)	0.84	0.03	0.00	0.00	123	100	76	38
Share of population with access to improved sanitization (%)	96	74	48	19	98	84	59	33
Share of rural population with access to improved water (%)	95	77	55	43	98	87	75	60
Domestic credit provided by financial sector as percentage of GDP	80	55	46	27	124	60	41	27

Number of countries: over 120

Source: Authors' calculation from WDI (2014) and EIA (2014) data

Table 2. Bangladesh's progress in infrastructure development (1981-2010)

Infrastructure services	**1981**	**1990**	**2000**	**2010**
% of rural population with access to improved water	-	64.8	73.7	82.7
% of population with access to improved sanitation	-	33.4	44.5	55
Net primary enrollment (%)	67	72	-	92
% of population with access to grid electricity	-	-	-	47
% road paved	-	-	10	-
Cellphone subscription per 100 people	0	0	0.21	45
Domestic credit provided by financial sector % of GDP	18	22	34	65
GDP per capita in current USD	209	271	356	643

Source: WDI (2014)

Table 3. Impacts of household electrification (FE-IV Estimates)

Outcome Variable	FE-IV Estimate	Endogeneity Test (Durban-Wu-Hausman X^2)
Economic (household-level) (N=20,900)		
Log per capita expenditure (Tk./year)	0.113** (0.022)	$X^2(1)=5.961$ Prob>X^2=0.015
Log per capita farm income (Tk./year)	0.313** (0.093)	$X^2(1)=0.054$ Prob>X^2=0.816
Log per capita non-farm income (Tk./year)	0.353** (0.165)	$X^2(1)=10.995$ Prob>X^2=0.001
Log per capita total income (Tk./year)	0.212** (0.034)	$X^2(1)=33.763$ Prob>X^2=0.000
Educational (children ages 5–18)		
Boys' completed schooling years (N=18,149)	0.233** (0.096)	$X^2(1)=5.596$ Prob>X^2=0.037
Girls' completed schooling years (N=16,517)	0.157* (0.088)	$X^2(1)=0.056$ Prob>X^2=0.812
Boys' study time (minutes/day) (N=18,149)	21.9** (6.546)	$X^2(1)=4.347$ Prob>X^2=0.044
Girls' study time (minutes/day) (N=16,517)	12.33** (5.649)	$X^2(1)=0.58$ Prob>X^2=0.455

Source: Khandker, Barnes and Samad (2012)
Note: Figures in parentheses are robust standard errors, corrected for clustering at the village level. Explanatory variables also include other covariates. * and ** indicate significance levels of 10% and 5%, respectively.

Table 4. Electrification impact on poverty

Estimate Type	Impact
FE-IV	0.133**
	(0.030)
Calculated poverty change from FE-IV estimates of per capita expenditure	0.130**
(from Table 7)	(0.025)
Sample mean of poverty headcount	0.453

Source: Khandker, Barnes and Samad (2012)
Note: Figures in parentheses are robust standard errors, corrected for clustering at the village level.
** indicates a significance level of 5% or more.

Table 5. Average treatment effect (ATE) of microcredit participation by gender (NHH = 1,509)

Explanatory variables	Per capita total income (Tk./month)	Per capita farm income (Tk./month)	Per capita non-farm income (Tk./month)	Per capita total expenditure (Tk./month)	Per capita food expenditure (Tk./month)	Per capita non-food expenditure (Tk./month)	Moderate poverty
Male participation	0.085	-0.198	0.422*	0.058	0.012	0.098	-0.010
	(0.64)	(-1.25)	(1.86)	(1.02)	(0.36)	(1.02)	(-0.17)
Female participation	0.158**	0.097	0.226*	0.045*	0.029	0.103**	-0.051*
	(2.65)	(0.88)	(1.95)	(1.72)	(1.48)	(2.06)	(-1.64)

Sources: World Bank–BIDS surveys, 1991/92 and 1998/99; World Bank–InM survey, 2010/2011.
Note: Income and expenditure variables are in log form.

Table 6. Estimations of policies variables on the sources of income and expenditure (log per capita)

Explanatory variables	**Total income**	**Total agr. income**	**Own farm income**	**Agr. wage income**	**Total non-agr. income**	**Non-farm enterprise income**	**Non-agr. wage income**	**Total expenditure**
Year	-0.008	1.039*	0.545	-0.714*	0.522	-0.252	-0.072	-0.095
	(-0.024)	(1.711)	(0.681)	(-1.707)	(0.720)	(-0.503)	(-0.099)	(-0.720)
% village land irrigated	0.301	-0.392	-0.911	0.814	2.531*	1.615*	1.795	-0.091
	(0.494)	(-0.387)	(-0.734)	(0.740)	(1.752)	(1.884)	(1.330)	(-0.371)
(% village land irrigated)^2	-0.685	-0.495	-0.124	-0.97	-3.193*	-2.443**	-1.776	0.219
	(-0.921)	(-0.449)	(-0.093)	(-0.747)	(-1.952)	(-2.200)	(-1.151)	(0.890)
% households with electricity in village	0.593**	0.836**	1.273***	0.427	-0.602	-0.13	-0.362	0.268***
	(2.231)	(2.051)	(2.677)	(1.270)	(-0.944)	(-0.311)	(-0.642)	(3.356)
Village has paved road within one-half km: Y=1, N=0	0.330***	0.146	-0.01	-0.184	0.698**	0.244	0.363	0.099**
	(3.028)	(0.598)	(-0.034)	(-0.936)	(2.257)	(0.925)	(1.253)	(1.981)
Number of MFIs in village	0.102**	-0.028	0.199*	-0.077	0.392***	0.628***	0.25	0.037**
	(2.114)	(-0.250)	(1.683)	(-0.644)	(2.692)	(3.820)	(1.593)	(2.477)
Number of commercial banks serving village	0.007	0.038	0.108**	-0.029	-0.02	0.007	0.019	0.004
	(0.237)	(0.605)	(2.244)	(-0.608)	(-0.298)	(0.147)	(0.328)	(0.343)
Hausman test of FE vs. RE (chi-square, 24 df)	162.8	203.1	150.1	135.9	140.64	171.2	211.4	182.1
R-squared	0.108	0.096	0.167	0.044	0.078	0.079	0.040	0.155
Observations	6446	6446	6446	6446	6446	6446	6446	6446

Source: Khandker and Koolwal (2010)
Notes: Only relevant variables are reported. t-statistics, accounting for clustering at the village level, in brackets.
*** p<0.01, ** p<0.05, * p<0.1

Table 7. Mechanisms of policy effects on sources of income: effects on factor markets

Explanatory variables	**Laspeyres agricultural output index**	**Laspeyres agricultural price index**	**Log agr. transport costs**	**Log men's daily agr. wage**	**Log men's labor days in agr.**	**Log wage costs for non-farm enterprises**	**Log men's daily non-agr.wage**	**Log men's labor days in non-agr.**
Year	-0.225	-0.079**	0.15	-0.071	-0.829*	-7.480***	-0.598	-0.034
	(-0.606)	(-2.170)	(0.418)	(-0.300)	(-1.761)	(-3.383)	(-1.158)	(-0.054)
% village land irrigated	2.072***	-0.067	-0.166	-0.203	-0.506	-11.660**	-2.01	0.989
	(3.628)	(-0.869)	(-0.390)	(-1.134)	(-0.857)	(-2.111)	(-1.57)	(1.201)
	(-2.297)	(1.441)	(-0.688)	(0.876)	(0.484)	(2.845)	(0.710)	(-0.570)
% households w/ electricity in village	0.151	0.057*	-0.362*	0.033	-0.019	0.931	-0.058	0.052
	(0.597)	(1.664)	(-1.778)	(0.396)	(-0.082)	(0.549)	(-0.156)	(0.168)
Village has paved road within ½ km	-0.006	-0.011	0.143	0.031	-0.04	-0.127	0.29	0.257*
	(-0.055)	(-0.601)	(1.489)	(1.001)	(-0.308)	(-0.109)	(0.870)	(1.658)
Number of MFIs in village	0.08*	0.003	0.016	0.024**	-0.024	-0.946*	0.012	0.175**
	(1.708)	(0.509)	(0.846)	(2.312)	(-0.378)	(-1.792)	(0.424)	(2.478)
Number of commercial banks serving village	0.024	0.001	-0.043**	0.026**	0.042*	-0.121	-0.091*	-0.041
	(0.698)	(0.341)	(-2.006)	(2.312)	(1.723)	(-0.641)	(-1.871)	(-0.933)
Hausman test (chi-square, 22 df)	75.82	115.79	151.80	202.73	193.0	66.21	96.82	189.2
R-squared	0.109	0.715	0.356	0.211	0.040	0.208	0.533	0.074
Observations	5448	5528	6322	6270	4888	968	3990	4888

Source: Khandker and Koolwal (2010)

Notes: T-statistics, accounting for clustering at the village level, in brackets. *** p<0.01, ** p<0.05, * p<0.1 . Additional variables controlled for include schooling among adult men and women in the family, sex of the household head, household land ownership. Full results are available upon request. "Labor days" refer to total days worked by men in HH in last month.

Table 8. Panel quintile estimates of the impacts policy variables on household outcomes

Outcomes	Percentile	Year	% village land irrigated	% households w/ electricity in village	Village has paved road within ½ km	Number of MFIs in village	Number of commercial banks serving village
Log per capita total income	0.2	0.180	-0.632	0.447**	0.116	0.169***	0.000
		(0.252)	(0.597)	(0.216)	(0.095)	(0.058)	(0.023)
	0.4	0.219	-0.520	0.524***	0.181**	0.055	0.028
		(0.170)	(0.368)	(0.176)	(0.081)	(0.065)	(0.021)
	0.6	0.290	0.030	0.402***	0.100	0.071	0.027
		(0.165)	(0.393)	(0.153)	(0.092)	(0.049)	(0.019)
	0.8	0.250	0.177	0.425***	0.160**	0.055	0.007
		(0.205)	(0.455)	(0.130)	(0.081)	(0.044)	(0.020)
Log per capita farm income	0.2	-0.515	-1.439	1.831***	0.206	-0.119	0.057
		(0.431)	(1.501)	(0.561)	(0.280)	(0.153)	(0.084)
	0.4	-0.679	-0.861	1.392***	0.083	-0.125	0.118***
		(0.394)	(0.908)	(0.484)	(0.167)	(0.138)	(0.050)
	0.6	-0.466	-0.426	0.712***	0.052	-0.069	0.110***
		(0.331)	(0.636)	(0.288)	(0.137)	(0.069)	(0.025)
	0.8	-0.508***	0.030	0.483***	-0.068	-0.018	0.099***
		(0.174)	(0.454)	(0.166)	(0.102)	(0.060)	(0.022)
Log per capita non-farm income	0.2	1.772	6.851	-0.648	1.261	0.819**	-0.148
		(1.854)	(6.064)	(2.359)	(1.012)	(0.403)	(0.296)
	0.4	0.526	4.160	-0.060	0.536	0.908***	-0.130
		(2.032)	(5.144)	(1.361)	(0.541)	(0.346)	(0.117)
	0.6	0.775	2.122*	-0.137	0.369	0.383*	-0.121
		(0.484)	(1.290)	(0.702)	(0.360)	(0.204)	(0.082)
	0.8	0.764	-0.053	0.270	0.390***	0.143**	-0.032
		(0.485)	(0.808)	(0.195)	(0.115)	(0.071)	(0.020)
Log HH per capita consumption expenditure	0.2	-0.076	-0.295	0.265***	0.097***	0.051***	0.025***
		(0.059)	(0.180)	(0.059)	(0.040)	(0.018)	(0.007)
	0.4	-0.025	-0.273	0.250***	0.111***	0.034	0.030***
		(0.064)	(0.193)	(0.054)	(0.039)	(0.023)	(0.006)
	0.6	0.005	-0.420**	0.282***	0.131***	0.027	0.030***
		(0.078)	(0.190)	(0.060)	(0.050)	(0.022)	(0.008)
	0.8	0.055	-0.389	0.290***	0.167***	0.005	0.030***
		(0.126)	(0.298)	(0.070)	(0.055)	(0.028)	(0.012)

Source: Khandker and Koolwal (2010)

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Standard errors in parentheses. Results include survey area dummies and other explanatory variables. The sample size for all outcome equations was 6,209.

Table 9. Predicted reduction in poverty from policies directly through impacts on consumption (percentage points)

Policies in effect			Percentile Distribution				Average (fixed-effects) impact
			20th percentile	40th percentile	60th percentile	80th percentile	
(A)	5% increase in cultivable land irrigated	Moderate poverty	0.0	1.1	5.4	8.0	1.3
		Extreme poverty	1.3	7.8	4.8	1.6	1.4
(B)	Paved road within ½ km of village	Moderate poverty	0.0	0.0	0.7	3.6	0.7
		Extreme poverty	0.1	1.3	1.7	0.9	0.6
(C)	HH microcredit participation	Moderate poverty	0.0	0.1	0.5	0.2	0.4
		Extreme poverty	0.4	1.2	0.4	0.0	0.5
(D)	Additional bank serving village	Moderate poverty	0.0	0.0	0.9	1.2	0.1
		Extreme poverty	0.0	1.0	1.5	0.0	0.04
(E)	5% increase in households having electrification in village	Moderate poverty	0.0	0.3	1.1	1.3	0.5
		Extreme poverty	0.7	1.2	1.1	0.2	0.7
(F)	Actual average yearly poverty reduction	Moderate poverty	0.0	1.7	4.5	6.8	3.1
		Extreme poverty	1.4	8.0	2.4	0.2	2.4

Source: Khandker and Koolwal (2010)
Note: Estimates stemming from statistically significant impacts in Tables 5 and 8 are in italic text.

Abstract (in Japanese)

要約

本論文は、バングラデシュに於ける構造変化と農村家計の厚生への影響について論じている。バングラデシュでは、道路、電気そして金融機関に対する公共投資が構造変化を促し、その結果農村に於ける所得の向上と多様化、消費の増大、貧困削減と教育の向上がもたらされた。データ分析によれば、村落部での MFI (マイクロファイナンス機関）が 1 支店増えることは、家計所得を 10 パーセント増大させ、消費支出を 4.7 パーセント増大させていることが分かった。また、送配電網への接続や道路への投資も所得や消費を増加させ、貧困削減に寄与していることが明らかとなった。更に、インフラへの投資の結果として、農業所得より非農業所得の方がより多く増大していた。こうした最近の進歩は、バングラデシュにおいて今まさに構造変化が進行中であることを示唆している。

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