The Spillover Effects of Public Investment: Implications for Formal and Informal Sector Firms in India*

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Abstract

This paper uses firm-level data on formal and informal production in the manufacturing sector in India to examine the sectoral consequences of government investment in public infrastructure. The average output elasticity of the flow of public investment for an informal sector firm is three times smaller than its formal counterpart. For the accumulated stock of public capital, this difference increases to a factor of seven. However, the sectoral size distribution of firms matters for the effects associated with public investment: for the formal sector, there is very little variation in the output elasticity of public investment across the size distribution of firms. On the other hand, the output elasticity for informal sector firms is strictly increasing in firm size. Further, the relationship between public investment and capital intensity in production for formal sector firms is negative, especially for firms in the middle of the size distribution. By contrast, the corresponding relationship is strictly positive and increasing with firm size for the informal sector, indicating strong complementarities.

Keywords: Informal sector, public investment, output elasticity, capital intensity, quantile regressions.

JEL Classification: E2, H4, H5

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1 Introduction

Informal production is a pervasive feature of most developing countries. As such, this sector consists of small, unregistered firms that typically produce labor intensive non-traded goods and services, with little or no access to capital markets, and limited outward labor mobility to the formal or organized sector (La Porta and Shleifer, 2014). However, this sector plays an important role in the structural evolution of these countries, accounting for about 42 percent of GDP, and absorbing between $48 - 54$ percent of the labor force (Schneider et al. 2010). Given underlying capital and labor market rigidities, informal sector firms may have to rely heavily on government-provided investment goods such as transportation, power, water, etc. for production purposes. This is especially relevant, with many public goods and services being non-excludable in developing countries. However, very little, if anything, is known about the benefits of government investment (and the resulting stock of public capital) for informal production in developing countries. In this paper, we use two large firm-level datasets on formal and informal production in the manufacturing sector in India to examine the sectoral consequences of government investment in public infrastructure.

Despite being a high-growth emerging market, the Indian economy is largely informal, with this sector contributing to 55 percent of GDP and employing about 84 percent of the non-agricultural labor force in 2010 (ILO, 2013).[1] Figures 1 and 2 depict the average firm-level capital intensity and output-labor ratio for cross-sections of manufacturing firms in the formal and informal sectors for 1999 and 2010, respectively. For example, in 2010 the capital intensity of formal sector firms exceeded that of informal firms by a factor of 5, while output per worker was higher by a factor of about 10. Interestingly, however, these gaps were smaller in 2010 than they were in 1999, suggesting that during this period, informal sector firms have indeed been able to improve both their relative usage of capital as well as labor productivity. This point is further underscored in Figure 3, which shows that the output share of the informal sector, though quite substantial, has been on a downward trend, declining from about 60 percent of GDP in 1999 to 55 percent in 2010.

One factor that may affect the output of both formal and informal sector firms is the government's provision of public infrastructure, which may serve as an input in the firm's production process. Essentially, public spending on roads, power, water, sanitation, commu-

[1] Mehrotra et al. (2014) document that between 2004-2012, a period of relatively high economic growth for India, the share of informal employment in the manufacturing sector was very large and persistent, at around 89 percent. Informal employment is a job-based concept, comprising of workers who lack access to basic legal protection, social security, and employment benefits (ILO, 2013).

nications, healthcare, and education may have complementary spillovers for private factors of production in both sectors. As such, public investment may help alleviate the credit and labor market constraints that firms typically face, especially in the informal sector. Indeed, infrastructure investment has been a centre-piece of public policy in India over the past two decades or so.[2] As shown in Figure 4, the share of total infrastructure spending in GDP increased from 5.8 percent in 2006 to about 8.4 percent in 2011, with more than 70 percent of this spending coming from the public sector. Further, this share is expected to rise to about 11 percent of GDP by 2017.[3] A critical consideration here is the effects of the rising share of infrastructure spending in India on the productivity of formal and informal sector firms. Given the relative magnitude of public investment and the share of the informal sector in India, their underlying relationship (if any) is of critical importance for the design and implementation of public policy.

In this paper, we attempt to bridge a gap between two strands of research that have evolved largely independently of each other. On the one hand, starting with the work of Aschauer (1989), a voluminous empirical literature has explored the productivity benefits of public investment in infrastructure, with a rich diversity of results.[4] However, these studies have, without exception, considered either industrialized countries (where the share of informal production is relatively small), or only for the formal sector in developing countries. On the other hand, the literature on the informal sector has mainly focused on issues of measurement of its output share (Schneider and Enste 2000, La Porta and Shleifer 2008, 2014, and Gomis-Porqueras et al. 2014), or issues pertaining to tax policy and enforcement (Rauch 1991, Ihrig and Moe 2004, Turnovsky and Basher 2009, Prado 2011, and Ordonez 2014). The quantitative importance of public investment for this type of production has generally been ignored. Consequently, by examining the benefits of government investment expenditures for private production in the formal and informal sectors, we seek to fill an important gap in this literature. This is the first contribution of our paper. Second, while most studies on public investment are conducted at a fairly aggregated level (at the level of a country, state or region), we attempt to estimate its sectoral productivity benefits at the level of the individual firm. In the case of India, for example, while Binswanger et al. (1993), Lall (1999), Mitra et al. (2002), Zhang and Fan (2004), and Hulten et al. (2006), among others, have examined the effects of public infrastructure for the formal sector at the state, district,

[2]See, for example, two recent reports by the McKInsey Global Institute (2013) and the Urban Land Institute and Ernst & Young (2013) on trends in public infrastructure spending in emerging markets like India.

[3]Source: Planning Commission of India.

[4]See, for example, Munnell and Cook (1990), Lynde and Richmond (1992), Gramlich (1994), and Holtz-Eakin and Schwartz (1995), and Devarajan et al. (1996) for some early contributions. Bom and Ligthart (2014) provide an excellent survey and meta-analysis of the recent empirical literature.

or industry level, there is no current evidence of its sectoral importance at the level of the firm. The firm-level datasets we use for our study enable us to shed light on the role of public investment and infrastructure at a much more disaggregated level than previously studied. We view this as an additional contribution to the literature.[5] Finally, from the perspective of designing public policy, it is important to know how the spillovers from public investment are dispersed over the size distribution of firms in each sector. In other words, do larger firms tend to benefit more or less relative to their smaller counterparts from government spending on public goods? This may help determine how public goods should be targeted to firms in each sector. To the best of our knowledge, our analysis is the first to shed light on this issue.

In India, the main source of information at the firm level for the formal sector is the Annual Survey of Industries (ASI), while for the informal sector it is the surveys conducted by the National Sample Survey Organization (NSSO). Though the ASI surveys firms on an annual basis, the NSSO survey is conducted once every 10 years. We use data from the 2010 round for each of these surveys, since that is the latest round for which firm-level information is currently available for *both* sectors. Restricting our coverage to only the manufacturing sector, we obtain a cross-section of $32,388$ formal-sector firms (from the ASI) and $82,748$ informal-sector firms (from the NSSO) for 2010. We proxy public investment by state-level data on government *Development Expenditures*, obtained from the Reserve Bank of India (under the category of "Capital Expenditures").[6] Here, we consider two sub-categories of expenditures: (i) *Economic Services*, which include public expenditures on transport, communications, and energy, and (ii) *Social Services*, which include expenditures on health, education, water, sanitation, and other welfare programs, and construct measures of both the *flow* of public investment, using average annual expenditures over the $2006-2010$ period, as well as its accumulated *stock* at the per-capita level for each state, using data over the period $2000-2010$. The flow measure is intended to capture the short-term effects of public investment, while the stock measure captures its effects over the longer term. Henceforth, we will interchangeably refer to the broad category of Development Expenditures as *public investment*, and the corresponding stock measure as *public capital*.

Our empirical strategy can be described as follows. First, we estimate the output elasticities of the flow of public investment and the accumulated stock of public capital at the firm level in the formal and informal sector. While this gives us information on how the

[5] Two recent studies, namely Datta (2011) and Ghani et al. (2016) examine the spatial role of India's recent expansion of its interstate system on plant-level production. These studies, however, do not distinguish between formal and informal production at the firm level.

[6] This is the highest level of disaggregatetion at which public expenditure data is available, especially for infrastructure goods.

average firm in each sector is affected by public investment, it masks the distribution of the sectoral elasticities across firms. We then employ quantile regressions (QR) to examine how the sectoral output elasticities vary across the size distribution of firms. Further, we also examine the relationship between public investment and the sectoral capital intensity in production across this size distribution. The QR approach is of critical importance from the policy perspective, since public investment may serve as a potential mechanism through which the government may aim to reduce not only the size of the informal sector, but also increase the relative usage of private capital in that sector.

The empirical analysis also raises some important econometric issues. First, it is plausible that the inclusion of public investment generates a reverse causality problem with output. Using firm-level data along with state-level government expenditures helps alleviate this problem to some extent, as it is unlikely that an individual firm will have any systematic effect on public spending at the state level. Second, while informal sector firms are generally characterized by very low geographical mobility (La Porta and Shleifer, 2014), we conduct a robustness check to examine if a formal sector firm's location choice is driven by the stock of public capital in a given state. Specifically, we check to see if younger firms in a state are associated with larger benefits from public capital (as measured by its output elasticity), relative to older firms (at the mean of the age distribution). Third, the usage of private inputs like capital and labor may be endogenous to the firm's decision to produce output. Here, we use a method suggested by Levinsohn and Petrin (2003) and Sivadasan (2009) that uses past values of estimated productivity of intermediate inputs and exploits the repeated cross-sectional nature of our dataset to control for the unobserved productivity shock at the firm-level in each sector.

Our results indicate that though the output elasticity of public investment (and capital) is positive and statistically significant for both formal and informal sector firms, there are important sectoral and distributional consequences. With the flow specification of public investment, we estimate an output elasticity of 0.088 for formal sector firms. The corresponding output elasticity for the average informal sector firm is about three times lower, at 0.027. When we consider the stock of public capital, the difference in sectoral output elasticities is much larger, with the estimate for formal firms at about 0.17, about seven times larger relative to their informal counterparts. Since the stock measure of public investment is intended to capture its long term productivity spillovers, these results suggest that the benefits accruing to formal sector firms from the accumulated stock of public capital are much larger relative to those for informal sector firms. Within the sub-categories of public investment, we find that Economic Services is associated with higher productivity spillovers relative to Social Services in both sectors, irrespective of whether we use the stock or flow

specification.

While these results only represent the effects associated with the *average* firm in each sector, it is important to consider how the estimated output elasticity of public investment varies across the size distribution of firms (measured by their gross value added). For the formal sector, we find that there is very little variation in the output elasticity of public investment across the size distribution of firms. By contrast, for the informal sector this association is strictly positive across the entire size distribution of firms. Another important issue is whether public investment influences the relative capital intensity of firms in each sector. This is especially relevant for firms in the informal sector, who tend to have extremely low capital-labor ratios. Here, we find that while public investment generally raises the capital intensity of informal sector firms, the effects are relatively stronger for the top 20 percent of firms, suggesting that the complementarity between public investment and capital intensity is the highest for the largest firms in the informal sector. This has important implications for public policy: rather than a one-size-fits-all approach, more public investment goods might be targeted for the largest informal sector firms. By contrast, public investment is negatively associated with the capital intensity of formal sector firms, suggesting that it may serve as a substitute for private factors in this sector.

The rest of the paper is organized as follows. Section 2 discusses the data and summary statistics, while Section 3 describes the empirical specification and our strategy to address the issue of endogeneity. Section 4 reports the results of the empirical analysis, and Section 5 concludes.

2 Data

We use firm-level data from two sources, namely the (i) Annual Survey of Industries (ASI), and (ii) National Sample Survey Organization (NSSO). The ASI covers formal sector firms registered under Sections 2(m)(i)-(ii) of India's Factories Act of 1948, and reports annual data on firm-level receipts, expenses, and operational (firm-specific) characteristics. The data set is a repeated cross-section, where the sampling of firms changes in every round of the survey. The NSSO's "Survey of Unincorporated Non-Agricultural Enterprises" is the predominant source of firm-level information for the informal sector in India. The survey is conducted every ten years, and provides firm-level information on the ownership category, location, and other operational characteristics. Specifically, the NSSO survey includes household proprietary and partnership enterprises that are not registered under the Factories Act of 1948 or the Bidi and Cigar Workers (Condition of Employment) Act of 1966. Public sector enterprises and cooperatives are excluded from the survey. Since the ASI reports data on an

annual frequency, while the NSSO does so on a ten-year frequency, we use the cross-sections from both surveys for 2010, which the latest available survey round for the NSSO, in order to maintain compatibility between the two sectors.

The ASI survey covers $52,243$ formal sector firms in 2010. The coverage is skewed heavily towards manufacturing firms: 93.7 percent of the firms surveyed were engaged in manufacturing. The 2010 NSSO survey of the informal sector covers $334,474$ firms. Of these, only 30 percent are in the manufacturing sector, with trading activities (36 percent) and services (34 percent) making up the rest. To ensure that the sample of formal and informal sector firms are comparable, we restrict the coverage to only manufacturing firms in both sectors. This gives us a sample of $32,388$ formal-sector firms and $82,748$ informal-sector firms in 2010.

Output for both the formal and informal sector firms is measured by the gross value added (GVA; the value of total output net of total inputs). Private capital is given by the closing balance of gross fixed capital (owned and rented) at the end of the accounting year, and labor is measured by the average number of workers employed during the accounting year. An important consideration for our empirical strategy is the value of intermediate inputs. For the formal sector, we use the value of electricity consumed at the firm level as the proxy for an intermediate input. For informal sectors firms, the value of electricity usage has many missing values, as many informal sector firms do not report electricity consumed. Therefore, we use the value of total operating expenses for the firm, which includes the combined cost of fuel, electricity, repairs, and maintenance.[7] All monetary values are expressed in terms of $2004-2005$ Indian Rupees.

Data on public investment have been collected from the State Finances Database of the Reserve Bank of India. We use state-level data on public expenditures (payments for accumulation of assets financed by borrowed funds) for two categories: (i) *Economic Services*, which include expenditures on transport, communications, and energy, and (ii) *Social Services*, which include expenditures on health, education, water and sanitation, and other welfare programs. The sum of these two categories is defined as *Total Development Expenditures*, and serves as a proxy for state-level public investment in our analysis. We scale each category of public expenditure by the population in each state, to obtain per-capita measures of government spending by state. To estimate the output elasticity of public investment for a firm's production function in 2010, we use average annual per-capita public expenditures at the state level for the past five years, i.e., for the period 2006-2010, to factor out any

[7] This could be due to informal sector firms using unauthorized or illegal sources of electricity, such as "borrowing" from a neighbor's or public power line. Reporting an aggregated number for operating expenses makes it difficult to distinguish different types of energy consumption. These costs are reported for the past-30 day reference period, which is then converted to an annual figure.

annual idiosyncratic changes to the level of public spending. This gives us an average *flow* measure for public investment.

In addition to the flow measure, we also construct a *stock* measure for public capital using the perpetual inventory method. Specifically, we use the year 2000 to pin down the initial stock of public capital, since some Indian states before 2000 were part of bigger states. The initial level of public capital stock is measured by

$$K_{G,0} = \frac{G_{I,0}}{g + \delta_G} \tag{1}$$

where $G_{I,0}$ is the flow of public investment in the initial period, g is the growth rate of public investment, and δ_G is the depreciation rate for public capital. We follow Gupta et al. (2014) and set the annual depreciation rate to 2.5 percent. The stock of public capital at the end of the time period is given by the following accumulation equation

$$K_{G,t} = K_{G,0} + \sum_{t=1}^{T} (1 - \delta_G)^t \, G_{I,t} \tag{2}$$

We compute the stock measure of public capital in 2010 by using the public expenditure flows for each year during 2000-2010 (measured at 2004-2005 prices), using the average growth rate of public investment across the sample as a lower bound to measure the initial stock. The total stock measure is then divided by the state-level population to obtain a per-capita estimate by state.

Finally, we use several other state-level controls such as state GDP (Net State Domestic Product or NSDP), total labor force, literacy rate, dependency ratio, crime rate, and total number of enterprises. The data sources for these variables are provided in the appendix.

2.1 Summary Statistics

Table 1 presents the summary statistics for firm-level characteristics for the formal and informal sectors, respectively, for 2010. Firms in the informal sector were much smaller in size (as measured by their GVA), with average capital-labor and output-labor ratios being significantly smaller than their formal-sector counterparts. For example, capital intensity (measured by the capital-labor ratio) in production was about 5 times higher for formal firms, while output per worker was higher by a factor of about 10. About 60 percent of formal sector firms were situated in urban areas, with a large majority being privately owned. About 50 percent of informal sector firms were in urban areas, with only 20 percent being registered with some government-level authority. About 70 percent of these firms were male-owned

proprietary businesses.

Table 2 lists the average state-wise public development expenditures, along with its two sub-categories (Social and Economic Services) (i) as a share of state GDP (Net State Domestic Product-NSDP), and (ii) in per-capita terms, for the period 2006-2010. On average, Indian states spent about 4.9 percent of state GDP on development expenditures, with about 69 percent being allocated to expenditures on Economic Services (transport, communications, and energy). There is significant variation in public expenditures on development across Indian States: while the north-eastern state of Manipur spends the most, with about 13 percent of state GDP allocated to public investment, the southern state of Kerala spends the least, at about 1.3 percent. This comparison is also consistent for the per-capita measure of government expenditures. The average per-capita level of development expenditures across states between 2006-2010 was about Rs. $1,611$(approximately \$24 in current prices), with Economic Services again accounting for about 69 percent of per-capita development spending. Data on the average stock of pubic capital in 2010 across Indian States is presented in Table 3. On average, the stock of public capital represented about 37 percent of state GDP, with the Economic Services sub-category accounting for about 26 percent of state GDP.

3 Empirical Specification

The main objective of our empirical analysis is to estimate the output elasticity of public investment for the formal and informal sectors. To do this, we estimate a Cobb-Douglas production function without any *a priori* restriction on the returns to scale in production:

$$Y_{ist} = A_{ist} L_{ist}^{\alpha} K_{ist}^{\beta} \tag{3}$$

where Y_{ist} denotes the flow of output for a firm i in a given sector (formal or informal), located in state s, at time t. Correspondingly, L_{ist} is the firm's labor input , K_{ist} is its stock of private capital, and A_{ist} represents a firm-sepcific productivity shock. We assume that productivity at time t for a firm i located in state s is given by

$$A_{ist} = \varepsilon_{ist} G_{st}^{\gamma} \tag{3a}$$

where G_{st} denotes state-level public investment, and ε_{ist} is an unobserved productivity shock, specific to the firm. The specifications in (3) and (3a) are consistent with the voluminous literature on the link between output and public investment, starting with Aschauer (1989)

and Barro (1990).[8] Taking logs and using firm-level Gross Value-Added (GVA) as a proxy for output, we can write the empirical specification as

$$\ln GVA_{ist} = \alpha \ln L_{ist} + \beta \ln K_{ist} + \gamma \ln G_{st} + \theta X_{ist} + \rho Z_{st} + \varepsilon_{ist} \tag{4}$$

In (4), output is measured by firm-level Gross Value-Added (GVA), and α, β, and γ are the output elasticities of labor, private capital, and public investment, respectively. Since the unit of observation is the firm, X is a vector of firm-level characteristics that include age of the firm, type of ownership, industrial category (NIC 2-digit level), and geographical location (rural or urban). We use the same set of characteristics for both formal and informal sector firms, with the addition of registration status for informal sector firms. Additionally, the vector Z controls for state-level factors other than public investment that may have an effect on the firm's output. It includes state GDP (Net State Domestic Product or NSDP), total labor force, literacy rate, dependency ratio, crime rate, and the total number of enterprises in the state.[9]

One issue with the production function approach in (4) is that it may produce biased estimates of output elasticities if there exists reverse causality between the private factors of production and output. We use a method developed by Levinsohn and Petrin (2003) and Sivadasan (2009) to address this issue. The source of endogeneity in the specification (4) is the unobserved productivity shock that is observed by the firm, but not by the econometrician. This may induce the firm to choose private inputs (capital and labor) endogenously. Hence, the error term that contains the unobserved productivity shock may be correlated with the choice of private inputs. To fix ideas, we start by decomposing the error term (ε_{ist}) into two components

$$\varepsilon_{ist} = \omega_{ist} + \eta_{ist} \tag{5}$$

where ω_{ist} is the productivity shock observed by the firm but not by the econometrician, and η_{ist} is the classical error term or the productivity shock unobserved by both the firm and the econometrician. The issue here is that the firm might take the productivity shock

[8] Two issues need to be clarified with respect to specification (3) and (3a). First, even though we use cross-sectional data for 2010 for our estimation, the time subscript t is needed to address issues related to endogeneity. As we will discuss subsequently, cross-sectional data for 1999 will be used to estimate past sectoral productivity. Second, the even though the variable G_{st} in (3a) refers to the state-level *flow* of public investment, we will also consider a *stock* measure of public capital at the state level.

[9] It is important to note here that there are alternative approaches to estimate output elasticites of factors of production. For example, the cost function approach, based on duality theory, estimates a a translog cost function where, in our specific case, public investment would be included as an unpaid factor of production. Direct estimation of this cost function would produce an estimate of the marginal benefit (or cost reduction) from public investment. The elasticity of public investment would then be backed out with the help of duality theory; See, for example, Lynde and Richmond (1993).

ω_{ist} into account when making input choices. Since this unobserved productivity shock is included in the composite error term, ε_{ist}, specification (4) violates the basic assumption of OLS, i.e., $E\left(\mathbf{x}'\varepsilon_{ist}\right) = 0$, where $\mathbf{x}'$ is a vector for the private inputs K and L. This renders the OLS estimates inconsistent. Levinsohn and Petrin (2003) develop a strategy that uses intermediate inputs to control for the unobserved productivity shock. Specifically, they assume a demand function for intermediate inputs of the form

$$m_{ist} = m\left(\omega_{ist}, K_{ist}\right) \tag{6}$$

where $m\left(.\right)$ is the firm's intermediate input demand function, which is assumed to be monotonically increasing in the firm's unobserved productivity (ω_{ist}). Private capital, being a state variable, determines the optimal choice of intermediate inputs. Levinsohn and Petrin (2003) assume that input and output prices are constant across firms. The monotonicity assumption allows us to invert the input demand function and write the unobserved productivity shock as a function of intermediate input and private capital:

$$\omega_{ist} = \omega\left(m_{ist}, K_{ist}\right) \tag{7}$$

Equation (7) can be written as a polynomial function

$$\omega_{ist} \equiv \omega\left(m_{ist}, K_{ist}\right) = \sum_{n=0}^{3}\sum_{j=0}^{3-n}\delta_{nj} m_{ist}^{j} K_{ist}^{n} \tag{8}$$

Combining (7) with (5), and using in (4), we can write

$$\ln GVA_{ist} = \alpha \ln L_{ist} + \gamma \ln G_{st} + \theta X_{ist} + \rho Z_{st} + \phi\left(m_{ist}, K_{ist}\right) + \eta_{ist} \tag{9}$$

where, $\phi\left(m_{ist}, K_{ist}\right) = \beta \ln K_{ist} + \omega\left(m_{ist}, K_{ist}\right)$. Note that the coefficient on private capital (β) cannot be identified from equation (9) because of the function $\phi(.)$. In order to identify this coefficient, Levinsohn and Petrin (2003) use a final identification restriction by assuming that the productivity shock ω_{ist} is governed by a first order Markov process:

$$\omega_{ist} = E\left(\omega_{ist}|\omega_{is,t-1}\right) + \xi_{ist} \tag{10}$$

where ξ_{ist} is an innovation to productivity that is uncorrelated with K_{ist}. The underlying economic interpretation is that a firm's current productivity can be predicted by its produc-

tivity in the previous period. This assumption implies the following moment condition

$$E\left[\xi_{ist}K_{ist}\right] = E\left[K_{ist}\left\{\omega_{ist} - E\left(\omega_{ist}|\omega_{is,t-1}\right)\right\}\right] \tag{11}$$

The moment condition (11), used by Levinsohn and Petrin (2003) to identify the coefficient on capital relies on panel information (estimate of last period's productivity, $\omega_{is,t-1}$), which is not available for our case, given the limitation of our dataset. However, given that we have repeated cross-section data comprising of different samples of firms drawn for the years 1999 and 2010 (two cross sections where *both* the ASI and NSSO data are available), we can use a modification to (11) proposed by Sivadasan (2009). Specifically, with repeated cross-section data we can estimate the average productivity for a particular industry in a particular state for the previous time period, which in our case is the 1999 round for both surveys (for brevity, we refer to this combination as a "cell") and use that estimate in place of $\omega_{is,t-1}$ in (11):

$$\bar{\omega}_{t-1} = \frac{1}{S_{ji}}\sum_{q=1}^{s_{ji}}\omega_{q,t-1} \tag{12}$$

where S_{ji} is the number of firms in a particular cell. $\omega_{q,t-1}$ is the firm-level estimate of the unobserved productivity shock located in a particular cell in the previous period. Essentially, the identification process involves three steps. First, we estimate the individual firm's unobserved productivity for the year 1999.[10] Second, we find the average productivity within a NIC 3-digit industry code and within a particular state. The last step involves matching the average productivity of a particular cell in year 1999 to the firm located in same industry and the same state (i.e., in the same cell) in the year 2010. This process allows us to write (10) as

$$\omega_{ist} = E\left(\omega_{ist}|\bar{\omega}_{t-1}\right) + \xi_{ist} \tag{13}$$

According to (13), firm-level productivity for the current year can be predicted by the previous period's average "cell" productivity. Now, the coefficient on private capital (β) can be identified by the following second step regression

$$v^*_{ist} = \beta K_{ist} + E\left(\omega_{ist}|\bar{\omega}_{t-1}\right) + \eta^*_{it} \tag{14}$$

where, $v^*_{it} = \ln GVA_{ist} - \alpha \ln L_{ist} - \gamma \ln G_{st} - \theta X_{ist} - \rho Z_{st}$, and $\eta^*_{ist} = \omega_{ist} - E\left(\omega_{ist}|\bar{\omega}_{t-1}\right) + \eta_{ist}$.

Another econometric issue relates to the potential for reverse causality between a firm's output and public investment. While the limitations of our dataset prevent us from fully

[10] Table A2 in the Appendix provides the summary statistics for the formal and informal sectors for the year 1999.

addressing this issue, we do conduct a robustness check in Section 4.5, examining the sensitivity of the output elasticity of public capital to the age distribution of firms in a given state.[11] The idea here is that states with higher levels of infrastructure may attract new firms, with younger firms being associated with a higher output elasticity relative to their older counterparts (say, those at the mean of the age distribution). As we show later, we do not find any evidence that a firm's location choice is driven by state-level public investment. Further, since our unit of analysis is the firm, it is unlikely that an individual firm's output will have any influence on the level of public investment in a given state.[12]

4 Results

In this section, we report the results from our empirical analysis. Specifically, we start with an OLS estimation of the output elasticity of public investment and its sub-categories (for both the flow and stock measures) for firms in the formal and informal sectors. Given the possibility of biased estimates from the OLS specification, we then re-estimate the sectoral output elasticities using the method proposed by Levinsohn and Petrin (2003) and Sivadasan (2009) (henceforth LP-S), and described in (5)-(14) above. Next, we use quantile regressions to examine the distributional consequences of public investment for the formal and informal sectors. Here, we (i) estimate the sectoral output elasticities of public investment and (ii) its effects on the capital intensity of production in each sector across the sectoral size distribution of firms, based on their gross value-added (GVA). The results are reported in Tables 4-9 and Figures 5-12. All standard errors reported in the tables are heteroskedasticity-robust.

4.1 Formal Sector

We begin our empirical analysis with an OLS estimation of the output elasticity of the private factors of production (capital and labor) and public investment for firms in the formal sector. Table 4 reports the results of regressing firm-level GVA on the private and public inputs, along with controls at both the level of the firm and the state. Column (1) reports the results for the aggregated category of public investment, i.e., development expenditures. Columns (2) and (3) report results for its two sub-categories: social services and economic services, respectively. The OLS results suggest output elasticities of labor and private capital for formal sector firms of about 0.78 and 0.33, respectively, reflecting the presence of increasing

[11] These limitations include the cross-sectional nature of our data, and the fact that informal sector firms are surveyed by the NSSO once every ten years.

[12] However, if the unit of observation had been at the industry or state level, we would not have been able to make this assumption.

returns to scale in the private factors of production (note that the empirical specification does not impose any *a priori* restriction on returns to scale in the production function). As for the public input, the aggregated category of development expenditures has an output elasticity of about 0.03, indicating a small, but positive effect of public investment on firm-level output in the formal sector. The sub-category of economic services expenditures has a similar elasticity measure, and social services expenditures are not statistically significant.

As mentioned in the previous section, the OLS estimates reported in Table 4 can be biased, due to the endogeneity of private inputs in production. To address this issue, we use the strategy outlined in (5)-(14), developed by Levinsohn and Petrin (2003) and Sivadasan (2009), to obtain more robust estimates of the output elasticities of the private and public inputs. The results from this estimation (labeled LP-S) for formal-sector firms are presented in Table 5. Correcting for the endogeneity of private inputs alters the results significantly: for example, the returns to scale for the private inputs are now much closer to 1, with the output elasticities for labor and capital being about 0.66 and 0.37, respectively. For public investment, the estimated elasticities are now much larger than those suggested by the OLS estimation. Development expenditures are associated with an elasticity of 0.088, while those for the sub-categories of economic and social services are also higher (and statistically significant) at 0.077 and 0.045, respectively.

Table 6 presents the results from a LP-S estimation of the production function, but with government investment measured as a per-capita *stock* variable, rather than a flow. The estimated elasticities associated with the aggregated and sub-categories of government expenditure turn out to be much larger with the stock specification. For example, the output elasticity of development expenditure is now about 0.17, and that for economic services is about 0.16, indicating that the productivity benefits from the accumulated stock of public capital significantly exceed those from the flow of public investment for formal sector firms.

4.2 Informal Sector

Tables 7 and 8 report the estimation results for the output elasticities of private and public inputs for informal sector firms, along with firm and state-level controls. Table 7 reports results from the OLS estimation, while Table 8 reports the LP-S estimation, correcting for the endogeneity of private inputs. Comparing the OLS results from Tables 4 and 7, we see that informal sector firms have a significantly higher (lower) output elasticity for labor (private capital) relative to the formal sector. As with the OLS results for the formal sector, the informal sector also exhibits increasing returns to scale in the private inputs. The productivity effect of the public input, however, is not statistically significant, in contrast to

its positive impact on formal sector firms. Within the sub-categories of public expenditures, while economic services do not have any systematic effect on private productivity, social services expenditures do have a significant, but negative effect on firm-level productivity.

Given the endogeneity issue with the OLS estimation, we turn our focus to Table 8, which corrects for this problem, using the LP-S methodology. As with our results for the formal sector, the results change significantly. First, with respect to the private inputs, we get output elasticities of 0.63 and 0.32 for labor and capital, respectively. Interestingly, in contrast to firms in the formal sector, returns to scale for the private inputs in informal sector production is less than one. The output elasticity of development expenditures is about 0.027, which is about three times smaller than the corresponding elasticity for formal sector firms. Similarly, the output elasticity with respect to economic services expenditures for informal firms is lower than their formal counterparts by a factor of about two. On the other hand, while social services expenditures had a positive impact on the productivity of formal firms, its effect on informal firms is negative and statistically significant. The intuition behind this result may have to do with the composition of social services expenditures: health, education, water and sanitation, and welfare programs. States that spend more on this category might have a more educated and healthy workforce, thereby benefiting formal sector firms at the expense of their informal counterparts (by making labor more expensive for the less productive informal sector firms).

Table 9 presents the LP-S estimation of the informal sector production function, but with the stock measure of public investment. Qualitatively, the results in Table 9 are consistent with the results for the flow specification: while the stock measure for aggregate development expenditures and the sub-category of economic services have positive and significant coefficients, social services expenditures have a negative and significant association with output. However, quantitatively, the difference in magnitudes of these sectoral effects are now much larger. For example, with the stock measure, the output elasticity for informal sector firms is lower than its formal sector counterpart by a factor of about seven, with respect to development expenditures (for the flow measure it was about three). For the economic services category, the contribution of public investment for the informal firm is more than four times lower than for the formal firm (for the flow measure it was about two). These results suggest that the benefits of the accumulated stock of public capital are much stronger for the formal sector than the informal sector, relative to the benefits from the flow measure of public investment.

4.3 Firm Characteristics

The firm-level control variables we use for our empirical specification include a firm's age, location (rural versus urban), and ownership status (government versus private for the formal sector, and proprietary versus partnership for the informal sector). Additionally, we use registration status for informal sector firms. Since all formal sector firms, by definition, are already registered under the Factories Act, the focus for this variable is on the informal sector. Specifically, though informal sector firms are not registered under the Factories Act, they might still be registered with other local government entities like a municipal corporation or village panchayat. Therefore, the registration status for informal sector firms includes any kind of registration *outside* of the Factories Act. In our sample, only about 20 percent of informal sector firms fall under this category.

The discussion of firm-level characteristics draws on the LP-S estimation results from Table 5 (formal sector) and Table 8 (informal sector). The age of a firm is not a systematic predictor of productivity for formal sector firms. Informal sector firms, however, are adversely affected by age, though the magnitude of the coefficient is very small, and probably not economically meaningful. Both formal and informal sector firms are affected by their location: firms in both sectors that are located in rural areas produce, on average, about 10 percent less output (in terms of GVA) than their urban counterparts. Accessibility to ports, airports, roads, and transportation infrastructure, as well as high quality labor and capital could be major factors driving this result. Registration status is an important determinant of the output for informal sector firms: firms that are registered under some authority (outside of the Factories Act), produce, on average, about 16 percent more output relative to firms that are not registered. This suggests that registration might improve access for informal sector firms to credit and final goods markets, thereby improving their GVA. However, the fact that a majority (80 percent) of the informal sector firms in our sample are not registered indicates the existence of other barriers to registration, such as bureaucracy, corruption, and potential benefits from avoiding tax obligations. Finally, privately owned firms in the formal sector produce about 23 percent less output than public sector firms. For the informal sector, proprietary firms owned by the females produce about 43 percent less output compared to corresponding firms owned by males. Partnerships involving members of the same household are less productive relative to those that involve members from different households. Trusts and self-help groups also tend to have lower output within the informal sector.

4.4 Distributional Effects

An important consideration in the context of our empirical strategy is that the point estimates of the output elasticity of public investment reported in Tables 4-9 represent the effects for an *average* firm in each sector. However, it is plausible that the effect of public investment may vary across the size distribution of firms. In other words, do small firms in each sector benefit more or less from public investment, relative to larger firms? Another related issue is the relationship between factor usage, specifically capital intensity in production, and public investment. In other words, are there complementary effects between public and private inputs and, if so, how do they vary across the size distribution of firms in each sector? To understand this better, we employ a quantile regressions (QR) analysis for firms in each sector, by constructing a size distribution of firms based on their GVA, and then estimating the firm-level (i) sectoral output elasticities of public investment and (ii) effects on the capital-labor ratio in each quantile in this distribution. We use the same set of firm and state-level controls as in Sections 4.1 and 4.2.

4.4.1 Sectoral Output Elasticity

Figures 5-10 graphically illustrate how the quantile elasticities of public investment (measured by per-capita development expenditures at the state level for both the flow and stock measures) vary across the size distribution of firms in the formal and informal sectors, with the shaded areas denoting the confidence intervals.[13] For formal sector firms, the effect of public investment (flow specification) is more or less even across the firm's size distribution, with elasticities in the range of 0.07-0.09, and with very little variation (Figure 5). For the stock specification, however, the productivity benefits of public investment do not show any trend for the bottom 60 percent of formal sector firms, but increase very gradually for firms in the top 40 percent of the size distribution. Figures 6 and 7 depict the quantile output elasticities for the two sub-categories of public investment, namely Economic and Social Services. Here, we see that while the quantile elasticity for Economic Services increases with firm size, the opposite is true for the Social Services category. When aggregated, Figures 6 and 7 help us understand why the there is so little variation in the output elasticity for Development Expenditures across the size distribution of formal sector firms, with the quantile elasticities for the two sub-categories moving in roughly opposite directions. It also underscores the fact that formal sector firms derive larger benefits from government spending on Economic Services (transport, communications, energy), relative to Social Services (health, education, water and sanitation. etc.).

[13] The quantitaitve results, in table format, are reported in the Appendix.

By contrast, Figures 8-10 indicate that for informal sector firms the picture is quite different. Here, the output elasticity of public investment increases persistently with firm size, irrespective of the flow or stock measure for public investment, with the largest firms benefitting the most from government investment. Further, in contrast to the case of formal sector firms, the quantile elasticities for both Economic and Social Services increase with firm size in the informal sector.[14] Even though informal sector firms use less capital per worker than their formal counterparts, larger firms may derive strong complementary effects from public investment. Smaller informal firms, with very little capital and labor, may not be able to appropriate the productivity spillovers generated by public investment expenditures. For example, the largest informal sector firms may have more access to credit, and hence private capital, than their smaller counterparts. Consequently, they may be able to better utilize infrastructure goods and services such as roads and electricity, which in turn yields a relatively larger output elasticity with respect to public investment goods.

4.4.2 Capital Intensity in Production

Since public investment generates productivity spillovers for the firm's production function, and important question is how it affects the firm's relative usage of private capital, i.e., its capital intensity, measured by the capital-labor ratio. The issue at hand is whether public investment can substitute for or complement the usage of private factors. This is especially relevant for the production structure of firms in the informal sector, which are characterized by very low levels capital intensity, as documented by La Porta and Shleifer (2014). Therefore, low capital-labor ratios in this sector may be an impediment towards "formalization." From a policy perspective, it is natural to ask if public investment plays a role in increasing this ratio for informal sector firms. Figures 11-12 present some evidence on this question, for both formal and informal sector firms across their size distribution, for both the flow and stock measures of public investment.

Figure 11 illustrates the quantile effects of public investment on the capital intensity of formal sector firms. Surprisingly, public investment (both flow and stock) is negatively associated with the capital intensity of formal sector firms, suggesting that it may be a substitute for private factors. The negative effect is the largest for firms in the middle of the size distribution, giving the plot for the quantile elasticities a non-monotonic U-shaped curvature. In sharp contrast, the relationship between public investment and capital intensity for informal sector firms, as depicted in Figure 12, is strictly positive across the size

[14] Figures A1 and A2 in the Appendix plots the quantile output elasticities for two individual components of the Economic Services sub-category for each sector, namely spending on transport and energy (for the stock specification). As can be seen from these figures, the direction of the results are consistent with those for the more aggregated categories of public investment.

distribution, with larger firms benefitting significantly more than their smaller counterparts. For example, for the top 20 percent of firms in this sector, an increase in public investment is associated with about a 20 percent increase in their capital intensity, which is almost twice as large as the effect for firms in the bottom 20 percent of firms. Figure 12 indicates that public investment can play a complementary role in influencing the usage of private factors in the informal sector, thereby pointing to an important role for productive public goods in this sector.[15]

4.5 Robustness: Self-Selection for Formal Sector Firms

An econometric issue that arises in the context of our firm-level analysis is geographical self-selection of firms. Essentially, a firm may choose to be located in a state with a larger stock of public infrastructure, leading to a biased estimate for the corresponding output elasticity. This problem is more relevant for formal sector firms, who have more mobility than informal firms (La Porta and Shleifer, 2014). Moreover, it is the *stock* of accumulated public capital that is more relevant for a firm's location choice, rather than the annual flow of public investment (which may be subject to contemporaneous fluctuations).

To address this issue, we estimate the output elasticity of the stock measure of public capital for formal sector firms in our sample, conditional on their age in a given state (i.e., duration of operation), and then compare these elasticities to the corresponding elasticity of firms at the mean of the age distribution of firms. Essentially, the idea is that if the stock of public capital is indeed a determinant in the firm's decision to locate in a particular state, then a younger firm (with presumably better technology), would have a higher output elasticity relative to an older firm in the same state. To see this, we consider two categories of formal sector firms in each state: those that have been operating in the state for less than (i) one year, and (ii) three years, and compare their output elasticities with respect to public capital with those for firms at the mean of the age distribution. This decomposition gives us 570 firms who have been in a state for less than a year, and 3,564 firms that have been in a state for less than three years. The mean age of formal sector firms in our sample is about 17 years, with 20,247 firms in that category. Table 10 reports the output elasticity of public capital (per-capita stock measure) across the age distribution of formal sector firms, using the LP-S method. As can be seen, for firms less than a year old, the elasticity measure is higher than for those at the mean, but is not statistically significant. For firms that are less

[15] Figures A3-A6 in the Appendix plots the association between the two sub-categories of public investment (Economic and Social Services) and capital intensity for formal and informal sector firms. The overall direction of the effects remain similar to the aggregated level of public investment, for both the flow and stock specifications.

than 3 years of age, the output elasticity is very close to that for firms at the mean of the age distribution. Therefore, there is no suggestive evidence that formal sector firms self-select into states with a larger stock of public capital.

5 Conclusions

Government investment in infrastructure goods such as roads, transportation, water and sanitation, and energy is a key element of public policy is developing countries. At the same time, these countries are, on average, are characterized by a significant amount of production that takes place in the informal sector, populated by small, unregistered firms that produce non-traded goods and services that are highly labor intensive . As such, these firms have very low capital intensity in production and face significant barriers to outward labor mobility, relative to the formal sector. One possible way in which productivity may be influenced in this sector is through government provision of public goods such as infrastructure, which are often non-excludable in developing countries. However, very little is known about the spillovers generated by public investment for the informal sector, both with respect to output produced, as well as factor usage. In this paper, we use two firm-level datasets from India's manufacturing sector to estimate the output elasticities of public investment for firms in the formal and informal sector. We also examine how these output elasticities and relative capital intensity vary across the size distribution of firms in each sector.

Our results indicate that while public investment is an important factor in influencing firm-level productivity in both the formal and informal sectors, there are important sectoral differences. First, the average output elasticity of the flow measure of public investment for an informal sector firm is lower than that of its formal counterpart by a factor of about three. When we consider a stock measure for public investment, this difference increases to a factor of seven, indicating that the benefits of the accumulated stock of public capital are much larger for firms in the formal sector. The sub-category of Economic Services, containing public expenditures on goods such as transport, communications, power, etc. is associated with systematically larger output elasticities relative to Social Services, which include spending on education, healthcare, water and sanitation, etc. In estimating these sectoral elasticities, we use a method proposed by Levinsohn and Petrin (2003) and Sivadasan (2009) to control for firm-level endogeneity in the usage of private factors of production. Second, results from our quantile regressions suggest that the size distribution of firms in each sector matter for the effects associated with public investment. For example, for formal sector firms, there is very little variation in the output elasticity of public investment across their size distribution. On the other hand, the corresponding output elasticity for informal

sector firms is strictly increasing in firm size. Further, the relationship between public investment and the capital intensity in production for formal sector firms is negative, with the effect being the most negative for firms in the middle of the size distribution. This suggests that public investment may be a substitute for private factors in formal production. By contrast, the relationship between public investment and capital intensity is strictly increasing with firm size for the informal sector, indicating strong complementarities. Again, the largest firms in the informal sector benefit the most from public investment. Finally, we do not find any evidence that the location choice for firms in the formal sector is driven by the level of public capital in a given state.

From a policy perspective, our results suggest that firms in the informal sector do indeed benefit significantly from public investment, even though these benefits are relatively smaller on average than those for their counterparts in the formal sector. The largest firms in the informal sector benefit the most from public investment, both with respect to the overall output elasticity as well as their capital intensity. Consequently, an effective way to increase the productivity and capital usage of informal sector firms might be to send more public investment goods to the largest firms in that sector. This may have the added advantage of lowering the relative size of the informal sector, by helping to formalize the largest and most productive firms, rather than a one-size-fits-all approach.

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Table 1: Summary Statistics for Formal and Informal Sectors, 2010

	Formal		Informal	
	mean	sd	mean	sd
Gross value added (GVA) (in thousand Rs)	97603.0	677048.7	86.7	158.0
Net Fixed Assets (K) (in thousand Rs)	169607.2	2021480.7	231.8	840.7
Total workers (L)	192.2	697.1	2.2	1.7
K/L (in thousand Rs)	476.8	2771.8	91.9	221.1
Y/L (in thousand Rs)	346.5	3029.7	34.0	33.9
Rural	0.4	0.5	0.5	0.5
Age of firm	17.1	13.0	12.3	9.4
Registered under any act/ authority?	.	.	0.2	0.4
Ownership				
Wholly Central Government	0.002	0.05		
Wholly State and/or Local Govt	0.007	0.09		
Central Government and State jointly	0.002	0.04		
Joint Sector Public	0.007	0.08		
Joint Sector Private	0.009	0.09		
Wholly Private Ownership	1.0	0.2		
Proprietary (male)	.	.	0.7	0.4
Proprietary(female)	.		0.3	0.4
Partnership with members of the same household			0.02	0.1
Partnership between members from different households			0.005	0.07
Not known			.	.
Self-help Group			0.0008	0.03
Trusts			0.00007	0.009
Others			0.0001	0.01
Observations	32388		82748	

Table 2: Average State-wise Public Development Expenditures (2004-05 Rs)

Flow measure, 2006-2010	Average Share (% of NSDP): 2006-2010			Average per capita: 2006-2010		
States	Development	Social	Economic	Development	Social	Economic
JAMMU AND KASHMIR	13.0	4.8	8.2	3259.2	1191.5	2067.7
HIMACHAL PRADESH	4.9	1.9	2.9	2008.9	784.0	1224.9
PUNJAB	1.8	0.5	1.2	800.4	252.7	547.7
HARYANA	2.4	0.7	1.7	1324.9	406.5	918.4
DELHI	3.6	1.1	2.5	3031.7	899.3	2132.4
RAJASTHAN	2.9	1.3	1.6	744.3	336.6	407.7
UTTAR PRADESH	5.1	1.0	4.1	849.6	165.6	684.0
BIHAR	5.6	0.7	4.9	618.1	78.9	539.1
NAGALAND	9.0	3.5	5.5	2828.0	1109.4	1718.7
MANIPUR	19.0	7.2	11.8	4300.6	1630.7	2669.9
TRIPURA	7.6	2.9	4.6	2188.0	845.4	1342.6
MEGHALAYA	4.5	1.8	2.8	1435.0	553.1	881.8
ASSAM	3.1	0.5	2.6	622.2	91.9	530.2
WEST BENGAL	1.2	0.3	0.9	344.3	81.8	262.5
ORISSA	2.6	0.6	2.0	645.8	149.2	496.5
MADHYA PRADESH	5.3	0.9	4.4	1075.1	174.7	900.4
GUJARAT	2.7	0.6	2.1	1247.1	296.9	950.2
MAHARASTRA	2.3	0.3	2.0	1176.1	139.7	1036.4
ANDHRA PRADESH	3.7	0.6	3.1	1340.1	229.0	1111.1
KARNATAKA	3.9	1.0	2.9	1468.8	378.6	1090.2
GOA	3.7	1.0	2.7	3885.6	1028.2	2857.4
KERALA	1.4	0.4	1.0	590.6	173.7	417.0
TAMIL NADU	2.8	0.7	2.1	1267.6	314.1	953.5
Mean	**4.9**	**1.5**	**3.4**	**1611.0**	**491.8**	**1119.1**
S.D	**4.1**	**1.7**	**2.5**	**1119.6**	**432.9**	**716.7**
Observations	23	23	23	23	23	23

Table 3: State-wise Public Development Expenditures (2004-05 Rs)

Stock measure, 2010	Share (% of NSDP): 2010			Per capita: 2010		
States	Development	Social	Economic	Development	Social	Economic
JAMMU AND KASHMIR	86.6	27.7	58.9	24831.3	7940.3	16891.0
HIMACHAL PRADESH	41.4	17.6	23.8	19594.7	8311.7	11283.1
PUNJAB	16.5	3.4	13.1	8486.8	1747.2	6739.6
HARYANA	16.2	4.1	12.1	10843.5	2767.3	8076.2
DELHI	29.4	8.9	20.5	28272.2	8548.5	19723.7
RAJASTHAN	23.5	9.7	13.7	7390.6	3059.6	4331.0
UTTAR PRADESH	33.4	5.5	27.8	6284.0	1042.8	5241.2
BIHAR	35.9	4.5	31.4	4856.5	612.1	4244.4
NAGALAND	83.3	34.5	48.8	27375.2	11334.4	16040.8
MANIPUR	118.8	46.1	72.7	27782.9	10780.4	17002.4
TRIPURA	75.0	28.6	46.3	23749.5	9075.0	14674.5
MEGHALAYA	47.5	18.3	29.2	16247.4	6260.1	9987.3
ASSAM	26.6	3.6	22.9	6225.4	846.4	5379.0
WEST BENGAL	14.2	2.0	12.2	4711.1	651.9	4059.2
ORISSA	21.7	5.1	16.6	6075.6	1432.2	4643.5
MADHYA PRADESH	36.5	5.8	30.7	8280.3	1320.8	6959.5
GUJARAT	21.5	5.8	15.7	11935.2	3239.0	8696.2
MAHARASTRA	20.4	2.0	18.4	11968.2	1193.8	10774.3
ANDHRA PRADESH	29.8	5.3	24.5	12681.2	2267.5	10413.7
KARNATAKA	26.5	6.3	20.2	11592.6	2758.6	8834.0
GOA	24.8	7.1	17.7	29143.2	8300.0	20843.2
KERALA	10.8	2.6	8.2	5246.2	1249.1	3997.1
TAMIL NADU	16.5	5.3	11.2	9046.4	2913.9	6132.5
Mean	**37.3**	**11.3**	**25.9**	**14027.0**	**4245.8**	**9781.2**
S.D	**27.6**	**11.9**	**16.4**	**8626.3**	**3611.3**	**5305.1**
Observations	23	23	23	23	23	23

Table 4: OLS Estimation of Production Function, Formal Sector with Flow Measure of Public Investment

Sector: Formal			
Dependent variable: *ln GVA*	(1)	(2)	(3)
ln L	0.778***	0.778***	0.778***
	(0.005)	(0.005)	(0.005)
ln K	0.325***	0.325***	0.325***
	(0.003)	(0.003)	(0.003)
ln Development expenditure per capita	0.034*		
	(0.015)		
ln Social Services expenditure per capita		0.003	
		(0.014)	
ln Economic Services expenditure per capita			0.033*
			(0.014)
Firm-level controls			
Age of the firm	0.002***	0.001***	0.002***
	(0.000)	(0.000)	(0.000)
Rural	-0.110***	-0.110***	-0.110***
	(0.011)	(0.011)	(0.011)
Ownership			
Wholly State and/or Local Govt	-0.302**	-0.302**	-0.301**
	(0.114)	(0.114)	(0.114)
Central Govt and State jointly	-0.107	-0.106	-0.106
	(0.150)	(0.150)	(0.150)
Joint Sector Public	-0.317**	-0.317**	-0.317**
	(0.116)	(0.116)	(0.116)
Joint Sector Private	-0.305**	-0.304**	-0.305**
	(0.112)	(0.112)	(0.112)
Wholly Private Ownership	-0.303**	-0.302**	-0.302**
	(0.101)	(0.101)	(0.101)
State-level controls			
Log of NSDP per capita (2010)	0.074***	0.089***	0.075***
	(0.020)	(0.020)	(0.020)
Log of Total Labor Force (2010)	0.542***	0.549***	0.539***
	(0.025)	(0.026)	(0.026)
Literacy rate (2011)	0.012***	0.012***	0.012***
	(0.001)	(0.001)	(0.001)
Old-age Dependency ratio (2001)	-0.033***	-0.036***	-0.033***
	(0.004)	(0.004)	(0.004)
Crime rate per hundred (2010)	-0.744***	-0.741***	-0.730***
	(0.081)	(0.085)	(0.081)
Share of Unregistered Manufacturing (in total manufacturing)	-0.001*	-0.001**	-0.001*
	(0.001)	(0.000)	(0.001)
Log of total number of enterprises	-0.511***	-0.521***	-0.512***
	(0.024)	(0.023)	(0.023)
Constant	5.364***	5.514***	5.433***
	(0.295)	(0.322)	(0.287)
Industry dummies (NIC 2-digit)	Yes	Yes	Yes
N	32388	32388	32388

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: . LP-S Estimation of Production Function, Formal Sector with Flow Measure of Public Investment.

Sector: Formal			
Dependent variable: *ln GVA*	(1)	(2)	(3)
ln L	0.664***	0.665***	0.665***
	(0.005)	(0.005)	(0.005)
ln K	0.369***	0.369***	0.369***
	(0.002)	(0.002)	(0.002)
ln Development expenditure per capita	0.088***		
	(0.015)		
ln Social Services expenditure per capita		0.045***	
		(0.014)	
ln Economic Services expenditure per capita			0.077***
			(0.013)
Firm-level controls			
Age of the firm	0.001*	0.001	0.001*
	(0.000)	(0.000)	(0.000)
Rural	-0.105***	-0.104***	-0.106***
	(0.010)	(0.010)	(0.010)
Ownership			
Wholly State and/or Local Govt	-0.186	-0.190	-0.184
	(0.108)	(0.108)	(0.108)
Central Govt and State jointly	-0.060	-0.062	-0.057
	(0.142)	(0.142)	(0.142)
Joint Sector Public	-0.254*	-0.254*	-0.253*
	(0.110)	(0.110)	(0.110)
Joint Sector Private	-0.248*	-0.247*	-0.247*
	(0.106)	(0.106)	(0.106)
Wholly Private Ownership	-0.225*	-0.225*	-0.223*
	(0.095)	(0.095)	(0.095)
State-level controls			
Log of NSDP per capita (2010)	-0.057**	-0.035	-0.050**
	(0.020)	(0.019)	(0.019)
Log of Total Labor Force (2010)	0.402***	0.438***	0.397***
	(0.024)	(0.025)	(0.024)
Literacy rate (2011)	0.015***	0.016***	0.015***
	(0.001)	(0.001)	(0.001)
Old-age Dependency ratio (2001)	-0.024***	-0.028***	-0.024***
	(0.004)	(0.004)	(0.004)
Crime rate per hundred (2010)	-0.621***	-0.685***	-0.586***
	(0.077)	(0.081)	(0.077)
Share of Unregistered Manufacturing (in total manufacturing)	-0.002**	-0.002***	-0.001**
	(0.000)	(0.000)	(0.000)
Log of total number of enterprises	-0.396***	-0.423***	-0.401***
	(0.022)	(0.022)	(0.022)
Constant	7.851***	7.763***	8.058***
	(0.495)	(0.511)	(0.492)
Industry dummies (NIC 2-digit)	Yes	Yes	Yes
N	32388	32388	32388

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6. LP-S Estimation of Production Function, Formal Sector with Stock Measure of Public Investment.

Sector: Formal			
Dependent variable: *ln GVA*	(1)	(2)	(3)
ln L	0.664***	0.665***	0.665***
	(0.005)	(0.005)	(0.005)
ln K	0.369***	0.369***	0.369***
	(0.002)	(0.002)	(0.002)
ln Development expenditure per capita	0.173***		
	(0.019)		
ln Social Services expenditure per capita		0.036**	
		(0.013)	
ln Economic Services expenditure per capita			0.159***
			(0.017)
Firm-level controls			
Age of the firm	0.001*	0.001	0.001*
	(0.000)	(0.000)	(0.000)
Rural	-0.107***	-0.106***	-0.107***
	(0.010)	(0.010)	(0.010)
Ownership			
Wholly State and/or Local Govt	-0.183	-0.190	-0.178
	(0.108)	(0.108)	(0.108)
Central Govt and State jointly	-0.060	-0.061	-0.054
	(0.142)	(0.142)	(0.142)
Joint Sector Public	-0.256*	-0.253*	-0.256*
	(0.110)	(0.110)	(0.110)
Joint Sector Private	-0.246*	-0.246*	-0.244*
	(0.106)	(0.106)	(0.106)
Wholly Private Ownership	-0.224*	-0.224*	-0.220*
	(0.095)	(0.095)	(0.095)
State-level controls			
Log of NSDP per capita (2010)	-0.121***	-0.034	-0.115***
	(0.022)	(0.020)	(0.021)
Log of Total Labor Force (2010)	0.381***	0.437***	0.365***
	(0.024)	(0.025)	(0.025)
Literacy rate (2011)	0.015***	0.016***	0.014***
	(0.001)	(0.001)	(0.001)
Old-age Dependency ratio (2001)	-0.016***	-0.027***	-0.018***
	(0.004)	(0.004)	(0.004)
Crime rate per hundred (2010)	-0.431***	-0.684***	-0.318***
	(0.079)	(0.082)	(0.083)
Share of Unregistered Manufacturing (in total manufacturing)	-0.002**	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)
Log of total number of enterprises	-0.367***	-0.427***	-0.365***
	(0.023)	(0.022)	(0.023)
Constant	7.400***	7.794***	7.818***
	(0.499)	(0.515)	(0.493)
Industry dummies (NIC 2-digit)	Yes	Yes	Yes
N	32388	32388	32388

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7. OLS Estimation of Production Function, Informal Sector with Flow Measure of Public Investment

Sector: Informal			
Dependent variable: *ln GVA*	(1)	(2)	(3)
ln L	0.820***	0.820***	0.820***
	(0.005)	(0.005)	(0.005)
ln K	0.252***	0.254***	0.252***
	(0.002)	(0.002)	(0.002)
ln Development expenditure per capita	-0.002		
	(0.006)		
ln Social Services expenditure per capita		-0.048***	
		(0.006)	
ln Economic Services expenditure per capita			0.009
			(0.006)
Firm-level controls			
Age of the firm	-0.004***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.000)
Registration	0.267***	0.263***	0.268***
	(0.007)	(0.007)	(0.007)
Rural	-0.092***	-0.094***	-0.092***
	(0.005)	(0.005)	(0.005)
Ownership			
Proprietary(female)	-0.656***	-0.656***	-0.657***
	(0.007)	(0.007)	(0.007)
Partnership with members of the same hhd	-0.189***	-0.195***	-0.188***
	(0.019)	(0.019)	(0.019)
Partnership between members from different hhd	0.125***	0.125***	0.125***
	(0.035)	(0.035)	(0.035)
Self-help Group	-1.341***	-1.345***	-1.341***
	(0.087)	(0.087)	(0.087)
Trusts	-1.045***	-1.042***	-1.046***
	(0.287)	(0.287)	(0.287)
Others	0.015	-0.002	0.019
	(0.212)	(0.212)	(0.212)
State-level controls			
Log of NSDP per capita (2010)	0.215***	0.252***	0.209***
	(0.010)	(0.010)	(0.010)
Log of Total Labor Force (2010)	-0.056***	-0.078***	-0.058***
	(0.011)	(0.012)	(0.011)
Literacy rate (2011)	-0.005***	-0.007***	-0.005***
	(0.001)	(0.001)	(0.001)
Old-age Dependency ratio (2001)	-0.008***	-0.007***	-0.008***
	(0.002)	(0.002)	(0.002)
Crime rate per hundred (2010)	0.488***	0.512***	0.489***
	(0.038)	(0.038)	(0.038)
Share of Registered Manufacturing (in total manufacturing)	-0.004***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.000)
Log of total number of enterprises	-0.020*	-0.024*	-0.016
	(0.010)	(0.010)	(0.010)
Constant	5.998***	6.116***	6.085***
	(0.147)	(0.159)	(0.142)
Industry dummies (NIC 2-digit)	Yes	Yes	Yes
N	82748	82748	82748

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8. LP-S Estimation of Production Function, Informal Sector with Flow Measure of Public Investment.

Sector: Informal			
Dependent variable: *ln GVA*	(1)	(2)	(3)
ln L	0.628***	0.628***	0.628***
	(0.005)	(0.005)	(0.005)
ln K	0.317***	0.319***	0.317***
	(0.001)	(0.002)	(0.002)
ln Development expenditure per capita	0.027***		
	(0.006)		
ln Social Services expenditure per capita		-0.026***	
		(0.005)	
ln Economic Services expenditure per capita			0.039***
			(0.005)
Firm-level controls			
Age of the firm	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)
Registration	0.164***	0.159***	0.164***
	(0.006)	(0.006)	(0.006)
Rural	-0.102***	-0.104***	-0.102***
	(0.005)	(0.005)	(0.005)
Ownership			
Proprietary(female)	-0.430***	-0.430***	-0.430***
	(0.007)	(0.007)	(0.007)
Partnership with members of the same hhd	-0.140***	-0.146***	-0.138***
	(0.017)	(0.017)	(0.017)
Partnership between members from different hhd	0.070*	0.069*	0.070*
	(0.031)	(0.031)	(0.031)
Self-help Group	-1.099***	-1.101***	-1.099***
	(0.078)	(0.078)	(0.078)
Trusts	-0.849***	-0.847***	-0.849***
	(0.257)	(0.257)	(0.257)
Others	0.060	0.039	0.065
	(0.190)	(0.190)	(0.190)
State-level controls			
Log of NSDP per capita (2010)	0.114***	0.151***	0.110***
	(0.009)	(0.009)	(0.009)
Log of Total Labor Force (2010)	-0.098***	-0.108***	-0.103***
	(0.010)	(0.010)	(0.010)
Literacy rate (2011)	-0.002***	-0.004***	-0.002***
	(0.001)	(0.001)	(0.001)
Old-age Dependency ratio (2001)	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)
Crime rate per hundred (2010)	0.586***	0.598***	0.592***
	(0.034)	(0.034)	(0.034)
Share of Registered Manufacturing (in total manufacturing)	-0.004***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.000)
Log of total number of enterprises	0.039***	0.027**	0.043***
	(0.009)	(0.009)	(0.009)
Constant	8.031***	8.410***	8.027***
	(0.314)	(0.315)	(0.313)
Industry dummies (NIC 2-digit)	Yes	Yes	Yes
N	82748	82748	82748

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9. LP-S Estimation of Production Function, Informal Sector with Stock Measure of Public Investment.

Sector: Informal			
Dependent variable: *ln GVA*	(1)	(2)	(3)
ln L	0.628***	0.629***	0.628***
	(0.005)	(0.005)	(0.005)
ln K	0.317***	0.319***	0.317***
	(0.001)	(0.002)	(0.002)
ln Development expenditure per capita	0.024**		
	(0.008)		
ln Social Services expenditure per capita		-0.014**	
		(0.005)	
ln Economic Services expenditure per capita			0.036***
			(0.007)
Firm-level controls			
Age of the firm	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)
Registration	0.162***	0.160***	0.162***
	(0.006)	(0.006)	(0.006)
Rural	-0.103***	-0.104***	-0.103***
	(0.005)	(0.005)	(0.005)
Ownership			
Proprietary(female)	-0.430***	-0.430***	-0.430***
	(0.007)	(0.007)	(0.007)
Partnership with members of the same hhd	-0.141***	-0.145***	-0.140***
	(0.017)	(0.017)	(0.017)
Partnership between members from different hhd	0.070*	0.069*	0.070*
	(0.031)	(0.031)	(0.031)
Self-help Group	-1.100***	-1.101***	-1.102***
	(0.078)	(0.078)	(0.078)
Trusts	-0.848***	-0.847***	-0.848***
	(0.257)	(0.257)	(0.257)
Others	0.058	0.042	0.060
	(0.190)	(0.190)	(0.190)
State-level controls			
Log of NSDP per capita (2010)	0.114***	0.144***	0.107***
	(0.010)	(0.010)	(0.010)
Log of Total Labor Force (2010)	-0.096***	-0.105***	-0.098***
	(0.010)	(0.010)	(0.010)
Literacy rate (2011)	-0.003***	-0.004***	-0.003***
	(0.001)	(0.001)	(0.001)
Old-age Dependency ratio (2001)	0.003	0.002	0.004*
	(0.002)	(0.002)	(0.002)
Crime rate per hundred (2010)	0.602***	0.596***	0.622***
	(0.035)	(0.035)	(0.035)
Share of Registered Manufacturing (in total manufacturing)	-0.004***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.000)
Log of total number of enterprises	0.035***	0.029***	0.037***
	(0.009)	(0.009)	(0.009)
Constant	8.016***	8.338***	7.980***
	(0.317)	(0.317)	(0.315)
Industry dummies (NIC 2-digit)	Yes	Yes	Yes
N	82748	82748	82748

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10. Output Elasticities of Public Investment Across Firm Age

(LP-S Method with Public Capital Stock per-capita)

Sector: Formal

Dependent variable: $ln\,GVA$

Firm Age	N	Development Exp.	Social Services Exp.	Economic Services Exp.
At the Mean	20247	0.173***	0.036***	0.159***
Less than 1 year	570	0.352	0.072	0.328
Less than 3 years	3564	0.174**	0.062	0.143*

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1: Sectoral Capital Intensity, 1999 and 2010

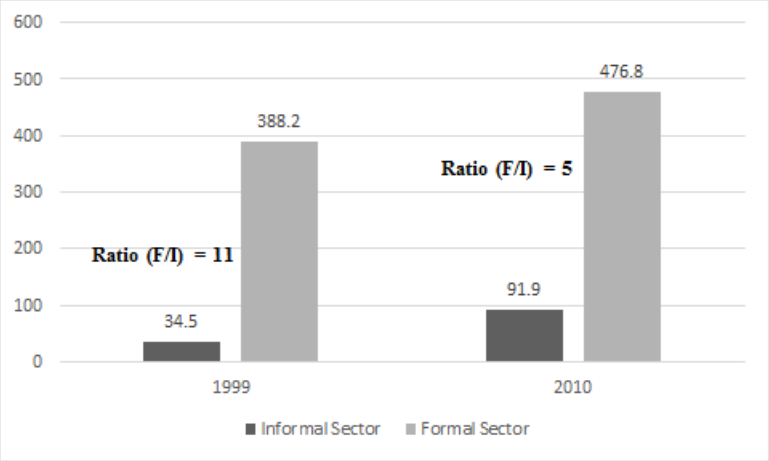


Figure 2: Sectoral Output per worker, 1999 and 2010

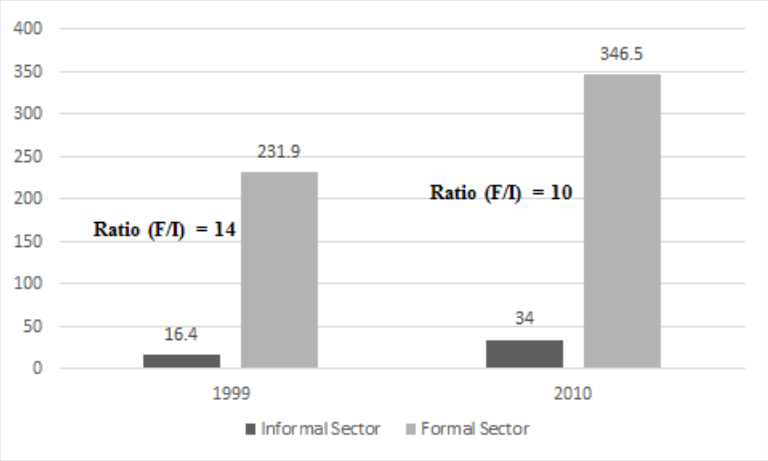


Figure 3: Share of Informal Sector in GDP, 1999-2010

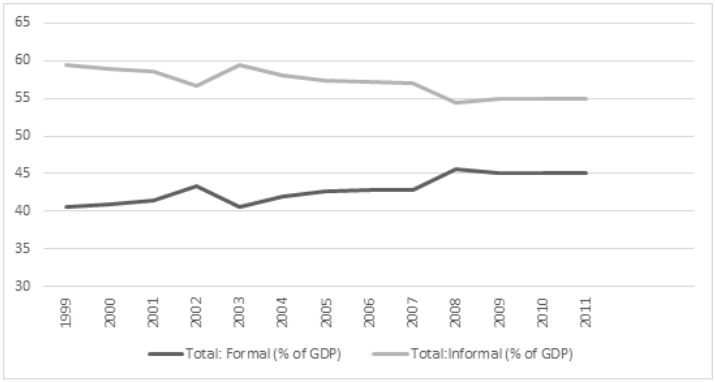


Figure 4: Share of Infrastructure spending in GDP, 2006-2010

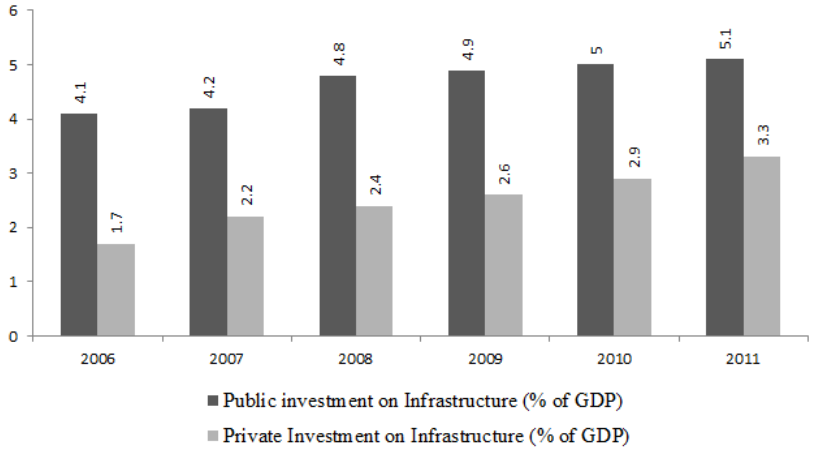
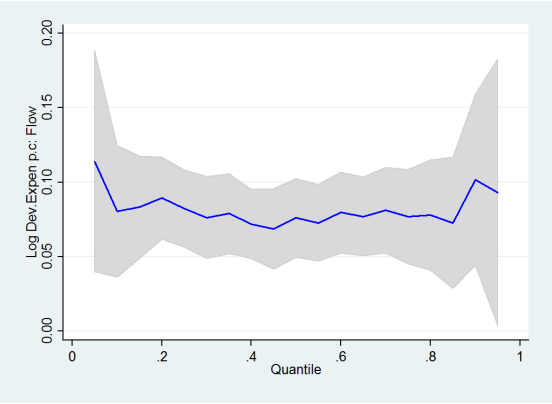


Figure 5: Quantile Output Elasticity of Public Investment, Formal Sector

(a) Flow



(b) Stock

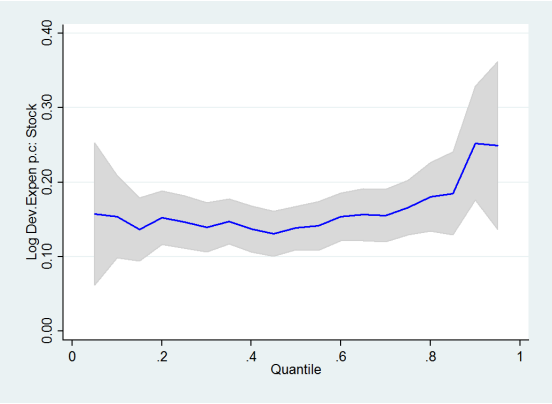
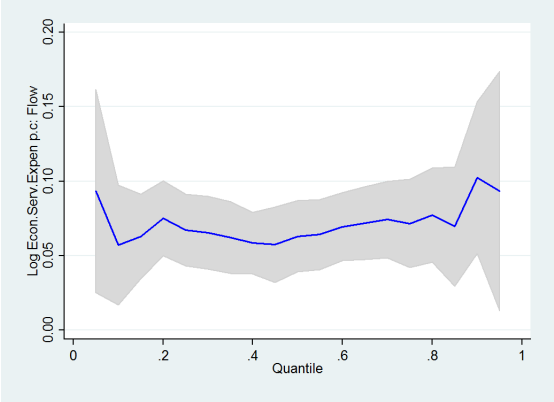


Figure 6: Quantile Output Elasticity: Economic Services, Formal Sector

(a) Flow



(b) Stock

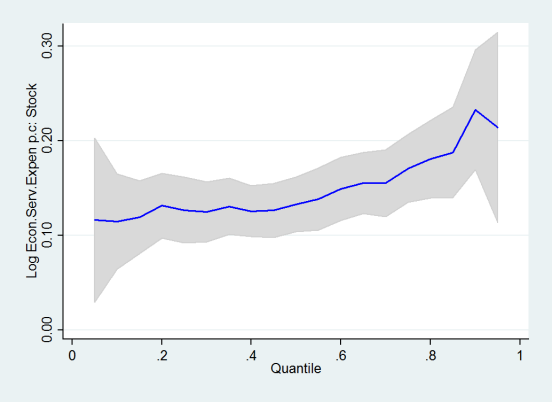
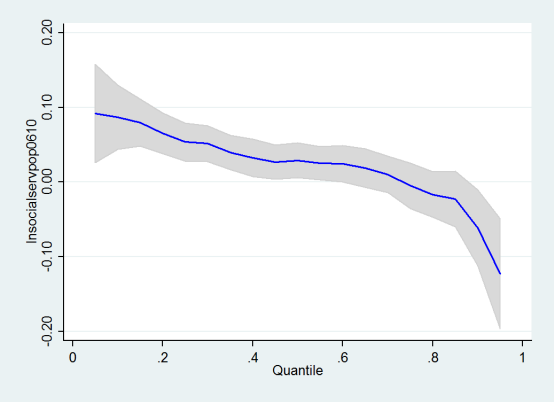


Figure 7: Quantile Output Elasticity: Social Services, Formal Sector

(a) Flow



(b) Stock

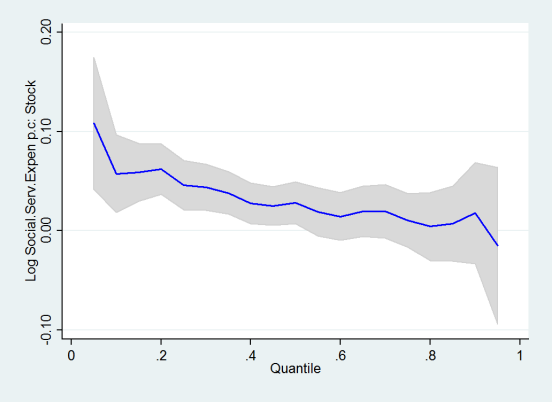
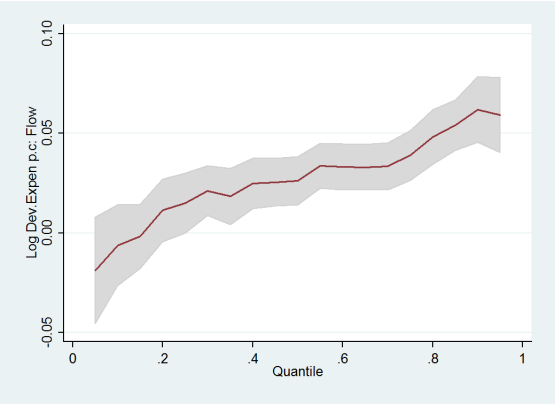


Figure 8: Quantile Output Elasticity of Public Investment, Informal Sector

(a) Flow



(b) Stock

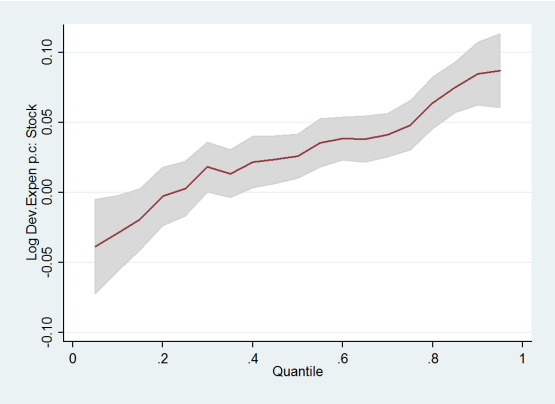
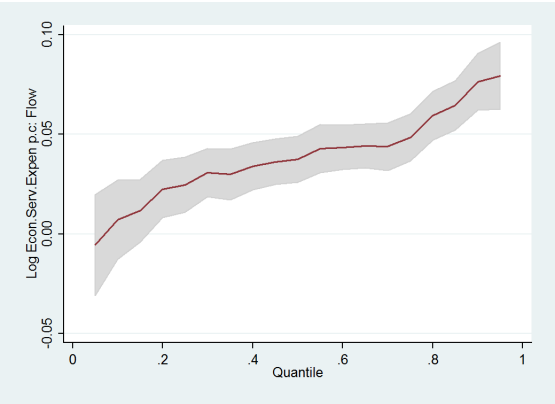


Figure 9: Quantile Output Elasticity: Economic Services, Informal Sector

(a) Flow



(b) Stock

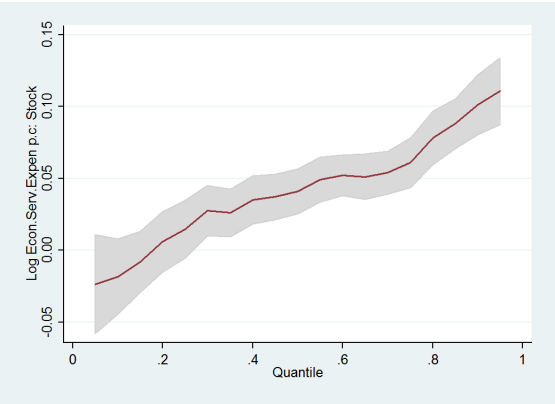
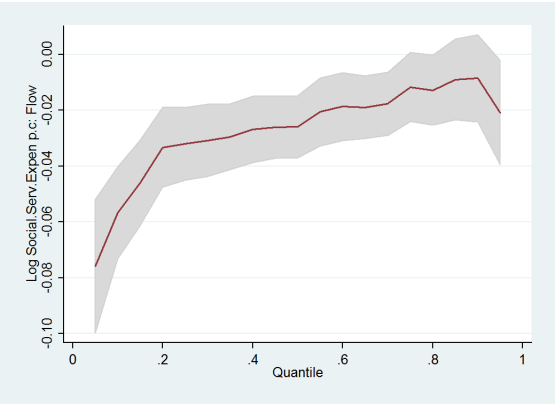


Figure 10: Quantile Output Elasticity: Social Services, Informal Sector

(a) Flow



(b) Stock

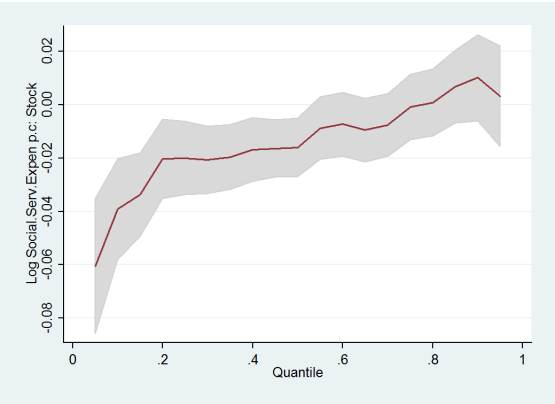
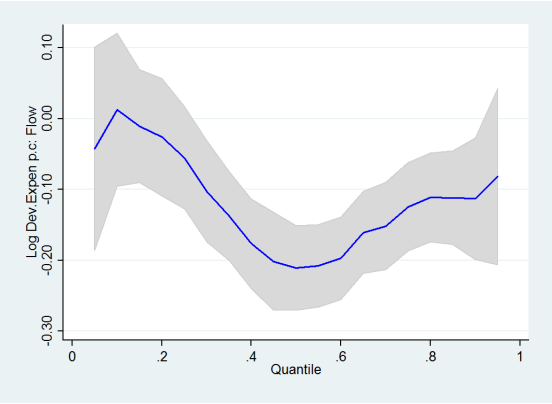


Figure 11: Public Investment and Firm-level Capital Intensity, Formal Sector

(a) Flow



(b) Stock

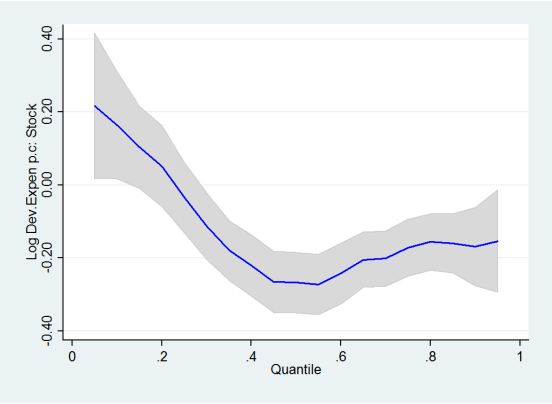
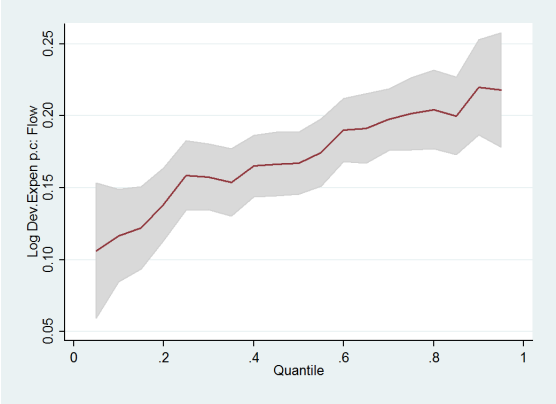
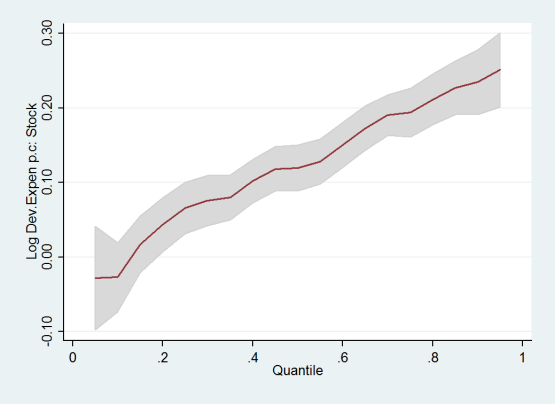


Figure 12: Public Investment and Firm-level Capital Intensity, Informal Sector

(a) Flow



(b) Stock



APPENDIX

Table A1: Data Sources

State Controls	**Source**
Log of NSDP per capita (2010)	Reserve Bank of India
Log of Total Labor Force (2010)	National Sample Survey Reports, Census
Literacy rate (2011)	Planning Commission
Old-age Dependency ratio (2001)	IndiaStat, Census
Crime rate per hundred (2010)	Crime Records Bureau
Share of Registered Manufacturing (in total manufacturing)	Reserve Bank of India
Total number of enterprises	National Sample Survey Reports

Table A2: Summary Statistics for Formal and Informal Sectors, 1999

	Formal		Informal	
	mean	sd	mean	sd
Gross value added (GVA) (in thousand Rs)	72453.5	600452.5	36.1	116.7
Net Fixed Assets (K) (in thousand Rs)	156303.4	1729834.5	79.6	429.1
Total workers (L)	181.8	951.2	2.0	1.4
K/L (in thousand Rs)	388.2	2282.2	34.5	96.8
Y/L (in thousand Rs)	231.9	718.8	16.4	20.8
Rural	0.3	0.5	0.6	0.5
Age of firm	16.4	11.9	.	.
Registered under any act/ authority?	.	.	0.1	0.3
Ownership				
Wholly Central Government	0.007	0.08		
Wholly State and/or Local Govt	0.01	0.1		
Central Government and State jointly	0.005	0.07		
Joint Sector Public	0.02	0.1		
Joint Sector Private	0.009	0.10		
Wholly Private Ownership	0.9	0.2		
Proprietary (male)	.	.	0.8	0.4
Proprietary(female)	.		0.2	0.4
Partnership with members of the same household			0.01	0.1
Partnership between members from different households			0.006	0.07
Not known			0	0
Self-help Group			.	.
Trusts			.	.
Others			.	.
Observations	19095		49720	

Table A3. Quantile Output Elasticities of Public Investment (Flow Measure)
Sector: Formal

	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	0.09***	0.07***	0.08***	0.08***
	(0.01)	(0.01)	(0.01)	(0.02)
Social Expen. p.c	0.07***	0.05***	0.03**	0.01
	(0.01)	(0.01)	(0.01)	(0.02)
Economic Expen. p.c	0.08***	0.06***	0.07***	0.08***
	(0.01)	(0.01)	(0.01)	(0.02)
Transport Expen. p.c	0.01	0.01	0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)
Energy Expen. p.c	0.00	0.00	-0.00	-0.01
	(0.00)	(0.00)	(0.00)	(0.01)

Table A4. Quantile Output Elasticities of Public Investment (Stock Measure)
Sector: Formal

	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	0.15***	0.14***	0.15***	0.18***
	(0.02)	(0.02)	(0.02)	(0.02)
Social Expen. p.c	0.06***	0.03**	0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.02)
Economic Expen. p.c	0.13***	0.13***	0.15***	0.18***
	(0.02)	(0.01)	(0.02)	(0.02)
Transport Expen. p.c	0.05***	0.06***	0.09***	0.12***
	(0.01)	(0.01)	(0.01)	(0.01)
Energy Expen. p.c	0.01	0.01	0.02	0.03
	(0.02)	(0.02)	(0.01)	(0.02)

Table A5. Quantile Output Elasticities of Public Investment (Flow Measure)
Sector: Informal

	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	0.01	0.02***	0.03***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)
Social Expen. p.c	-0.03***	-0.03***	-0.02**	-0.01*
	(0.01)	(0.01)	(0.01)	(0.01)
Economic Expen. p.c	0.02**	0.03***	0.04***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)
Transport Expen. p.c	0.02***	0.02***	0.03***	0.03***
	(0.01)	(0.00)	(0.00)	(0.00)
Energy Expen. p.c	-0.04***	-0.05***	-0.05***	-0.05***
	(0.00)	(0.00)	(0.00)	(0.00)

Table A6. Quantile Output Elasticities of Public Investment (Stock Measure)
Sector: Informal

	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	-0.00	0.02*	0.04***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)
Social Expen. p.c	-0.02**	-0.02**	-0.01	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
Economic Expen. p.c	0.01	0.03***	0.05***	0.08***
	(0.01)	(0.01)	(0.01)	(0.01)
Transport Expen. p.c	0.08***	0.09***	0.10***	0.13***
	(0.01)	(0.01)	(0.01)	(0.01)
Energy Expen. p.c	-0.23***	-0.21***	-0.20***	-0.19***
	(0.01)	(0.01)	(0.01)	(0.01)

Table A7. Public Investment and Firm-level Capital Intensity (Flow Measure)
Sector: Formal

	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	-0.03	-0.18***	-0.20***	-0.11***
	(0.04)	(0.03)	(0.03)	(0.03)
Social Expen. p.c	0.00	-0.07*	-0.08**	-0.01
	(0.04)	(0.03)	(0.03)	(0.03)
Economic Expen. p.c	-0.03	-0.16***	-0.19***	-0.11***
	(0.04)	(0.03)	(0.03)	(0.03)
Transport Expen. p.c	-0.06*	-0.04	-0.07***	-0.02
	(0.02)	(0.02)	(0.02)	(0.02)
Energy Expen. p.c	0.08***	0.08***	0.07***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)

Table A8. Public Investment and Firm-level Capital Intensity (Stock Measure)
Sector: Formal

	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	0.05	-0.22***	-0.24***	-0.16***
	(0.06)	(0.04)	(0.04)	(0.04)
Social Expen. p.c	-0.06	-0.14***	-0.13***	-0.07*
	(0.04)	(0.03)	(0.03)	(0.03)
Economic Expen. p.c	0.06	-0.17***	-0.19***	-0.14***
	(0.05)	(0.04)	(0.04)	(0.04)
Transport Expen. p.c	-0.05	-0.07**	-0.08***	-0.04
	(0.03)	(0.02)	(0.02)	(0.02)
Energy Expen. p.c	0.32***	0.25***	0.22***	0.22***
	(0.05)	(0.03)	(0.04)	(0.04)

Table A9. Public Investment and Firm-level Capital Intensity (Flow Measure)
Sector: Informal

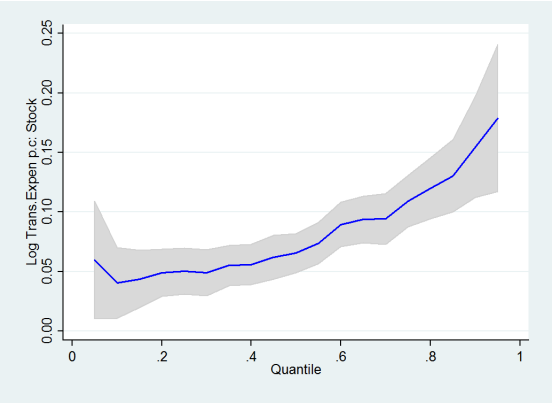
	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	0.14***	0.17***	0.19***	0.20***
	(0.01)	(0.01)	(0.01)	(0.01)
Social Expen. p.c	0.25***	0.26***	0.27***	0.29***
	(0.01)	(0.01)	(0.01)	(0.01)
Economic Expen. p.c	0.08***	0.10***	0.12***	0.13***
	(0.01)	(0.01)	(0.01)	(0.01)
Transport Expen. p.c	0.19***	0.17***	0.16***	0.14***
	(0.01)	(0.01)	(0.01)	(0.01)
Energy Expen. p.c	0.10***	0.10***	0.09***	0.09***
	(0.00)	(0.00)	(0.00)	(0.00)

Table A10. Public Investment and Firm-level Capital Intensity (Stock Measure)
Sector: Informal

	20^{th}	40^{th}	60^{th}	80^{th}
Development Expen. p.c	0.04*	0.10***	0.15***	0.21***
	(0.02)	(0.01)	(0.02)	(0.02)
Social Expen. p.c	0.18***	0.20***	0.22***	0.24***
	(0.01)	(0.01)	(0.01)	(0.01)
Economic Expen. p.c	-0.06**	0.01	0.05***	0.10***
	(0.02)	(0.02)	(0.01)	(0.02)
Transport Expen. p.c	-0.02	0.02*	0.04***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)
Energy Expen. p.c	0.06**	0.08***	0.10***	0.13***
	(0.02)	(0.02)	(0.02)	(0.02)

Figure A1: Quantile Output Elasticities for Transport and Energy Expenditures, Formal Sector

(a) Transport Stock



(b) Energy Stock

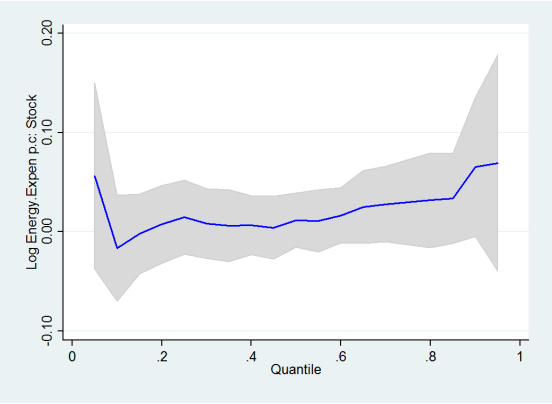
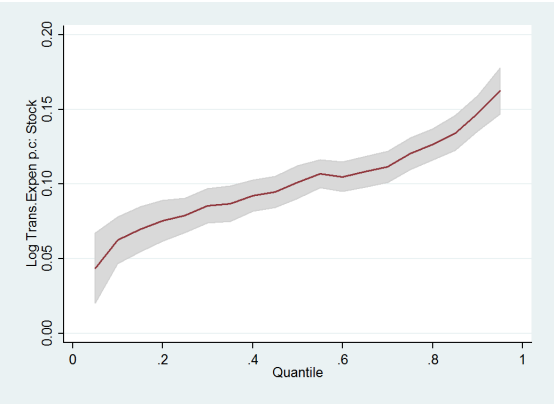


Figure A2: Quantile Output Elasticities for Transport and Energy Expenditures, Informal Sector

(a) Transport Stock



(b) Energy Stock

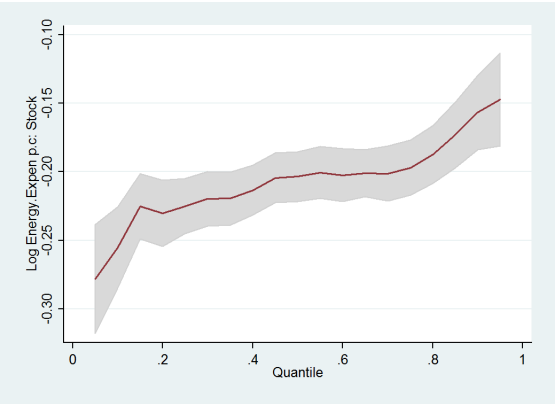
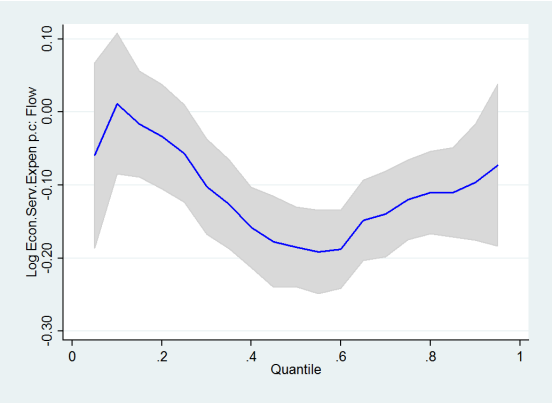


Figure A3: Economic Services Expenditures and Firm-level Capital Intensity, Formal Sector

(a) Flow



(b) Stock

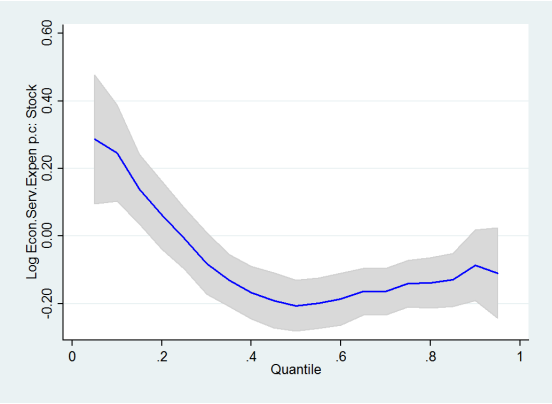
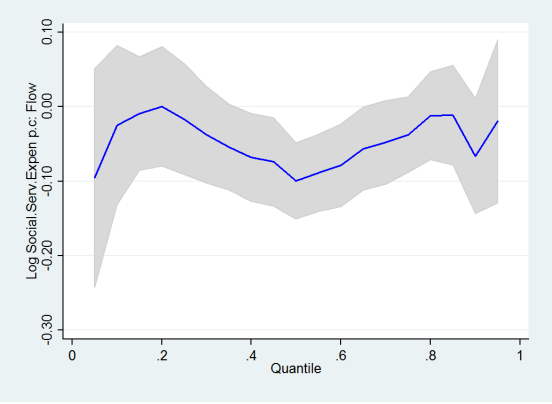


Figure A4: Social Services Expenditures and Firm-level Capital Intensity, Formal Sector

(a) Flow



(b) Stock

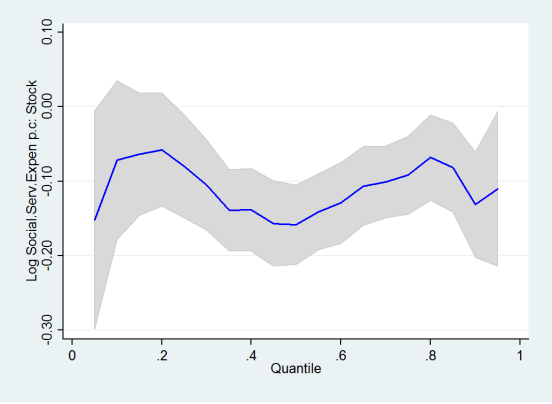
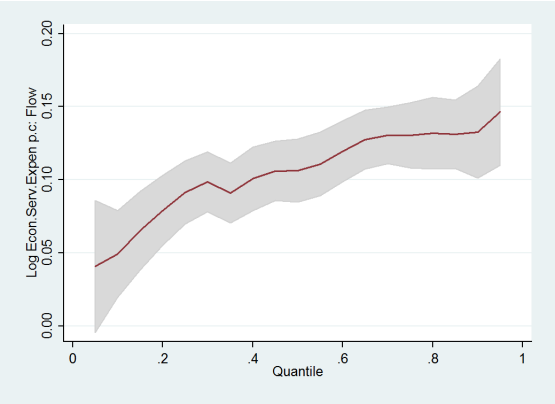


Figure A5: Economic Services Expenditures and Firm-level Capital Intensity, Informal Sector

(a) Flow



(b) Stock

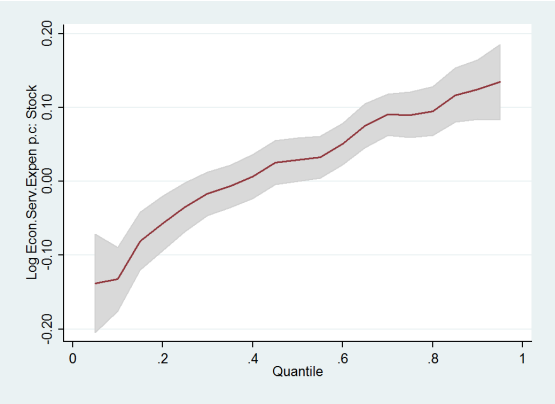
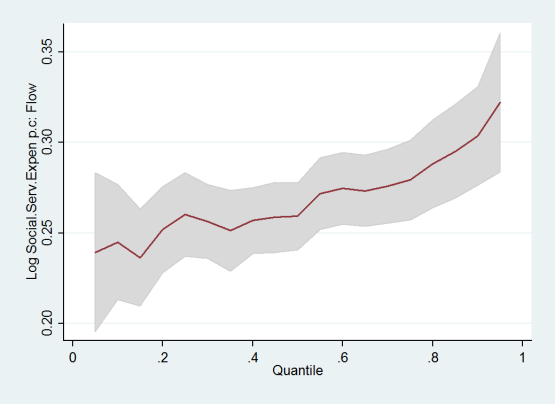


Figure A6: Social Services Expenditures and Firm-level Capital Intensity, Informal Sector

(a) Flow



(b) Stock