



Finding Obstacles to Growth: Is Infrastructure a Binding Constraint on African Light-Manufacturing Firms?

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ABSTRACT

For African countries to develop and reduce poverty, it is necessary to create productive jobs and industrialise - which can happen through the light manufacturing sector. For such firms to grow, however, a good business environment is necessary. Thus, this paper analyses whether infrastructure puts a binding constraint on light-manufacturing firms in 8 African countries, and thus comprise a real bottleneck for development. The results indicate that there indeed exists a real bottleneck because of insufficient infrastructure for light manufacturing firms in general. However, there does not seem to be any significant difference between different sub sectors within the light-manufacturing sector. These findings indicate that, even at current levels of productivity, a relaxation of the constraints (i.e., improvements in the infrastructure supply) would significantly increase the economic activity, even without improvements in other areas of the business environment.

Keywords: Africa, Infrastructure, Light Manufacturing

JEL Classifications: L6, O14

1. INTRODUCTION

Most countries in sub-Saharan Africa face a vicious circle of poverty and slow industrialization. It is the poorest continent in the world with the highest rate of people living under \$1.25 per day. Some of the countries with the highest child mortality rates are in this region and each day millions of people go hungry as it has the highest proportion of undernourished people (UN MDG report, 2014).

Sub-Saharan Africa is also facing a demographic picture that separates it from many other regions. It is currently the youngest region in the world with more than half of the population being under 25 years of age while also having the highest youth unemployment rate. At the same time the population is expected to grow to 1.6 billion people by 2030, thus accounting for approximately one fifth of the world population, and each year expected to increase by half a million more 15-year-old (AFDB 2012; AFC and The World Bank, 2014).

The importance of this demographic and economic situation is substantive. Unemployment, poverty and lack of alternatives is an

extreme burden for any person to bear, and with a rapidly growing population, the consequences of slow growth could be devastating. Job creation, economic development and poverty reduction is vital for the future of Africa.

However, in most African countries the economic progress has not been substantive. Even though some of the fastest growing economies during the first decade of the 21st century were African, the growth achieved was mostly centred on minerals, oil and other commodities thus making it neither an inclusive nor a sustainable growth. For African countries to rise from poverty they need to develop more productive sectors that also include a broader spectrum of the population.

Looking at the developed countries, from the UK to Japan to China, none were able to develop by relying on exports of raw materials. In fact, the common denominator between these countries is the role of the manufacturing sector, in particular light manufacturing. The Great Britain was the world's first industrialised country where the emerging textile industry played a central role (Mendels, 1972; Crafts, 1987). The transition from an agricultural society in Japan occurred through cotton and silk industries and in China food processing, textiles and

several other low-tech industries played a mayor role in the success story witnessed the last three and a half decades (Chenery et al., 1962; Anderson and Park, 1989; Howell, 1992).

In fact, long-run patterns of the role of different sectors in economies at different levels of per capita incomes have been studied for more than half a century (e.g., Kuznets, 1957; Chenery and Taylor, 1968; Kader, 1985; Herrendorf et al., 2013), and the manufacturing sector in general is continuously found to play a central role in early stages of development. Especially Syrquin and Chenery (1989) have done several studies in this area and the main finding is that the share of manufacturing of total value added increases at the lower income levels and then gradually diminishes as countries develop. Haraguchi and Rezonja (2010) further builds on this research both by extending their study to the present and by analysing the development at the two-digit ISIC level.¹ They find that not only does the manufacturing sector increase at a much more rapid pace in the initial stages of growth than earlier findings suggests, but that it, to a large part, occurs through different light manufacturing industries. Specifically, for both small and large countries, the food and beverage industry continuously cover a large share of gross domestic product (GDP). The share of textiles also peak at relatively low levels of GDP/capita.

However, the case for light manufacturing is based on more than historical and empirical evidence, it has also a theoretical appeal. Light manufacturing is intensive in labour, especially unskilled, thus making it a pathway for low-income countries to use their low cost labour for achieving competitiveness. This feature also creates a lot of job opportunities, making the potential growth and development much more inclusive. An inclusive growth is preferable not only because of humanitarian and moral reasons, but also because it increases the domestic market and the demand for domestic products, which in turn further spur growth.

Job creation is fundamental for the future of Africa and through the labour intensive light manufacturing sector the demographic picture can be turned into a huge advantage. The light-manufacturing sector (including agribusiness) can move African people from low productive jobs to industries creating more value added, and thereby increase their wages. It is also a stepping-stone into more high-tech industries. Therefore, the light manufacturing sector can help create the inclusive and sustainable growth that is needed to lift African countries out of poverty.

However, for development of any sector, and for the economy as a whole, firm growth is essential. For firms to flourish, they need to be surrounded by an environment that allows them to do so. The business environment entails a broad spectrum of institutions; from infrastructure and financial institutions to crime and corruption, etc., and, all else equal, the more favourable the business environment, the better the basis for firms to grow. As

¹ ISIC stands for International Standard Industrial Classification, and it is a classification system of what kind of economic activity certain data belongs to. The broadest categorisation shows if an activity sorts under the manufacturing sector, the service sector, etc. The more digits, the more detailed the classification. At the two-digit level it is possible to sort out low-tech industries from high-tech industries.

these institutions improve, resources will more easily move to where they are most productive and the overall productivity will increase. Domestic firms will also be more able to compete with foreign firms thus enhancing their chances of getting increased shares of global markets. On the contrary, a degraded business environment can halt firm growth, making the people suffer as less jobs are created - and those that are created might not be as effective as they would have been, thus decreasing the workers' wages as the marginal productivity of labour decreases.

Infrastructure is one aspect of the business environment that is crucial for development.² It positively affects growth in several channels. A high level of public capital in infrastructure has a direct effect as it increases the productivity of other input factors.³ Additionally, since the productivity of factors of production increases, the return on private capital increases as well. Infrastructure can thus spur private investment. For instance, the returns from a new factory are higher if it is connected to good transportation networks or a well-functioning power generator. Infrastructure has other indirect positive effects as well, such as increasing the durability of private capital (a vehicle operating on poor roads will be torn out faster than if the quality of the roads were higher, etc.).

1.1 Purpose of the Paper and Research Questions

That the business environment and infrastructure is important for growth does not directly lead to the conclusion that more spending should be done to improve it. One also needs to assess if the existing supply poses a binding constraint on firm growth. While many have studied the effect of the business environment and infrastructure on firm growth (e.g., Ayyagari et al., 2008; Dinh et al., 2010; Commander and Svejnar, 2011), not many have examined the effect it has on different sub sectors of the economy. Broad sectors such as manufacturing includes a heterogeneous group of sub sectors. There are no reason to believe that high-tech industries such as automotive or semiconductors are equally constrained by the business environment as low-tech industries such as the textile or the simple wood products industry.

Because of the importance of the light-manufacturing sector and the potential that a growing manufacturing sector entails, and because of the importance of the business environment and infrastructure for firm growth, there is a need to further analyse if the business environment constrains light-manufacturing firms in particular. This paper aims at deepening the understanding of this issue in general by analysing whether infrastructure poses a binding constraint on

² Infrastructure is a broad concept, covering both physical infrastructure such as electricity and transport and soft infrastructure such as sanitation and health. The latter also affect growth in several channels, but the focus here and elsewhere in the text is primarily on physical infrastructure.

³ This is illustrated by the following: suppose we have a Cobb-Douglas function of the form $Y = AK^\alpha L^\beta I^{1-\alpha-\beta}$ where I is infrastructure and $\alpha + \beta < 1$. The derivatives of capital and labour with respect to output show the marginal productivity of those two factors of production. Those derivatives are

$$MPK = \frac{\partial Y}{\partial K} = \alpha AK^{\alpha-1} L^\beta I^{1-\alpha-\beta} \text{ respectively } MPL = \frac{\partial Y}{\partial L} = \beta AK^\alpha L^{\beta-1} I^{1-\alpha-\beta}$$

The derivatives of the MPK and MPL with respect to infrastructure are positive for both labour and capital, meaning that the marginal productivity of labour and capital increases with infrastructure (as long as factors of production are gross complements this will be the case).

light-manufacturing firms in a selected number of African countries. Consequently, it aims at deepening the understanding of obstacles to growth in these countries, with a special focus on infrastructure. For simplicity the term “Africa” is used when speaking of the countries studied. The explicit research questions are as follows:

Does infrastructure pose a binding constraint on light-manufacturing firms⁴ in Africa?

Are different sub sectors within the light-manufacturing sector equally constrained by infrastructure?

The set of countries is; D.R. Congo, Ghana, Kenya, Nigeria, Senegal, Tanzania, Uganda and Zambia. All selected countries are facing roughly the same problems in terms of economic development and population growth, making the light-manufacturing sector a potential growth engine. Crucial for the selection was also whether firm-level data were available for light manufacturing firms and at least some sub sectors. This selection criterion does not allow for direct generalisations for other parts of Africa. However, the results will add to the aggregated knowledge of constraints on growth in general and light manufacturing firms in particular. Furthermore, the findings for these countries are of interest in itself as it helps explain what is needed for growth and development in this set of countries.

When speaking of a constraint it is important to distinguish between binding and not binding constraints. If a firm wants to acquire more of a good, such as infrastructure, but cannot do so because it breaks the firm’s overall budget constraint, it is not classified as a binding constraint on firm growth. However, when a firm cannot acquire more of the good because of an insufficient supply of it, even though their budget allows them to use more of it, then it is classified as a binding constraint on the firm. That is, a binding constraint indicates that a bottleneck exists.

Focusing on bottlenecks is important because their removal can increase the economic activity even without improvements in other areas of the economy. Finding such constraints is vital since governments in most African countries cope with extremely scarce resources, meaning that a laundry-launch approach where several problems are identified without indicating which ones are truly binding is unfeasible.

The industries included in the light-manufacturing category in this paper is food and beverages, tobaccos, textiles, garments, leather, wood processing and wood products, and basic metals.⁵

4 This study only analyses small (5-19 employees) and medium-sized firms (20-99 employees). The reason for this is further explained in section 4. The term “firms” will still be used for simplicity throughout the paper.

5 There is no distinct definition of when an industry sorts under low- or high-tech manufacturing. One sector that could have been included is chemicals; partly because some parts of it are relatively labour intensive and partly because it also has played a central role in the earlier parts of development for some countries (Haraguchi and Rezonja 2010). However it is not included mainly because the data set used is stratified on the 2-digits level, and given that many sub sectors at the 4-digits level within the chemicals sector are high-tech industries, inclusion of those could significantly drive the results. Now the selection of sub sectors is done in line with Harrison et al. (2011) instead.

1.2 Disposition

The disposition of the text is as follows. First, there will be a review on the existing literature on constraints facing firms. Secondly, we will model for the possible implicit cost of infrastructure, and then present and discuss the econometric method used. Afterwards the material used is presented. Finally, the empirical findings are given and analysed, followed by the conclusion.

2. LITERATURE REVIEW

Several papers have studied the constraints on firm performance posed by a weak business environment. Some analyse the effect of various business-environment variables (e.g., Ayyagari et al. 2008) while others focus specifically on infrastructure (e.g., Reinikka and Svensson 2002). Among those trying to explain the effect of all aspects of the business environment the most common approach is a regression analysis with cross-sectional data, or panel data where it is available. Ayyagari et al. (2008) use subjective measures⁶ from the full World Bank Enterprise Surveys (WBES), but infrastructure has no significant effect on firm performance according to their results. Also Commander and Svejnar (2011) find similar results with respect to infrastructure when using firm-level panel data for firms in South-Eastern Europe and the countries from the Commonwealth of Independent States. Dollar et al. (2005) on the other hand use the objective measures of how much (as a percentage of sales) that was lost due to power outages as a proxy for infrastructure and find it to negatively affect firm performance.

For those studying Sub-Saharan Africa in particular there is mixed results as well, even though infrastructure appears more frequently as a constraint. Reinikka and Svensson (2002) study 243 firms in Uganda, and note that the cost of insufficient infrastructure is significant - either because of direct losses or because of indirect losses as costly private solutions are needed. The result found in Côte d’Ivoire by Sleuwagen and Goedhuys (2009) points in the same direction. Olawale and Garwe (2010) analyse the growth of firms in South Africa. Infrastructure, mainly transport costs, seems to be a barrier albeit not the most pressuring one.

Others study larger parts of the region to find general patterns of constraints facing firm growth. Aterido and Hallward-Driemeier (2010) use power losses and losses while in transit to proxy for infrastructure and find that poor infrastructure negatively affects firm performance in Sub-Saharan Africa more than in other parts of the world. Iacovone et al. (2013) find similar results. However, based on their result from using firms’ ratings of how big an obstacle infrastructure is, Dinh et al. (2010) argue that it is not a binding constraint on growth. Neither Harrison et al. (2011) find infrastructure to be a constraint when using the same measure. When they test for the effect of the time to clear customs as a proxy for infrastructure they do, however, find a significant effect.

6 Subjective measures are those where the firm rates or ranks an issue, while objective measures are measures such as if a firm has experienced power outages, if a firm has a loan, if a firm exports, etc.

3. MODEL

Thus, while there indeed is evidence indicating that infrastructure poses a constraint on firm growth in Sub-Saharan Africa, the evidence presented is not clear-cut. To some extent this could be explained by the measures used in the different studies. The papers using objective measures more often find infrastructure to negatively affect firm performance than those using subjective measures. The reason for this might be twofold; firstly, the subjective and the objective variables might measure two different aspects of infrastructure. While the latter measures the direct effect of weak infrastructure, the former measures the indirect effect, i.e., the implicit cost in terms of foregone production (this is further explained in section 3). Secondly, in line with the first reason, if infrastructure is indeed a public good with a fixed supply at the country level there will be an attenuation towards zero in the regressions if one does not simultaneously control for objective measures of infrastructure - thus making it harder to get reliable results (this is further explained in section 3.1). A reasonable conclusion from the existing literature might therefore be that there in many parts of Sub-Saharan Africa probably is a significant direct effect on firm performance caused by weak infrastructure, though the evidence on possible indirect costs are less well explored.

Furthermore, not many evaluate what constraints different industries are facing (except broader sectors such as manufacturing, or services). One comprehensive paper on sub sectors is done by Dinh et al. (2012) in their case study on the light manufacturing sector in three African countries. They find that especially transportation costs account for a large share of total costs. For instance, they argue that high transportation costs add a production cost penalty of more than 2% in the apparel industry (ibid: 88). The paper by Dollar et al. (2005) is also focused on the light manufacturing sector as they specifically study garment firms, though all of the countries studied are Asian. Harrison et al. (2011) differ between low- and high-tech manufacturing. However, their quantitative measures do not cover central aspects of infrastructure such as electricity and transportation, and the subjective measure seem to be prone to measurement errors. The fact that there are few papers on the constraints facing light manufacturing firms in particular further makes the issue worth analysing.

This paper aims at filling in the literature in three important ways. Firstly, it focuses exclusively on African light-manufacturing firms. Except being important for its own reasons (expressed in section 1), this adds a somewhat overlooked perspective of the wider question of what binding constraints firms in developing countries are facing. Secondly, it goes one step further by analysing how different sub sectors within the light-manufacturing sector at the two-digit level are affected by infrastructure. This is useful for policy reasons as well since countries might have different possibilities being competitive in different industries. Thirdly, the paper aims at analysing whether infrastructure creates significant implicit costs, rather than explicit costs (such as if output have been lost during transit because of inadequate roads, etc.). Studying if there exist implicit costs is important since it indicates if a real bottleneck exists. This is because the implicit costs show if firms, at current levels of net productivity, would significantly increase their output if the constraint were to be relaxed. This is further explained below.

To explain how to analyse if there are significant implicit costs because of infrastructure, it is useful to follow the approach by Carlin et al. (2006). Of utmost importance is that one takes into consideration what character the good infrastructure has. In contrast to private goods such as cars and machineries that are plentiful and which firms can acquire as long as it does not break their overall budget constraint, infrastructure should be treated as a public good that has a fixed supply at the country level. Since the supply is fixed and equal for all firms, it is reasonable to suggest that better performing firms, that expand and need more inputs, will be more likely to be bound by the constraint that the fixed supply poses. To see why better performing firms should feel the constraint more severely we can, in line with Carlin et al. (2006), state the reasoning more formally.

If we assume that all firms have a Cobb-Douglas production function and that two inputs are used, labour (L) and infrastructure (I) the following production function in a one-period model applies:

$$Y = F(L, I) = AL^\alpha I^{1-\alpha} \quad (1)$$

where A is the productivity parameter, Y is output and $\alpha < 1$.⁷

If we assume that there is some kind of tax on output, t_Y and on labour, t_L , the profit function for the firms is:

$$\pi = (p_Y - t_Y)Y - (w + \bar{t}_L)L - \bar{p}_I I. \quad (2)$$

Where p_Y is the price of the output and p_I is to be considered the price on the infrastructure used. The first term on the right hand side represents the net revenue after tax, the second term represents the cost of labour including taxes and the third term is the cost of infrastructure. Let there be a cash-in-advance constraint, \bar{M} , (in which capital implicitly enters the model) on the payment of labour, M , that does not exceed the fixed money balance in the beginning of the period. Thus, we have:

$$M = (w + t_L)L \leq \bar{M}. \quad (3)$$

Rearranging we get

$$\bar{M} - (w + t_L)L \geq 0 \quad (4)$$

As infrastructure is treated as a public good with a fixed supply at the country level we can state that each firm's input of infrastructure must follow the infrastructure constraint:

$$I \leq \bar{I}, \quad (5)$$

and rearranging we get

$$\bar{I} - I \geq 0. \quad (6)$$

⁷ It then follows that the marginal productivity of labour respectively infrastructure is $\frac{\partial Y}{\partial L} = \alpha AL^{\alpha-1} I^{1-\alpha}$ respectively $\frac{\partial Y}{\partial I} = (1-\alpha)A(\frac{L}{I})^\alpha$.

Each firm try to maximize profit subject to the constraints posed by the cash-in-advance- and the infrastructure constraint. Each firm thus face the following maximization problem,

$$\begin{aligned} \max & (p_Y - t_Y)Y - (w + t_L)L - p_I I \\ \text{s.t.} & \bar{M} - (w + t_L)L \geq 0, \\ & \bar{I} - I \geq 0. \end{aligned}$$

which yields the following Lagrange function:

$$\mathcal{L} = (p_Y - t_Y)Y - (w + t_L)L - p_I I + \lambda_M (\bar{M} - (w + t_L)L) + \lambda_I (\bar{I} - I) \tag{7}$$

When the infrastructure and the cash-in-advance constraints bind, the optimized value of inputs (i.e., labour and infrastructure) is determined by the value of the constraints. Furthermore, when the constraint holds the Lagrangian is identical to the original function and each firm is at a corner solution. At that point we cannot use the comparative static analysis to determine the movement of input choices with respect to input prices.

However, this paper takes interest in the implicit cost of the constraint in terms of foregone profits, and such comparative static analysis is still doable.

Thus, we continue from (2) and replace Y with $F(L, I)$ and denoting profit maximization and labour input with π^* respectively L^* when the constraints hold, we state the profit function with binding constraints:

$$\pi^* = (p_Y - t_Y)F(L^*, \bar{I}) - (w + t_L)L^* - p_I \bar{I}. \tag{8}$$

Since $M = \bar{M}$, from (3) we get

$$L = \frac{\bar{M}}{w + t_L}. \tag{9}$$

We put (9) in the production function and write the constrained profit function finally as:

$$\pi^* = (p_Y - t_Y)A \left(\frac{\bar{M}}{w + t_L} \right)^\alpha \bar{I}^{1-\alpha} - \bar{M} - p_I \bar{I}. \tag{10}$$

It follows that the derivatives of the constrained profit function shows the implicit cost in terms of foregone profits of the cash respectively infrastructure supply constraint. These are:

$$\begin{aligned} \lambda_M &= \frac{\partial \pi^*}{\partial \bar{M}} = \alpha (p_Y - t_Y) A \left(\frac{1}{w + t_L} \right)^\alpha \bar{M}^{\alpha-1} \bar{I}^{1-\alpha} - 1 = \\ & \alpha A \frac{p_Y - t_Y}{(w + t_L)^\alpha} \left(\frac{\bar{I}}{\bar{M}} \right)^{1-\alpha} - 1, \end{aligned} \tag{11}$$

for the cost of the cash-in-advance constraint and

$$\begin{aligned} \lambda_I &= \frac{\partial \pi^*}{\partial \bar{I}} = (1 - \alpha) A (p_Y - t_Y) \left(\frac{\bar{M}}{w + t_L} \right)^\alpha \bar{I}^{-\alpha} - p_I = \\ & (1 - \alpha) A \frac{p_Y - t_Y}{(w + t_L)^\alpha} \left(\frac{\bar{M}}{\bar{I}} \right)^\alpha - p_I, \end{aligned} \tag{12}$$

for the infrastructure constraint. The derivatives from (11) respectively (12) show how the cost of the constraints change with the variables included. This paper takes primary interest in two of these comparative static results; the derivative of the cost of the infrastructure constraint with respect to the productivity parameter respectively the derivative of the cost of the infrastructure constraint with respect to the cash-in-advance constraint. These are:

$$\frac{\partial \lambda_I}{\partial A} = (1 - \alpha) \frac{p_Y - t_Y}{(w + t_L)^\alpha} \left(\frac{\bar{M}}{\bar{I}} \right)^\alpha > 0, \tag{13}$$

$$\frac{\partial \lambda_I}{\partial \bar{M}} = \alpha (1 - \alpha) A \frac{p_Y - t_Y}{(w + t_L)^\alpha} \bar{M}^{\alpha-1} \bar{I}^{-\alpha} > 0. \tag{14}$$

Equation (13) shows that as the productivity increases, the cost of the infrastructure constraint increases as well, and (14) shows a similar relation between the cash-in-advance constraint and the infrastructure constraint. That is, the implicit cost of the infrastructure constraint in terms of foregone development will be greater for better performing firms (i.e., those with higher productivity and less cash constrained). Therefore, if the constraint is binding, one will expect a positive relationship between the complaints on (i.e., the demand for) infrastructure and firm performance. This is because if the constraint binds, more productive firms, who feel the constraint more, will also complain more (assuming that firms' demands are reasonably correlated to their actual situation). We can thus use the firms' complaints on infrastructure to analyse whether a bottleneck exists.

3.1 Econometric Modelling

The method that will be used is a regression analysis with ordinary least squares estimates, building on the endogeneity problems with such an approach. First an augmented Cobb-Douglas production function including only the infrastructure measurement will be set up as follows:

$$y_i = \beta_0 + \beta_L L_i + \beta_K K_i + \beta_I I_i + \sum \beta_{C_h} C_{hi} + e_i,$$

where Y is sales, L is the number of permanent full-time employees, K is the net book value of assets after depreciation, and lower-case letters represent the natural logarithm of these variables. C represents a country dummy for each country, h (DRC being the base), and e is the error term (which contains an unobserved component of productivity). The measure of the infrastructure constraint is I . It is the arithmetic mean of two subjective questions from a survey asking firm managers to rate how big an obstacle insufficient electricity respectively transport is on a

scale of 0-4, 4 being the highest. This will be the variable of interest in the regression. Although subjective measures are not optimal to use in regressions, it is the most effective tool available to measure complaints on infrastructure, and therefore also the implicit cost. The measure also takes into account two central aspects of physical infrastructure and can thus capture the combined effect of infrastructure on firm growth. However, the measure will later be separated into its two components to see if both individually pose a binding constraint on firms.

Two other problems arise when using this measure. First, it is possible that the responses vary with firm characteristics. Specifically it is possible that worse performing firms tend to blame external factors for their bad performance. In this case the correlation between firm performance and the infrastructure measure will be biased downward, thus making it harder to find infrastructure to be a constraint even if it is. This bias will be hard to account for but including other firm characteristics variables might control out this effect to some extent.

The second problem is how accurate the manager's responses are, even if they intentionally do not try to over- or underestimate any obstacle. Once again this cannot be completely controlled for, but to the extent that firm characteristics such as export status correlates with firm performance, and to the extent that better performing firms also are better at accurately analysing their faced obstacles, inclusion of control variables such as export status will diminish the problem. Nevertheless, given the reasoning in section 3 the subjective question is a good variable to analyse if a constraint is binding since it captures the demand for the good and thus also measures the implicit costs in terms of foregone development - in contrast to objective variables that measures the direct effect of infrastructure.

Assuming that managers reasonably accurately assess the obstacle of infrastructure, the variable consists of two parts. One part consists of the explicit experience of insufficient infrastructure - such as if a firm has experienced power outages or how often that happens. All else equal, the higher the direct costs of infrastructure, the worse performance should be and the higher the levels of complaints about infrastructure should be. The other part consists of the implicit costs in terms of foregone profits that a potential infrastructure constraint would create. This is the part modelled for in section 3 and this is the part that will be felt more for better performing firms. The relationship between the implicit cost of infrastructure and firm performance will thus be positive if the constraint is binding. It is the latter part that we want to use in the forthcoming regression analysis.

Since these two parts of the measure oppose each other in their relation to performance, there will be attenuation towards zero for the coefficient, thus making it harder to get reliable results.⁸ To diminish this effect we need to separate the part that covers the implicit cost from the part that covers the explicit cost so that we can accurately measure the former part. To separate these

two effects, we will later extend the model with a quantitative variable assessing how often a firm experiences power outages. By controlling for this, the part of the infrastructure measurement that is of interest in this paper (i.e., the one measuring the implicit cost) can partly be differed out.

First, however, we add four firm characteristics variables, which have shown to be important elsewhere (e.g., Bigsten and Söderbom, 2006), to cover for omitted variable bias and possible confounding effects. The first is a dummy variable indicating the size of the firm (small = 5-19 employees, medium = 20-99 employees), the second is a dummy variable telling if the establishment is part of a larger firm, the third is a dummy variable indicating ownership status, especially if it is foreign or domestically owned (the threshold is at 10% foreign ownership), and the fourth is a dummy variable indicating if the firm exports or not. The second model is thus:

$$y_i = \beta_0 + \beta_L I_i + \beta_K k_i + \beta_I I_i + \sum \beta_{X_j} X_{ji} + \sum \beta_{C_h} C_{hi} + e_i$$

where X represent different firm characteristic variables. The main reason for not including more firm characteristics variables is to reduce the amount of missing data. For instance, while the business environment might affect male respectively female owners differently, there are a lot of missing values from the questions concerning gender ownership status.

Since there are other parts of the business environment than infrastructure that affect firm performance and could correlate with the included independent variables, we also add 13 other business environment variables included in the survey to diminish the omitted variable bias. To this model we also add the objective measure of infrastructure. The extended model will be:

$$y_i = \beta_0 + \beta_L I_i + \beta_K k_i + \beta_I I_i + \beta_P P_i + \sum \beta_{X_j} X_{ji} + \sum \beta_{Z_m} Z_{mi} + \sum \beta_{C_h} C_{hi} + e_i,$$

where Z consist of 13 subjective measures covering a broad spectrum of the business environment and P is the quantitative measure showing how often a firm has experienced power outages the last fiscal year.⁹ More quantitative measures will not be used, however, since there are much more missing data or incomplete data amongst them. The one used is preferred mainly because it covers a central aspect of infrastructure, because it is relatively complete for most firms, and because it has been used extensively elsewhere to measure the impact of infrastructure on firm growth.

Finally, a fourth model will include an interaction term, T , between the infrastructure variable and an industry dummy to the extended model above. This is to assess the second research question; if

8 Specifically, since a binding constraint is found only if the coefficient is positive, the attenuation towards zero will make it harder to find infrastructure as a constraint even if it is.

9 The business environment variables included cover questions regarding how big an obstacle the following are; telecommunications, customs and trade regulations, practices of competitors in the informal sector, access to land, crime, theft and disorder, access to finance, tax rates, tax administration, business licensing and permits, political instability, corruption, labour regulations, and inadequately educated workforce.

different sub sectors within the light manufacturing sector are equally affected by infrastructure.¹⁰

The method builds on the problem with reverse causality that was explicitly modelled in section 3. The variable for infrastructure, I , is correlated with the part of the error term that contains the unobservable component of productivity, as more productive firms should feel the indirect cost in terms of foregone profits because of insufficient infrastructure more than less productive firms. Therefore β_I is expected to be positive if infrastructure is indeed a binding constraint on firm growth. However, to the extent that the subjective measure I correlates with excluded objective measures of infrastructure there should be a causality running in the other direction - a higher measure of I causes lower firm productivity. To cancel out this effect the paper uses an objective control variable; how often the firm has experienced power outages the last year, P . As this measure controls for the part of the subjective variable that measures the explicit cost of infrastructure shortages, the latter variable should more accurately measure the cost in terms of foregone development. Thus, in line with the modelling in the previous sections, a positive sign on β_I indicates that infrastructure poses a binding constraint on firms.

Therefore, the regression analysis is not a classic set up where a variable Y is regressed on a variable X that is assumed to have a causal effect on Y . Rather it specifically model for the endogeneity problems with a standard regression model and uses the regression framework to control for other variables in order to show whether a relationship between performance and infrastructure exists.

Since the data to study total factor productivity is rather noisy, especially the data on the capital level, another measure of performance will be used as a robustness check. For this, employment growth will be used as the dependent variable. Since the increase in employment in smaller firms is proportionally much higher than an equal increase in employment in a larger firm, a percentage-based measure of employment growth can be misleading. In line with Aterido and Hallward-Driemeier (2010) - who builds on Davis-Haltiwanger's method of converting percentage rates into the ratio of the absolute difference in employment to the average number of employees - we use the following variable to more accurately measure employment growth, EG:

$$EG = \frac{L_t - L_{t-3}}{(L_t + L_{t-3}) / 2}$$

The full model with employment growth as the dependent variable will therefore be:¹¹

$$EG_i = \beta_0 + \beta_I I_i + \beta_P P_i + \sum \beta_{X_j} X_{ji} + \sum \beta_{Z_m} Z_{mi} + \sum \beta_{C_h} C_{hi} + \beta_T T_i + e_i$$

¹⁰ This model is therefore:

$$y_i = \beta_0 + \beta_L L_i + \beta_K K_i + \beta_I I_i + \beta_P P_i + \sum \beta_{X_j} X_{ji} + \sum \beta_{Z_m} Z_{mi} + \sum \beta_{C_h} C_{hi} + \beta_T T_i + e_i$$

¹¹ The three models without the interaction term from the augmented production function above will also be run with employment growth as the dependent variable, before running this regression.

Finally, we use the extended augmented production functions and separate the infrastructure variable into its two components to see if one of its components has a much larger effect than the other and thus drives the results. Four models are run; one with the electricity variable, one with the transport variable and one each with those variables interacted with the industry variable, respectively.

To answer the first research question all above models will first be run on all light manufacturing firms. To answer the second research question we use the models with the interaction term between infrastructure and the industry dummy. Food processing will be the reference variable.

All models will be run with correction for heteroscedasticity. Cluster on country level would be desirable, yet it is not done since the number of clusters is only 8; far too few to be asymptotically valid. Country dummies will be used to cover for the effects between countries. Since these dummies pick up factors such as nation-wide institutions, political instability, trade policy, etc. they should to some extent capture the unobservable fixed level of infrastructure supply within each country.

Additionally, the regression will be a complete-case analysis. To the extent that missing values does not arise randomly this will diminish the randomness of the data and could therefore cause trouble with making generalizations outside the sample. The paper nonetheless takes such an approach since the to the author available imputation techniques (such as simple imputation by regression) is considered insufficient to tackle the problem. It does not add any new information while biasing the results in favour of the coefficient from the existent data. Thus it would not eliminate the uncertainty caused by the missing values but the standard deviations would be artificially low. However, as two different measures assessing firm performance are used the missing values will arise because of different survey questions. If the results are robust to these changes the problem of missing data should not be considered too large to vastly diminish the external validity of the study.

To summarize, firm performance - both measured through an augmented production function and employment growth - will be regressed on an infrastructure variable measuring both electricity and transport. This measure could be interpreted as the implicit cost in terms of foregone profits because of insufficient infrastructure, which is higher for more productive firms if it is binding. If infrastructure is a binding constraint on firms the coefficient should be (significantly) positive. The regression will control for omitted variable bias by including firm characteristic variables, other business environment variables, an objective measure of infrastructure as well as country dummies. Finally, what is of consideration is not the exact value of the coefficient; it does not give any information stating that as the assessment of the obstacle X increases by one unit, employment growth changes by Z . While it is important for policy reasons to know what the exact effects of improved infrastructure are, it is also necessary to know if the constraints are binding. Not least since this is an indicator that a bottleneck exists.

Therefore the importance for this paper is the sign of the coefficient and what the significance level is.

4. DATA

The material that will be used is firm-level, cross-sectional data from the WBES (Enterprise Surveys, The World Bank).¹² For almost 20 years the World Bank has regularly been conducting interviews with enterprises from the developing world in order to provide statistically significant indicators on the business environment that are comparable between countries, and to assess the constraints facing the private sector growth. To analyse the present situation facing African firms, this paper uses a newly available data set, with interviews from all countries conducted between 2012 and 2014.

The questionnaire for the interviews includes nearly 200 variables. The manufacturing module consists of 12 parts; (1) Control information (size, industry, etc.), (2) General information (ownership information, legal status, etc.), (3) Infrastructure and Services (power, water, transport and communications technologies, etc.), (4) Sales and Supplies (imports, exports, supply and demand conditions, etc.), (5) Degree of competition (price and supply changes, competitors, etc.), (6) Land (land ownership, land access, etc.), (7) Crime (extent and losses due to crime, etc.), (8) Business-Government Relations (quality of public services, consistency of policy, etc.), (9) Investment Climate Constraints (evaluation of general obstacles), (10) Finance (sources of finance, terms of finance, etc.), (11) Labour (worker skills, training, employment, etc.) and (12) Productivity (numbers needed to estimate productivity, such as total cost of factors of production, the net book value, etc.).

The questionnaire includes both subjective and objective measures. Example of a subjective question is the following: "Is access to financing, which includes availability and cost (interest rates, fees and collateral requirements), no obstacle, a minor obstacle, a major obstacle or a very severe Obstacle to the current operations of this establishment?" That is, these measures often include some sort of rating or ranking of the effect of different parts of the business environment. Such questions are posed in the end of most sections of the questionnaire, and it is these that are used in the regressions to capture the business environment. There are also a vast amount of objective, or quantitative, measures. For instance, the questionnaire asks if the establishment has submitted an application for a water connection, what year it started exporting or how much of the land is owned respectively leased by the establishment.

The subjective measures are useful as control variables since each variable covers a broader part of each issue than any corresponding objective measure. Furthermore, the data from these questions is much more complete than the objective data.

To achieve the purposes of the survey and to get a representative sample, the World Bank uses a randomized stratified sampling technique. The main stratification is sector, where manufacturing,

services and transport, storage and communications are the population of industries included. The manufacturing sector is sub stratified at the two digits level of the ISIC revision 3.1. In the countries for this paper the food and beverages, textiles, garments and in some cases chemicals industries were subject to stratification.

Two other levels of stratification is done; size and location. The latter is only done for large economies in order to provide statistically significant estimates, though regional variability is always taken into account by including the main industrial areas of any country. With respect to size, stratification occurs with three groupings; small enterprises (5-19 employees), medium enterprises (20-99 employees) and large enterprises (≥ 100 employees). This paper only analyses the first two groups for two reasons. Firstly, many papers have found that there exists a skewness in the size distribution of African firms, with proportionally few medium-sized firms. This has coined the expression of "the missing middle." Given that medium-sized firms often account for a lot of the employment, it is crucial to understand what constrains small firms from growing into medium firms and what constraints the current medium-sized firms are facing. Secondly, many (e.g., Reinikka and Svensson, 2002; Sleuwagen and Goedhuys, 2009; Tybout, 2000) argue that when public capital in infrastructure is insufficient, larger firms sometimes have resources to build their own substitutes (e.g., a private generator). For the assumption of an equally fixed supply to hold, it is reasonable to exclude larger firms from the analysis.

4.1 Advantages and Caveats

Since this is the only comprehensive database on a micro level in developing countries it has been used widely in other studies, and it is the main rationale for its application in this study. While there exist other material on the investment climate much is either not comparable across countries or not made on a firm-level. For example, the Doing Business indicator (also done by the World Bank) is on an aggregated level for whole countries and does only provide de jure measures of the regulatory environment. Another advantage is the richness of the data. A lot of different and relevant variables are included. This makes it easier to control for omitted variable bias in order to answer this text's research questions correctly. The common methodology also enables comparison between different types of enterprises as well as cross-country comparisons.

One disadvantage with the WBES in general is that it does not always include stratification on sub sectors of the manufacturing industry. To use such data to answer this paper's research questions, while possible, would be less robust as there would be a lot of noisiness in the data. In later surveys this problem has been solved as more sub sectors are subject to stratification, which is the case for all countries studied in this paper.

Another problem is the firm-size distribution in the survey. Especially, all informal firms as well as micro firms (< 5 employees) are excluded. Because of this reason, this paper cannot speak of the whole population of light manufacturing firms. However, most job creation occur at medium sized enterprises and given the "missing

¹² All descriptive information in this section builds on the manuals, notes, and data-sets collected from The World Bank. Please see www.enterprisesurveys.org for more information.

middle” observed in Africa it is in a sense more important to assess what constrains firms to grow from small enterprises to medium and large ones, rather than what constrains firms from growing from micro firms to small ones. It is also important to assess the constraints facing formal firms as it is probable that a better environment for them would increase the incentives for informal firms to become formal, which is important not least because the governments does not get revenue from informal firms.

4.2. Revisiting the Camels and the Hippos

A commonly mentioned critique is the one raised by Hausmann and Velasco (2005) concerning the “camels and hippos.” The story goes that since there are only camels living in the desert, if you are in such an area and interview the residing animals of the problems with their living environment you would get different answers than if you went to the river and asked the hippos about the problems with living in the desert. The point is that there might be a cause of self-selection in the survey. For instance, the results found in this paper cannot be used to answer what impedes firms from entering the market as the sample frame by definition only includes existing firms. Although this is important to keep in mind, it is still necessary to analyse the impediments facing existing firms as they account for the current employment and output.

5. RESULTS¹³

We begin by running the first augmented production function with only infrastructure and a country dummy as independent variables, except labour and capital. Infrastructure enters positively with a p-value of 0.035 thus being significant at the 5% level. When running the regression with correction for heteroscedasticity it is still positive with virtually the same p-value.

We then add four firm characteristics variables; whether the firm is an exporter, whether it has foreign ownership, whether it is a part of a larger firm, and a size dummy. Again infrastructure enters positively and significant both with and without correction for heteroscedasticity. Its p-value decreases from 0.0404 to 0.0398 when using robust standard errors.

Next we extend the model by adding 13 variables to cover a wide spectrum of the business environment, to diminish possible omitted variable bias. We also add a quantitative measure of infrastructure to better single out the part of the main infrastructure variable that is of interest. In this full model, it is reassuring to note that the coefficients of capital and labour are reasonable, as are the sign of the firm characteristics variables’ coefficients - even though they are not of primary interest in this paper. With respect

13 All results from the regressions with the augmented production function are shown in Table 1. The results from the regressions with employment growth as dependent variable are shown in Table 2 and the results from the regressions with the measures of electricity and transport separated are shown in Table 3. In the tables, only the regressions with correction for heteroscedasticity are presented. The F-statistic is not presented but its p-value is $<10^{-6}$ in all models, so every regression as a whole is significant. The R^2 is not of interest in this paper since we focus on the effect of one specific variable rather than trying to explain the whole variance of the dependent variable. Nonetheless, the adjusted R^2 varies between approximately 5% and 75% depending on the specifications of the models.

to infrastructure, it is once again positive, now with a lower p-value (at 0.020). We run the model with robust standard errors and infrastructure is still positive and significant at the 5% level. When testing for multicollinearity none of the variables get a VIF-value higher than 2.5, except the country dummy¹⁴, indicating that perfect multicollinearity biasing the infrastructure variable does not seem to be present.

It seems, therefore, as if better performing firms pay a higher implicit cost in terms of foregone development, as indicated by their higher demand for infrastructure supply. These results indicate that poor infrastructure poses a binding constraint on small and medium sized firms in Africa. However, even though caution has been taken to diminish the omitted variable bias, there is always a possibility that other omitted variables could significantly affect the results. For instance, aspects such as norms, culture, religion, etc. have not been controlled for and it could be possible that inclusion of such variables could change the results. Although it is important to bear such limitations in mind, they do not completely eradicate the findings from the paper. Also, to the extent that our objective measure did not fully separate the direct cost from the indirect cost in the main variable of interest, our results probably underestimates the constraint posed by infrastructure. It therefore seems reasonable to state that the results indicate that insufficient infrastructure creates a bottleneck for economic growth in the countries studied.

To answer the second research question we add an interaction variable between the industry dummy and the infrastructure variable, food processing being the base. The coefficient for infrastructure is both significant and positive, and when running the regression with correction for heteroscedasticity the infrastructure variable is still positive, now significant with a p-value at 0.0119. The results from the interaction term indicate that infrastructure does not pose a binding constraint on garment firms, as its coefficient is both significant and negative with a higher absolute value than the base coefficient. The basic metals industry enters positively indicating that it is more constrained by insufficient infrastructure than the others. However, except for the garment industry, neither of the coefficients from the interaction term is significant on conventional significance levels. Therefore, it seems that there are no significant differences between the other sub sectors concerning the binding constraint posed by infrastructure.

5.1 Robustness Checks

As the results might have arisen because of what measure of performance has been used, it is useful to run another variable measuring firm performance on the infrastructure variable. Furthermore, in the existing literature on constraints on firms, the dependent variables often differ. To some extent it could be so that the discrepancies between different authors might have arisen because of such differences in how one measures firm performance. The data on total factor productivity is also more incomplete than other measures, which makes it useful to change

14 Given that the number of observations from the base country is only a small fraction of the total amount this is not surprising. Nonetheless, since it is mainly a control variable the high VIF-value does not affect the coefficient of infrastructure and thus does not distort the results.

Table 1: Augmented production functions

Independent variable	Dependent variable: log sales			
	(1)	(2)	(3)	(4)
Log labour	0.833*** (0.127)	0.721*** (0.128)	0.665*** (0.155)	0.608*** (0.154)
Log capital	0.262*** (0.060)	0.268*** (0.055)	0.235*** (0.063)	0.230*** (0.061)
Infrastructure	0.189** (0.089)	0.180** (0.087)	0.268** (0.127)	0.334** (0.132)
Power outages			-0.001 (0.008)	0.002 (0.008)
Size		0.268 (0.208)	0.261 (0.263)	0.210 (0.253)
Establishment		0.194 (0.232)	0.189 (0.275)	0.004 (0.287)
Foreign ownership		1.063*** (0.329)	1.345*** (0.378)	1.273*** (0.368)
Exporter		0.326 (0.330)	0.045 (0.361)	0.070 (0.365)
Telecom			-0.054 (0.107)	-0.059 (0.104)
Customs trade reg			0.001 (0.086)	0.004 (0.084)
Crime theft disorder			0.012 (0.101)	-0.042 (0.102)
Finance			-0.100 (0.103)	-0.121 (0.098)
Tax rates			0.043 (0.128)	0.075 (0.134)
Tax administration			-0.051 (0.135)	-0.089 (0.143)
Licens permits			-0.068 (0.097)	-0.085 (0.094)
Political instability			-0.080 (0.097)	-0.091 (0.100)
Corruption			0.058 (0.085)	0.050 (0.085)
Informal sector			-0.097 (0.089)	-0.067 (0.088)
Land			-0.003 (0.096)	0.013 (0.093)
Labour regulations			0.013 (0.112)	0.031 (0.114)
Education workforce			-0.032 (0.091)	-0.015 (0.092)
Ghana	-4.294*** (0.418)	-4.228*** (0.400)	-4.646*** (0.576)	-4.913*** (0.616)
Kenya	-0.532 (0.362)	-0.636* (0.378)	-0.710 (0.446)	-0.920* (0.468)
Nigeria	-2.168*** (0.377)	-2.364*** (0.437)	-2.668*** (0.573)	-2.742*** (0.589)
Senegal	0.454 (0.377)	0.489 (0.363)	0.668 (0.520)	0.404 (0.529)
Tanzania	0.447 (0.410)	0.536 (0.396)	0.670 (0.486)	0.520 (0.483)
Uganda		0.661 (0.435)	0.631 (0.576)	0.372 (0.599)
Zambia	0.756* (0.435)	1.681*** (0.466)	1.534*** (0.578)	1.392** (0.573)
Textiles				-0.132 (0.154)
Garments				-0.431*** (0.133)
Leather				-0.290 (0.186)
Wood				-0.063 (0.121)
Basic metals				0.226 (0.310)
Constant	10.904*** (0.739)	10.934*** (0.708)	12.108*** (0.986)	12.655*** (1.053)
Degrees of freedom	375	367	271	266

Note: * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$

the dependent variable to employment growth to test the robustness of the results.

We use firm growth instead of sales growth since the former are not as closely related to the dependent variable in the augmented production function. Additionally, the reporting errors that might have arisen in the survey with respect to questions concerning employment stem from different sources than reporting errors with respect to questions concerning sales.¹⁵

Thus, we run all above models with employment growth as the dependent variable. Both when we run the simple model without any control variables and when we add firm characteristic variables the coefficient for infrastructure is negative and insignificant. However, when we extend the model, including all business environment variables as control, infrastructure once again enters positively and significantly. Running the model with robust standard errors does not affect the sign of the coefficient and only increases the p-value to 0.0256. Although

the results are not as robust as the findings from the augmented production functions, the fact that it still enters positively and significant when running the extended model further indicates that infrastructure poses a binding constraint on light-manufacturing firms in Africa.

We also run the extended model with the industry-infrastructure interaction term. The coefficient for infrastructure is still positive and significant, although neither of the coefficients from the interaction term is. This is in contrast to the results above, where the garment industry did not seem to be bound by infrastructure. That the result is not the same when running the regression with another dependent variable justifies more caution when drawing conclusions on whether the garment industry indeed is constrained by the infrastructure. However, that the base coefficient is positive and significant in both models, and none of the other coefficients are, is an indication that all other sub sectors studied are equally bound by infrastructure.

Next, we again use the augmented production function but separate the infrastructure variable into its two components to see if one of its components has a much larger effect than the

¹⁵ For instance, while sales growth is different from the level of sales, incomplete data arising from issues such as underreporting because of sales tax issues, etc. are the same for both sales level and sales growth.

Table 2: Regressions with employment growth

Independent variable	Dependent variable: Employment growth			
	1	2	3	4
Infrastructure	-0.005 (0.013)	-0.007 (0.014)	0.048** (0.021)	0.048** (0.020)
Power outages			-0.001** (0.0004)	0.001** (0.0003)
Size		-0.026 (0.028)	-0.076** (0.032)	-0.075** (0.034)
Establishment		-0.026 (0.037)	-0.072* (0.041)	-0.068 (0.043)
Foreign ownership		-0.020 (0.050)	0.006 (0.062)	0.022 (0.054)
Exporter		-0.0004 (0.052)	-0.016 (0.059)	-0.016 (0.055)
Telecom.			-0.006 (0.015)	-0.006 (0.016)
Customs trade reg			-0.024 (0.016)	-0.026 (0.016)
Crime theft disorder			-0.012 (0.015)	-0.012 (0.016)
Finance			-0.021 (0.014)	-0.022 (0.015)
Tax rates			0.017 (0.021)	0.016 (0.019)
Tax administration			-0.008 (0.020)	-0.007 (0.021)
License permits			0.014 (0.017)	0.013 (0.018)
Political instability			-0.017 (0.014)	-0.018 (0.015)
Corruption			-0.006 (0.015)	-0.005 (0.015)
Informal sector			-0.005 (0.013)	-0.006 (0.014)
Land			-0.010 (0.013)	-0.009 (0.014)
Labour regulations			-0.018 (0.017)	-0.019 (0.019)
Education workforce			0.014 (0.017)	0.015 (0.017)
Ghana	-0.034 (0.074)	-0.036 (0.075)	-0.105 (0.095)	-0.093 (0.092)
Kenya	-0.127*** (0.048)	-0.117** (0.051)	-0.074 (0.063)	-0.071 (0.079)
Nigeria	-0.205*** (0.048)	-0.196*** (0.051)	-0.173*** (0.064)	-0.169** (0.077)
Senegal	-0.077* (0.045)	-0.075* (0.045)	-0.098 (0.061)	-0.093 (0.084)
Tanzania	0.016 (0.059)	0.027 (0.061)	0.055 (0.081)	0.057 (0.080)
Uganda	-0.149*** (0.045)	-0.145*** (0.045)	-0.144** (0.060)	-0.146* (0.080)
Zambia	-0.065 (0.049)	-0.061 (0.049)	-0.073 (0.062)	-0.072 (0.082)
Tobacco				-0.077 (0.150)
Textiles				0.016 (0.029)
Garments				0.0003 (0.020)
Leather				-0.041 (0.040)
Wood				0.018 (0.023)
Basic metals				-0.067 (0.047)
Constant	0.170*** (0.047)	0.182*** (0.049)	0.239*** (0.074)	0.235*** (0.082)
Degrees of freedom	1132	1091	798	792

Note: * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$

other and thus drives the results. Four models are run; one with the electricity variable, one with the transport variable and one each with those variables interacted with the industry variable, respectively, both with and without robust standard errors. Except in one of the models where transportation, while positive, has a p-value of 0.1422, both transport and electricity enters positively and significantly in all models. It seems therefore that especially electricity constrains firms. Weak transportation might also create a bottleneck, though the findings for such a conclusion are less robust. One reason could be that the objective variable used to diminish the attenuation towards zero measures electricity first and foremost, and that the direct cost with respect to transportation thus could not be properly distinguished from the indirect cost. The results from the interaction variable are also in line with those found when using the combined infrastructure variable.

Finally, we set the infrastructure variable as the dependent variable and run it on total factor productivity as a final robustness check. From this model we find that firm performance is positively and significantly related to higher demand (i.e. more complaints) for infrastructure.¹⁶

6. CONCLUSION

For African countries to develop and reduce poverty, it is necessary to create productive jobs and industrialise - which can happen through the light manufacturing sector. For such firms to grow, however, it is fundamental to remove real bottlenecks. Thus, this paper has analysed whether infrastructure puts a binding constraint on African light-manufacturing firms and thus comprise a real bottleneck for development.

The results indicate that infrastructure pose a binding constraint on African firms. In all models from the augmented production function, infrastructure enters significantly and positively, and although it is insignificant in the two simplest models with employment growth as the dependent variable, it is once again positive and significant when running the fully extended model (both with and without the interaction term). The results are most robust for electricity, which is positive and significant in all models. The conclusions regarding transport is in the same direction, although it should be made with more caution as one of the fully extended models shows a relatively high p-value of the coefficient for transport.

With respect to the second research question, if different sub sectors within the light-manufacturing sector are equally constrained, the

¹⁶ The results from these models are available upon request.

Table 3: Regressions with electricity and transport separated

Independent variable	Dependent variable: Log sales			
	(1)	(2)	(3)	(4)
Log labour	0.693*** (0.153)	0.614*** (0.148)	0.693*** (0.148)	0.672*** (0.150)
Log capital	0.236*** (0.065)	0.230*** (0.061)	0.244*** (0.060)	0.243*** (0.058)
Electricity	0.158* (0.085)	0.265*** (0.097)		
Power outages	-0.002 (0.007)	0.001 (0.007)		
Transport			0.147 (0.100)	0.204* (0.114)
Size	0.226 (0.255)	0.166 (0.240)	0.225 (0.238)	0.199 (0.238)
Establishment	0.210 (0.275)	0.036 (0.279)	0.054 (0.262)	-0.052 (0.270)
Foreign ownership	1.338*** (0.374)	1.222*** (0.357)	1.289*** (0.376)	1.225*** (0.368)
Exporter	0.034 (0.359)	0.072 (0.354)	0.030 (0.346)	0.048 (0.352)
Telecom.	-0.041 (0.107)	-0.047 (0.106)	-0.016 (0.094)	-0.029 (0.094)
Customs trade reg	0.031 (0.082)	0.006 (0.080)	0.041 (0.079)	0.060 (0.080)
Crime theft disorder	0.029 (0.101)	-0.030 (0.101)	-0.036 (0.094)	-0.065 (0.096)
Finance	-0.095 (0.103)	-0.119 (0.096)	-0.066 (0.121)	-0.071 (0.125)
Tax rates	0.042 (0.129)	0.074 (0.134)	0.062 (0.120)	0.077 (0.125)
Tax administration	-0.069 (0.136)	-0.113 (0.142)	-0.066 (0.121)	-0.071 (0.125)
License permits	-0.061 (0.096)	-0.064 (0.094)	-0.056 (0.089)	-0.064 (0.090)
Political instability	-0.070 (0.097)	-0.092 (0.099)	-0.066 (0.087)	-0.060 (0.090)
Corruption	0.050 (0.085)	0.049 (0.085)	0.067 (0.082)	0.061 (0.085)
Informal sector	-0.098 (0.090)	-0.069 (0.088)	-0.091 (0.082)	-0.081 (0.083)
Land	-0.015 (0.097)	0.003 (0.092)	-0.034 (0.084)	-0.022 (0.084)
Labour regulations	0.057 (0.114)	0.070 (0.113)	0.052 (0.103)	0.066 (0.105)
Education workforce	-0.027 (0.091)	-0.004 (0.090)	-0.076 (0.088)	-0.085 (0.090)
Ghana	-4.635*** (0.574)	-4.899*** (0.610)	-4.591*** (0.542)	-4.793*** (0.579)
Kenya	-0.690 (0.447)	-0.862* (0.459)	-0.740* (0.418)	-0.922** (0.435)
Nigeria	-2.411*** (0.529)	-2.628*** (0.531)	-2.285*** (0.460)	-2.386*** (0.461)
Senegal	0.689 (0.532)	0.490 (0.517)	0.786* (0.456)	0.565 (0.468)
Tanzania	0.693 (0.494)	0.565 (0.480)	0.711 (0.461)	0.540 (0.457)
Uganda	0.619 (0.574)	0.381 (0.595)	0.585 (0.501)	0.432 (0.514)
Zambia	1.556*** (0.590)	1.402** (0.572)	1.623*** (0.552)	1.551*** (0.545)
Textiles		-0.135 (0.113)		-0.107 (0.182)
Garments		-0.363*** (0.094)		-0.306** (0.151)
Leather		-0.287* (0.159)		-0.215 (0.187)
Wood		-0.029 (0.102)		-0.139 (0.115)
Basic metals		0.210 (0.269)		0.208 (0.328)
Constant	12.095*** (0.998)	12.612*** (1.030)	12.095*** (0.900)	12.326*** (0.921)
Degrees of freedom	272	267	307	302

Note: * $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$

data does not reveal much difference between sub sectors. The only significant difference is that there does not seem to exist a binding constraint on garment firms - although such conclusions should be made carefully since it does not show up when changing the dependent variable to employment growth.

These findings add to the aggregated knowledge of obstacles to firm growth. While not all, many studies have shown that infrastructure has a direct effect on firm growth. This paper's results indicate that, at least for the light-manufacturing sector in the selected countries, there is also a significant indirect effect in terms of foregone development. It seems therefore that investment in public capital in infrastructure would significantly increase the economic activity of the light-manufacturing sector in this set of countries, even at current levels of net productivity.

However, these countries are coping with extremely scarce resources and even though the results in this paper indicate that a bottleneck exists, it does not give any quantitative information of how great the implicit costs are. Further research on the exact costs and gains from investment in infrastructure would therefore be valuable.

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