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Firm Inventory Behavior in East Africa

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Abstract

Firms normally keep certain inventories, including raw materials, work-in-progress, and finished goods, to operate seamlessly and not to miss possible business opportunities. But inventory is costly, and the optimal firm inventory differs depending on various economic conditions, including trade and transport costs. The paper examines firm inventory behavior in East Africa, in which transport connectivity, especially to the ports, is considered as one of the major business constraints. Using firm-level data from Burundi, Kenya, Rwanda, Tanzania, and Uganda, it is shown that transport connectivity significantly affects firm inventory behavior. In particular, road density and transport costs to the port are important to determine the optimal inventory level. With more roads in a city and/or cheaper access to the port, firms would hold smaller inventories.

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FIRM INVENTORY BEHAVIOR IN EAST AFRICA

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JEL classification: H54 ; H41 ; D22 ; C36.

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I. INTRODUCTION

Firms normally keep certain inventories, including raw materials, work-in-progress and finished goods, in order to operate seamlessly and avoid business interruptions. The optimal firm inventory differs depending on sector and surrounding economic conditions. In the U.S. real estate industry, for instance, homebuilders normally have considerable inventories, reflecting the high cost of land, the high transaction costs and time required to procure and obtain the necessary permissions, and considerable uncertainty. The inventory-sales ratio is as high as 0.7 (Chinloy and Wu, 2013). In the retail and wholesale industry in China, it was 0.8 in the 1970s and declined to 0.2 in the 2000s, as the economy grew. The normal inventory-sales ratio may be about 10 percent in general (Brown, 2011).

Inventory cost is a crucial determinant in firm productivity. Inventory is of course financially costly, but it also restricts firm's operational flexibility. Too much inventory prevents firms from investing elsewhere. Annual inventory costs are estimated at between 7 to 16 percent of the value of inventory. Since a firm normally keeps inventory of 10 percent of products, it means that the firm spends about 0.7-1.6 percent of total revenue to carry inventories (Brown, 2011). In East Africa, one recent study that the firm's cost elasticity with respect to inventory measured by the number of days of operation is 0.06–0.07, meaning that a 10 percent increase in inventory measured by the number of days increases firm operating costs by 0.6-0.7 percent (see Iimi et al. (2014)).

The current paper revisits the traditional inventory model of firms, using the case of five East African countries. In theory, the optimal inventory level is determined by the size of market demand, the costs of ordering and transportation, and inventory holding costs (e.g., Arrow et al. 1951). If the potential market of a firm is large, the firm would carry more inventory. If purchasing costs are high, for instance, because of unreliable transport infrastructure and slow customs clearance, firms would likely hold greater inventory to prepare for unexpected disruption in the supply of materials and equipment. If the opportunity cost of carrying inventory is high, firms are motivated to reduce their inventories.

The existing evidence is supportive of theory: In the United States, the level of firm inventory declined by 7 cents for every additional dollar of investments in the highway capital (Shirley and Winston, 2004). In China, each dollar of road spending is estimated to reduce firms' held inventories by 2 percent (Li and Li, 2013). Using the Golden Quadrilateral project liking the country's four largest cities as a quasi-natural experiment, Datta (2012) finds that firms in cities located along the improved highway reduced their inventory by 7 operating days' supply on average in India.

In Africa, the expected impact of improved transport infrastructure is likely to be larger than in other regions, reflecting the different densities, costs and reliability of the comparable networks currently. But there is little hard evidence available in the literature. The paper casts light on the East African Community, in which the member countries have different levels of transport connectivity to markets. While Kenya and Tanzania have the advantage of having major seaports situated on the Indian Ocean, Burundi, Rwanda and Uganda are landlocked countries and dependent on transit across the former countries for the closest international access.

The paper examines the firm inventory behavior in these five countries, using firm-level data from the Business Environment and Enterprise Performance Survey (BEEPS) and integrated spatial road data.[1] In the paper, a new instrumental variable is considered to deal with an endogeneity issue related to infrastructure placement. That is, governments may invest more in transport infrastructure where more efficient firms are located. More reliable transport infrastructure can reduce firm inventory, raising their productivity. Even after controlling for this problem, it is shown that firm inventory is crucially determined by the transport cost to the port.

[1] The paper mainly uses the 2006 BEEPS for Burundi, 2007 for Kenya, 2005 for Rwanda, 2006 for Tanzania, and 2006 for Uganda. Note that newer data in 2011 are available for Rwanda. For consistency purposes, however, the analysis relies on the 2005 survey.

The remaining sections are organized as follows: Section II provides some regional context. Section III develops an empirical model based on the basic inventory theory. Section IV discusses empirical issues. Section V presents main estimation results, and Section VI discusses some policy implications. Then Section VII concludes.

II. An Overview of Transport Infrastructure in East Africa

In East Africa, transport infrastructure is identified as one of the major business constraints: In Kenya, for example, about 40 percent of the surveyed firms responded that transport was a major constraint for their businesses (Figure 1). In the three landlocked countries, Burundi, Rwanda and Uganda, about 25-30 percent of the firms identified transport as a major constraint. Transport infrastructure is a matter of particular concern to firms involved in international trade. While about 30 percent of the domestic firms were concerned about transportation, nearly 60 percent of the exporting and importing firms felt constrained by transport (Figure 2).[2]

While some of the EAC countries have relatively extensive road networks by regional standards (Figure 3), the quality of transport infrastructure overall in the region is poor. About 30-70 percent of the road networks are estimated to be in poor condition. While the primary road networks are relatively well maintained, about half of the secondary and tertiary road networks remain in poor condition. In Rwanda and Uganda in particular, the majority of the secondary and tertiary roads need to be rehabilitated (Figure 4).

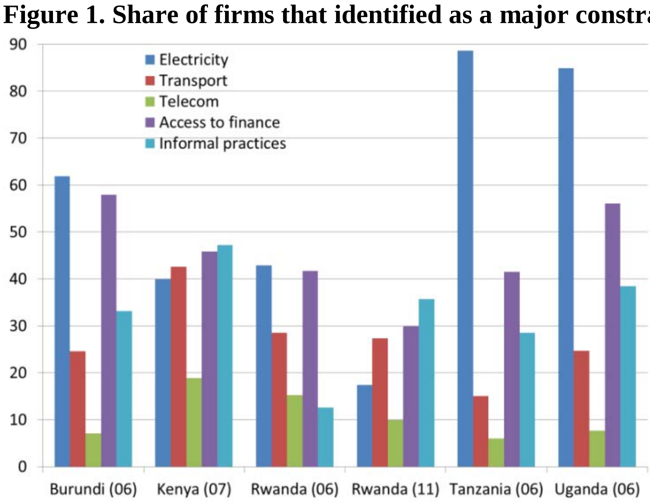
Railway assets are also deteriorated. Because of lack of proper maintenance, railway has been losing competitiveness against roads in the region. In Kenya, for instance, 93 percent of

[2] Exporting firms are defined as those who exported at least 10 percent of products to abroad. On the other hand, importing firms are defined as those who responded that they imported any material inputs and/or supplies directly from abroad.

all freight and passenger traffic is carried by road transport.[3] In Tanzania, the freight volume hauled by the Tanzania Railway Limited (TRL) in 2010 represented only 16 percent of the peak demand in 2003.[4] Urgent rehabilitation and proper maintenance are called for to restore the railways comparative advantage in long-haul transportation.

Regional major transshipment ports are becoming increasingly congested. The port productivity of Mombasa is 10 container moves per crane-hour, which is less than one-third of the port of Singapore and 50 percent less than the port of Durban. The TICTS container terminal in the port of Dar es Salaam has been operated by a private concessionaire since 2000 and exhibits better performance. It currently handles about 20 container moves per crane-hour. However, traffic has been growing rapidly, and the port has been experiencing capacity constraints in recent years. The total waiting time at the port is estimated at 330 hours.

Figure 1. Share of firms that identified as a major constraint (percent)



Sources: BEEPS.

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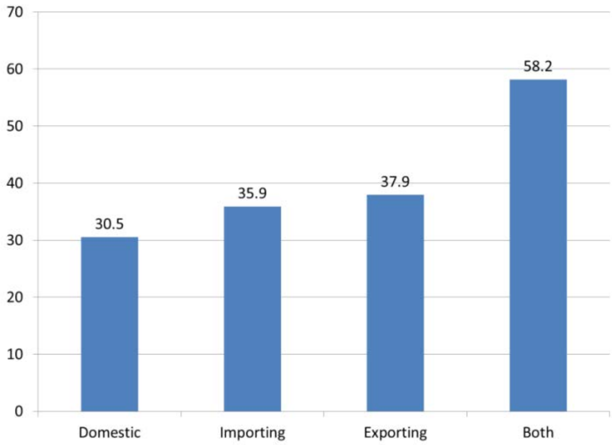
[3] "Road Sector Investment Programme and Strategy 2010-2024." Ministry of Roads, Kenya.

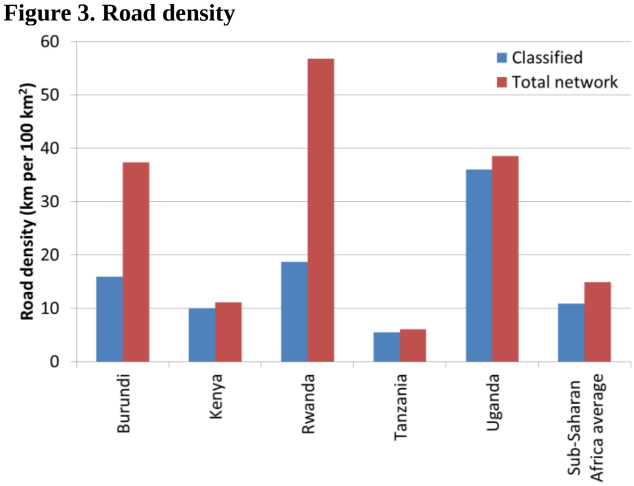
[4] "Comprehensive transport and trade system development master plan in the United Republic of Tanzania." 2011. Ministry of Transport, Tanzania.

Figure 2. Share of firms that identified transport as a major constraint (percent)



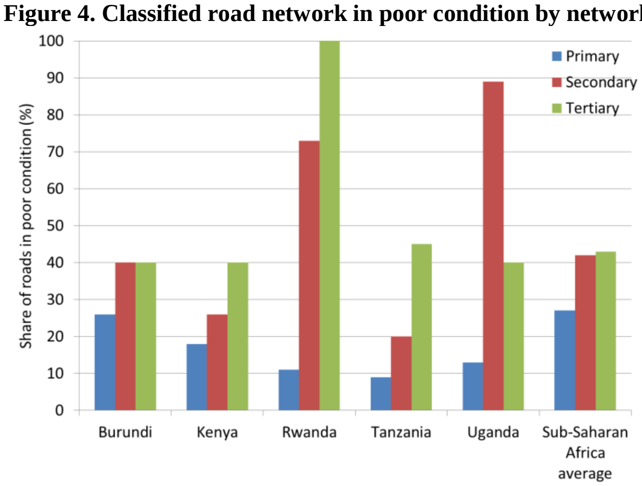
Sources: BEEPS.

Figure 3. Road density



Source: Gwilliam (2011).

Figure 4. Classified road network in poor condition by network type



Source: Gwilliam (2011).

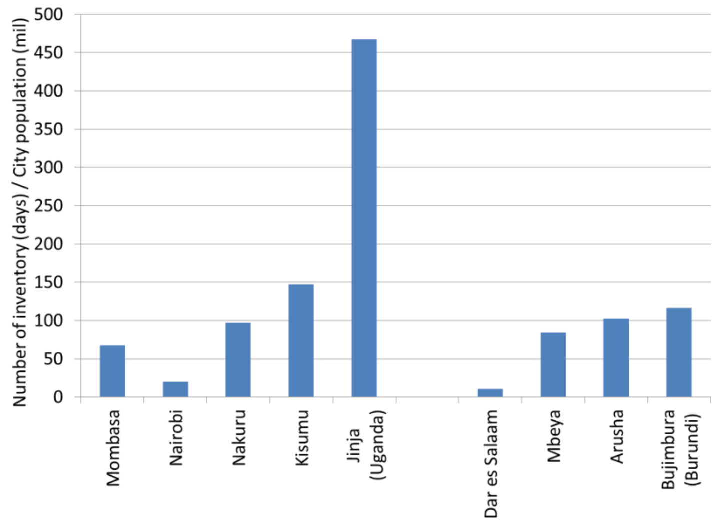
These transport constraints add to firm operating costs, diminishing their competitiveness in the regional and international markets. In addition, firms in the East Africa region are heavily dependent on imports for their inputs and equipment. About 60 percent of the firms operating in Rwanda relied on imports for inputs and/or supplies. And they waited for 15 days for their imports to be cleared at customs (BEEP 2011).

Even on a simple correlation basis, there seems to already be a relationship between the distance from the port and the average inventory of firms. The capital city of Kenya, Nairobi, is located about 480 km away from the port of Mombasa. The average inventory of firms in Nairobi is 20 days per 1 million head of population (Figure 5).[5] The average inventories of firms in cities further inland, such as Nakuru and Kisumu located 640 km and 810 km away from the port, are much larger at 97 and 147 days, respectively. . The average inventory in Jinja, Uganda, which is 1,040 km from Mombasa, is as much as 450 days.

Similarly, along the Central Corridor, average inventory of firms is 10 days in Dar es Salaam. But as the distance from the port increases, the level of inventory increases, adding to firm operating costs. Average inventory is 84 days and 102 days at Mbeya and Arusha, respectively. In Bujumbura, Burundi, average inventory reaches 116 days.

[5] Inventory costs need to be examined with the market size taken into account. In theory, the optimal level of firm inventory depends on the total demand or market size, transport and handling costs, and holding cost. See the following section.

Figure 5. Average firm inventory in selected cities (days per 1 million of population)



Source: World Bank calculation based on BEEP data.

III. Empirical Model and Data

Economic theory provides three major reasons for why firms hold inventory (see Blinder and Maccini (1991), and Guasch and Kogan (2003) for more discussion). First, firms want to have certain inventory to smooth their production (i.e., "production-smoothing"). Second, firms want to hold inventory not to lose business opportunities under uncertainty of demand (i.e., "buffer-stock"). Finally, firms hold inventory to minimize the costs of ordering and transporting goods. This is known as the economic order quantity model or (*S*,*s*) model. The first two models are considered to be most natural and conceptually accepted. However, empirical data may not be supportive of them, because production is often more variable than sales, which contradicts the production-smoothing model. In addition, the observed inventory levels do not seem to reduce despite the fact that information and communication technology (ICT) development must have reduced the needs for buffer (Blinder and Maccini, 1991).

The last economic order quantity model seems most plausible, which suggests that a firm determines its inventory level, depending on the size of total demand, ordering and transportation costs, and opportunity costs of inventory (e.g., Arrow et al. (1951), and more

recently, Mosser (1991), and Caplin and Leahy (2010)). The simplest deterministic model is as follows: Suppose that a firm is faced with constant demand over time and selects the optimal inventory level *S* to minimize the total purchasing and inventory cost:

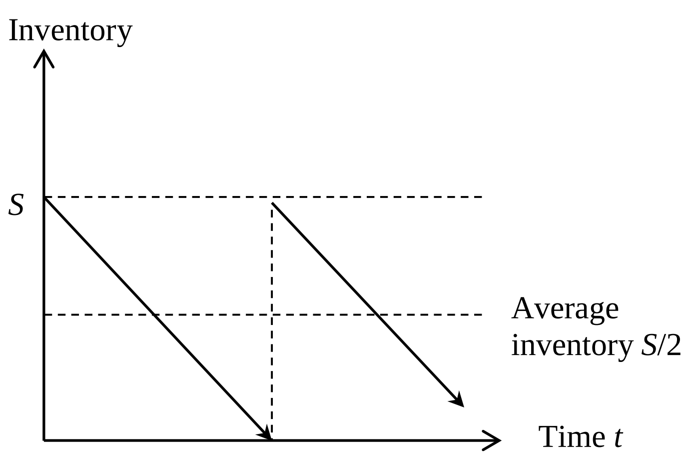
$$\min_{S} \frac{D}{S}k + \frac{S}{2}h \tag{1}$$

where *D* is the total demand per year, and thus, *S* is the number of orders per year. *k* represents the purchasing cost, including ordering, handling and transportation costs. This is fixed regardless of the quantity per order.

The firm has to bear the annual holding cost *h* per unit of inventory. Since the demand is assumed to be constant and continuous over time (Figure 6), the firm's inventory level is written by $S-t$ at *t*, and the average quantity of inventory is *S*/2. The optimal inventory is then:

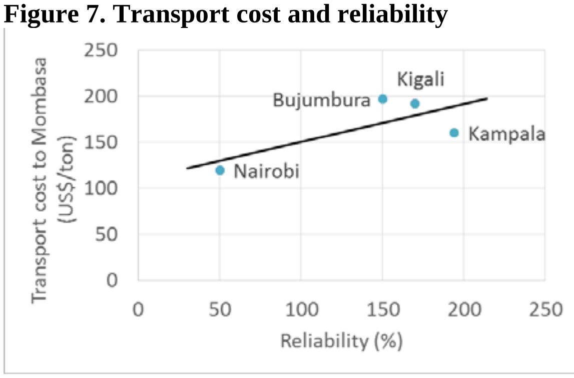
$$S^{*} = \sqrt{\frac{2Dk}{h}} \tag{2}$$

Figure 6. Economic order quantity model



Under stochastic demand (i.e., (Q, R) model), the literature also suggests that the optimal buffer inventory increases with uncertainty surrounding demand and deliveries during a purchase interval (Nahmias, 1997). It means that increased reliability of the supply chain, for instance, should have a favorable impact on the need for firms to hold buffer stocks against delivery failure. But it is a challenge to measure uncertainty or reliability in available data. Normally, it is correlated with transport costs. Our data are supportive of this, though the data points are limited. Transport reliability tends to be low where transport costs are high (Figure 7).[6] In addition, our data do not seem to support the impact of increased reliability of the supply chain on firm inventory.[7]

Figure 7. Transport cost and reliability



Source: Author's calculation and Nathan Associates (2011).

Given the limited data, the following reduced-form inventory equation focusing on transport connectivity or costs is considered (e.g., Shirley and Winston, 2004; Li and Li, 2013):

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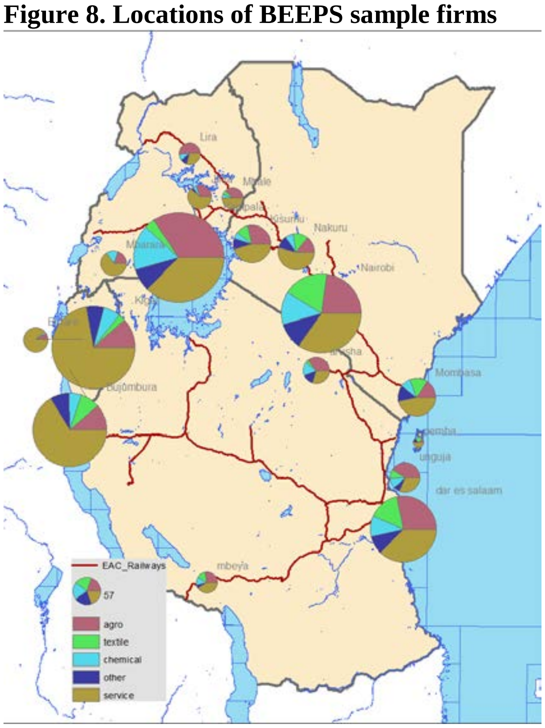
[6] Reliability is defined as the percentage of average transit time that accounts for 90 percent of the variation in transit time.

[7] A theoretical hypothesis is that a firm reduces its inventory if the supply network is more reliable or less uncertain. The instrumental variable estimation was performed with the average level of inventory by other companies in the same city, which is a proxy of reliability of the local supply network. The result turned out opposite: A firm is likely to have more inventory, if neighboring firms have more inventories. Thickness of inventory in a city does not reduce individual firm's inventory. This may be because firms do not rely on each other as supplier/buyers, or because it is highly correlated with the transport cost variable, which may absorb the reliability effect.

$$\ln S = \beta_0 + \beta_1 \ln CONN + \beta_2 \ln CONN^2 + \beta_3 \ln POP + \beta_4 \ln SALE + \beta_5 INTR + X'\beta_6 + \varepsilon \qquad (2)$$

where S denotes the quantity of firm inventory, which is measured by the number of days of inventory. Our firm-level data come from the 2005 Business Environment and Enterprise Performance Surveys (BEEPS), which were conducted by the European Bank for Reconstruction and Development and the World Bank. The BEEPS data normally focus on firms in major urban areas where firms are agglomerated. In East Africa, the data originally cover 2,775 firms (of which, 407 firms in Burundi, 781 in Kenya, 340 in Rwanda, 484 in Tanzania and 763 in Uganda) (Figure 8). The following analysis focuses on only about 1,754 firms, for which all necessary data are available.

Figure 8. Locations of BEEPS sample firms



Source: BEEPS data.

Our primary interest lies in the impact of transport connectivity on inventory, β_1 and β_2. Since the literature indicates the highly nonlinear effect of transport connectivity, the squared

term is included to allow the model to be flexible enough.[8] As discussed above, the firm's optimal level is expected to decrease with purchasing costs, largely depending on transport infrastructure conditions.

Transport accessibility can be measured in many ways. Three measurements are considered: (i) local connectivity (ii) distance to the nearest port, and (iii) lowest transport cost to the port. First, local connectivity is measured by road density around each city and denoted by $CONN_1$. While traffic congestion in urban areas is becoming increasingly heavy in Africa, higher road density is by and large expected to reduce local transportation costs and increase proximity among firms within the city. As the result, firm inventory could be reduced.

Second, distance to the seaport may be a good proxy to measure port connectivity and therefore firm inventory costs. As discussed, many firms in East Africa are involved in regional and international trade and business. A bottleneck is often connectivity to the seaports, and thus, global markets, especially in inland cities and landlocked countries. To calculate the road distance to the nearest seaport ($CONN_2$), a spatial technique is used with the national road network data merged within the region (Figure 9). In this paper, only two major seaports in the region are considered: Dar es Salaam and Mombasa.

Finally, the lowest possible transport cost per ton-km to the port is calculated (denoted by $CONN_3$). Physical distance may not well capture the actual transport connectivity. What really matters may be the transport cost that firms have to shoulder. This should include not only road user costs and fees and charges paid for transport operators but also opportunity time costs to wait at transport nodes, such as borders and ports. "Economic borders" are often thick in Africa (World Bank 2009). Therefore, regional trade and transport costs may be high even between neighboring countries in the same region.

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[8] In reality, firms need to hold certain level of inventory, if the purchasing costs are small. This is simply because firms prefer to prepare for unanticipated shocks and not to miss possible business opportunities. On the other hand, holding too much inventory is also unrealistic because of physical and financial reasons.

To measure these types of transport connectivity, a variety of data sets are used from different sources. The most important data are road network data, which come from the individual EAC countries. The timing of these data vary from 2006 to 2010 (Rwanda, Burundi and Uganda in 2006, Tanzania in 2008, and Kenya in 2010).[9] Thus, there is a slight difference between the dependent variable and transport connectivity data. However, the difference is considered to be small, especially when taking into account the fact that the road network data are not changed dramatically in the short term.

Various assumptions are made to calculate the lowest transport cost from a city to the port. It is composed of vehicle operating costs, which are assumed to differ according to road characteristics, such as road class, surface and road conditions, opportunity time costs of drivers, waiting time at transport nodes, such as rail stations and ports, and nodal fees and charges, such as cargo handling and customs fees. An optimal route is selected based on the lowest transport cost. Not surprisingly, firms in inland cities bear much higher transport costs than those in coastal cities (Figure 10). For instance, the transport cost for firms in Mombasa is estimated at $78.33 per ton, which includes various fees paid at the port and time costs of waiting in and outside of the port. The transport cost of conveying goods from Nairobi to Mombasa is estimated at $119.50 per ton. The transport costs from Kampala and Kigali are much higher at $160.18 and $191.82 per ton, respectively.[10]

Regarding other explanatory variables than transport connectivity, the city population is used to capture the local demand at the aggregate level (*POP*). The optimal inventory level is expected to increase with the size of total demand. In East Africa, Dar es Salam is the largest metropolitan area with 4.3 million of population, followed by Nairobi with 3.1 million and

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[9] The new generation of BEEP after 2011 does not include data on firm inventory, which unfortunately does not allow us to use some recent data for the analysis.

[10] These figures are broadly consistent with those in another freight cost survey, Doing Business by the World Bank. This is a cross-country and the data represent export and import freight costs from the country's largest business city. For instance, the import freight costs are estimated at $112 per ton for Kenya, $153 for Uganda, and $237 for Rwanda (http://www.doingbusiness.org/data/).

Kampala with 1.7 million. (Figure 11). To capture the potential market size that each firm is faced with, the amount of total sales is also included in the equation (*SALE*).

The firm's inventory is also affected by the stock holding cost per unit. Theoretically, this should be represented by the interest rate paid by firms (*INTR*). Inventory is idle capital, and therefore, the interest rate is its opportunity costs. Unfortunately, however, data on interest payments are limited in the BEEPS for Africa, simply because not many firms rely on external borrowing in the region. Only about one-fourth of the surveyed firms borrowed capital from outside. In addition, from the empirical point of view, analyzing only those who have external debt may raise concern about the sample selection bias, because they are presumably in a better financial position. They tend to be large-scale companies.

In the following analysis, we therefore use not only interest rate, *INTR*, but also another proxy of the firm's stock holding costs, which is foreign ownership [11] A dummy variable, D_{FO}, is set to one if the majority of stakes are owned by foreign investors and zero otherwise:

$$\ln S = \beta_0 + \beta_1 \ln CONN + \beta_2 \ln CONN^2 + \beta_3 \ln POP + \beta_4 \ln SALE + \beta_5 D_{FO} + X'\beta_6 + \varepsilon \qquad (2')$$

The idea is that the capital costs are likely to be lower for foreign-owned firms than domestic firms. Foreign-owned firms have presumably better access to the financial market, and their interest rates would be lower. As the result, their inventory levels are expected to be higher, holding everything else constant.

Other firm-level characteristics, such as firm age, are also included in *X* to control for heterogeneity among firms. The summary statistics are shown in Table 1. Firm age is expected to be a major observable to capture firm characteristics, possibly including business experience and financial strength. Whether a firm is engaged in international transactions

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[11] Still, the following analysis still estimates the model with *INTR* included. The results turned out to be broadly consistent. See the following sections.

(exports and/or imports) is also likely to be an important determinant of firm inventory. Presumably, firms operating in a broader domain may need more inventories, especially under circumstances where trade and transport services are unreliable. To control other unobservables, the industry-specific fixed-effects are included. Different levels of inventory are required in different industries.

Figure 9. Road distance to the nearest port (km)

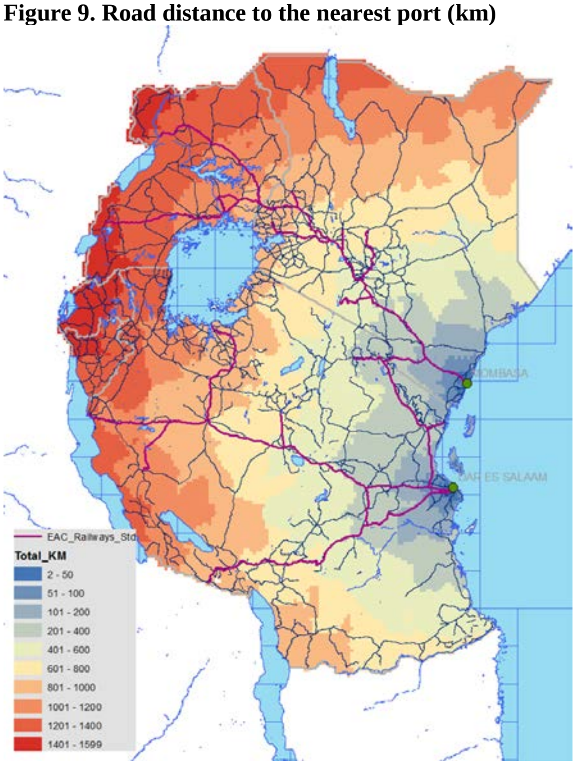

Figure 10. Transport costs to the port (US$ per ton)

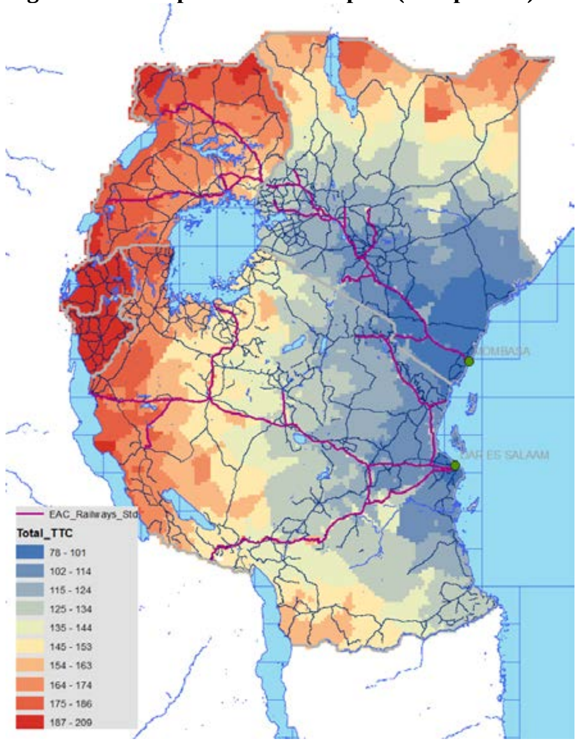

Figure 11. Major cities in East Africa

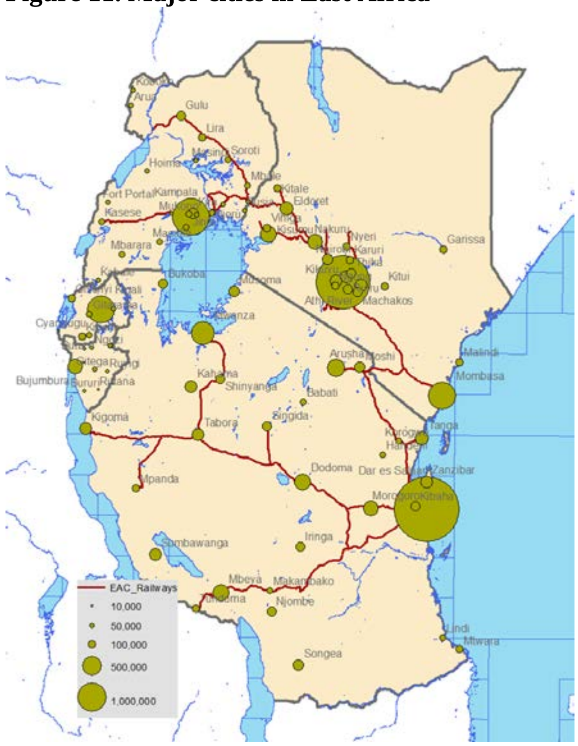

Table 1. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Firm inventory stock (days of operations)	1754	25.5	41.1	0.0	730.0
Road density around each city (km/km2)	1754	0.7	0.5	0.2	1.5
Road distance to the nearest port (km)	1754	796.5	501.3	6.0	1469.6
Transport cost to the port (US$/ton)	1754	142.4	36.5	78.3	199.1
City population (million)	1754	1.8	1.4	0.1	4.4
Annual sales before three year (US$ million)	1754	2.3	26.5	0.0002	1010.0
Dummy for foreign-owned firms [1]	1754	0.14	0.35	0	1
Interest rate (%)	554	16.1	6.9	0	100
Firm age (years)	1754	15.2	12.5	4.0	98.0
Dummy for importing firms [2]	1754	0.20	0.40	0	1
Dummy for exporting firms [3]	1754	0.15	0.35	0	1
Industry dummy variable: Textile	1754	0.10	0.30	0	1
Agrobusiness	1754	0.26	0.44	0	1
Metals & chemical	1754	0.11	0.32	0	1
Service	1754	0.39	0.49	0	1
Other manufacturing	1754	0.10	0.30	0	1

1/ Foreign-owned firms are defined by companies of which majority stakes are owned by foreign investors.
2/ Importing firms are referred to as those who claimed to import any material inputs or supplies directly from abroad.
3/ Exporting firms are defined by those who exported at least 10 percent of sales to abroad.

IV. Empirical Issues

A potential empirical challenge to estimate Equation (2’) is that transport connectivity might be endogenous, because infrastructure placement is normally targeted. Therefore, there is potentially an endogeneity issue: While productive firms prefer to be located where transport access is good,[12] the road authorities may also invest more in the places where productive firms exist or may be committed to invest in infrastructure to invite new firms. The reasons for investing in particular infrastructure are complex and hard to be specified. True abilities of firms are also unobservable for econometricians. Thus, the ordinary estimation is likely to be upward biased, if this self-selection matters.

[12] Evidence is supportive of this. Good road infrastructure can attract more firm investment and enable export-oriented growth (Cieślik and Ryan, 2004; Boudier-Bensebaa, 2005; Qureshi, 2008). Exporting firms also prefer to be located close to motorways with better accessibility to the interregional market (Holl, 2004).

To address this problem, the instrumental variable technique is used.[13] As an instrument to our transport connectivity, the straight-line distance is calculated from each city to the border line between Kenya and Tanzania (Figure 12). The underlying idea is that some African rail lines developed in the colonial era were politically motivated, and thus, their placement may be independent of economic outcomes that are observed at present (Jedwab and Moradi, 2012).

This border line dates from as early as the late nineteenth century and was artificially “drawn” based on the balance of political and military power between two European powers, Britain and Germany.[14] Few economic motives seem to have been involved at least at the early stage of the colonial era. While Britain wanted to secure a strategic position to control the White Nile from Lake Victoria to the Mediterranean, Germany, a newcomer to the colonial movement in Africa, also aimed at acquiring access to part of Lake Victoria (Amin, Willetts and Matheson, 1986). Along the line, the two powers were competing against each other and racing to extend their boundaries as far as possible.

The development of the transport infrastructure in East Africa in close relation to this border line was a logical corollary to the Berlin Treaty of1885 which required tangible signs of development in order to claim colonial rights (“principle of effective occupation”). Therefore, both Britain and Germany embarked upon and aggressive expansion of the railway network in the 1890s. “The railway proposal was just the kind of venture that many politicians in Britain were looking for (ditto).” In 1896 Britain started developing the most

[13] Another approach in the literature relies on panel analysis. As far as time-invariant location-specific effects are concerned, panel analysis can eliminate the selection bias to a large extent. Dercon et al. (2008) use long panel data, finding that poverty declined because of improved transport accessibility in Ethiopia. Khandker and Koolwal (2011) also apply a dynamic panel technique to show that per capita expenditure was increased by rural road construction in Bangladesh. Unfortunately, firm panel data are not available in East African countries.

[14] Since then, the border line has not changed much and remains almost the same as it stands now.

direct route inland from Mombasa to Kisumu. In parallel, Germany also began constructing its railway network from Tanga toward Mount Kilimanjaro in 1893. The Tanga Line became the first railway built in East Africa, though it was a meter-gauge line.[15]

Our instrument variable is constructed based on these historical events. The distance to the border line seems to be promising, though its validity has to and will be tested empirically. On one hand, the distance to the border line is less linked to economic activities in currently economically active cities, if the above history is true. On the other hand, the distance has been affecting transport infrastructure developments in the region. The areas closer to the border line would be more likely to receive "exogenous" benefits from railways and other transport modes developed subsequently.[16]

[15] There is another major rail line from Dar es Salaam to Kigoma, a port town situated on Lake Tanganyika and Mwanza on Lake Victoria. The Central Railway was proposed as early as 1894 but the construction was delayed until 1905, because of the political significance attached to the Tanga Line. The Central Line reached Kigoma in 1914 and Mwanza in 1928.

[16] Though it does not seem to be applicable to our case, there is another approach to construct instruments in the literature. Chandra and Thompson (2000), examining the impact of the U.S. interstate highways on earnings of firms, argue that the non-metropolitan counties served by highways received exogenous benefits, because the interstate highways first aimed at connecting metropolitan areas. Banerjee et al. (2012) also apply the same concept for the case of Chinese railways, calculating the distance from counties to straight lines connecting historic cities and ports, which can be arguably treated as exogenous.

Figure 12. History of railway development in East Africa and construction of an instrumental variable

V. Estimation Results and Policy Implications

To estimate Equation (2'), the instrumental variable (IV) estimation is performed. The estimation results are shown in Table 2. According to the conventional exogeneity test, our transport connectivity variables are likely to be endogenous. In most cases, the test statistics are found well above the conventional critical values. Therefore, our instrument seems valid, and the exogeneity hypothesis can be easily rejected, and ordinary least squares estimates would be likely biased. In addition, as expected, the instrumental variable tends to be adversely correlated with transport connectivity measurements. In the first stage, road density decreases with the distance to the border line, and the transport cost to the port increases when a firm is located far away from the border line.

The coefficients estimated by the IV technique are found to be broadly consistent with *a priori* expectations. Transport connectivity affects firms' inventory behavior. The amount of inventory decreases with local connectivity (measured by road density in our case). Thus, the

more local roads, the lower the inventory. The elasticity is estimated at -1.09.[17] This is not only consistent with theory, but also highlights the fact that urban traffic congestion is becoming a matter of serious concern in many large cities in Africa. Investing more in urban roads could help firms to reduce their inventory, strengthening firm competitiveness.

When transport connectivity is measured by road distance to the port ($CONN_2$), the results vary, depending on the assumed functional form. While the elasticity is estimated at -0.17 by the log linear model, the quadratic specification provides a positive elasticity of 0.79. Both are statistically significant. The results may be interpreted to support the view that road distance may not be a good measurement of transport connectivity.[18] The distance does not really matter to actual inventory behavior, because it cannot capture real economic costs that firms have to pay in terms of both freight fees and time costs.

By contrast, our evidence is supportive of the idea that what really matters is transport costs. When the transport costs ($CONN_3$) are used, the elasticity of inventory is 0.98 in the quadratic model. The coefficient of $CONN_3$ is positive but not statistically significant with the log linear specification. The impact of transport cost reduction on firm inventories seems to be highly nonlinear. Figure 13 depicts the predicted inventory levels by transport costs based on the last column model. All other variables are set at the sample means. The optimal inventory level would likely increase significantly if transport costs exceed US$150 per ton. As depicted in Figure 9, this is associated with most of the areas in Burundi, Rwanda and Uganda, and most inland areas in Kenya and Tanzania.

In respect of the other explanatory variables than transport connectivity, market size is found to be important to determine the optimal inventory level. Both *POP* and *SALE* have positive and significant coefficients, indicating that firms with greater demand in the market tend to

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[17] Although the quadratic specification also provides a significant and negative elasticity. But both coefficients associated with $CONN_1$ turned out insignificant. Therefore, the log linear model is perhaps more reliable.

[18] There is a similar argument in the literature. Chomitz and Gray (1996) argue that distance to markets is not correlated with agriculture production and use it as one of the instruments of road placement.

hold more inventories, consistent with the theory. Firms importing certain materials and equipment keep higher inventory. This is also an expected result in the East African context. High freight and time costs to import goods are considered as crucial bottlenecks to strengthening firm competitiveness in the region.

An unexpected result was that the inventory level does not appear to depend on the firm's ownership structure. Although the dummy variable of foreign owned firms (D_{FO}) was included as a proxy representing the inventory holding cost or the financial cost of holding idle capital, named as inventory. However, this dummy variable does not seem to be a good indicator of stock holding costs. Foreign owned firms are perhaps relatively large. This size effect may dominate the effect of having low inventory cost and thus low inventory level.

A more direct measurement, interest payment, is available but only for a limited number of firms. Table 3 shows the IV estimation results with interest rates (*RATE*). The number of observations is much limited to 554. In Africa, not many firms borrow money from outside sources. The coefficients of *RATE* are still not significant at the conventional critical levels, but all the coefficients are negative as expected, and the *p*-values are relatively high at 0.15-0.20 in most of the cases. Though not perfect, this can be interpreted as an indication that higher stock costs would reduce the optimal inventory level of firms.

Other main results remain unchanged: The transport connectivity variables are likely to be endogenous. Better transport accessibility (in terms of both local and port connectivity) could help firms to reduce their inventories. Market size matters. The estimated impacts are particularly important to firms importing goods and materials.

Table 2. Instrumental variable estimation of firms' inventory behavior

	(1)	(2)	(3)	(4)	(5)	(6)
ln$CONN_1$	-1.091 *	-0.205				
	(0.572)	(0.190)				
ln$CONN_1$ln$CONN_1$		0.289				
		(0.226)				
ln$CONN_2$			-0.166 **	-1.709 ***		
			(0.084)	(0.557)		
ln$CONN_2$ln$CONN_2$				0.187 ***		
				(0.058)		
ln$CONN_3$					6.109	-20.457 *
					(4.436)	(12.413)
ln$CONN_3$ln$CONN_3$						2.161 *
						(1.262)
ln*POP*	0.393 **	0.243 ***	-0.080	0.102 **	0.708	0.149 ***
	(0.181)	(0.067)	(0.074)	(0.043)	(0.481)	(0.037)
ln*SALE*	0.184 ***	0.139 ***	0.102 ***	0.142 ***	0.264 **	0.130 ***
	(0.042)	(0.018)	(0.018)	(0.019)	(0.111)	(0.017)
D_{FO}	-0.056	0.057	0.181 *	0.080	-0.337	0.077
	(0.138)	(0.094)	(0.098)	(0.097)	(0.357)	(0.094)
ln*AGE*	0.259 ***	0.214 ***	0.167 ***	0.194 ***	0.322 **	0.196 ***
	(0.072)	(0.052)	(0.049)	(0.052)	(0.128)	(0.051)
D_{IM}	0.670 ***	0.707 ***	0.735 ***	0.747 ***	0.746 ***	0.740 ***
	(0.116)	(0.097)	(0.094)	(0.098)	(0.148)	(0.095)
D_{IM}	0.224	0.100	0.018	0.084	0.289	0.049
	(0.152)	(0.098)	(0.093)	(0.100)	(0.248)	(0.095)
cons	-6.594 **	-3.575 ***	2.774 *	1.573	-41.545	46.366
	(3.377)	(1.093)	(1.597)	(1.311)	(30.048)	(30.427)
Obs	1754	1754	1754	1754	1754	1754
Wald chi2	406.80	499.59	488.56	461.09	217.20	500.27
R squared	0.051	0.180	0.195	0.154		0.187
No. of industry dummy variables	4	4	4	4	4	4
Exogeneity test statistics	4.237 ***	21.751 ***	1.458	43.939 ***	4.654 **	32.178 ***
Elasticity at means:						
$\partial \ln S / \partial \ln CONN$	-1.091 *	-0.388 ***	-0.166 **	0.788 ***	6.109	0.979 ***
	(0.572)	(0.112)	(0.084)	(0.225)	(4.436)	(0.258)

Figure 13. Predicted inventory levels by transport costs

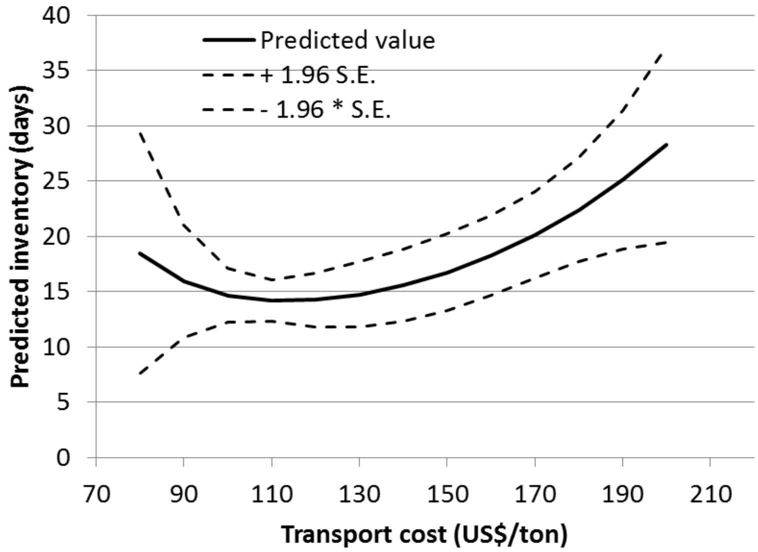

Table 3. Instrumental variable estimation with interest rates

	(1)	(2)	(3)	(4)	(5)	(6)
ln*CONN*$_1$	-0.563	-0.664				
	(0.527)	(0.475)				
ln*CONN*$_1$ln*CONN*$_1$		-0.057				
		(0.518)				
ln*CONN*$_2$			1.572	-0.657		
			(2.813)	(1.751)		
ln*CONN*$_2$ln*CONN*$_2$				0.106		
				(0.157)		
ln*CONN*$_3$					0.839	60.004
					(0.787)	(74.747)
ln*CONN*$_3$ln*CONN*$_3$						-5.861
						(7.479)
ln*POP*	0.170	0.182 *	0.942	0.217	0.050	0.125 *
	(0.190)	(0.103)	(1.777)	(0.157)	(0.087)	(0.073)
ln*SALE*	0.103 ***	0.106 ***	0.094	0.100 ***	0.095 ***	0.117 ***
	(0.037)	(0.033)	(0.067)	(0.039)	(0.033)	(0.039)
RATE	-0.018	-0.019	-0.060	-0.025	-0.017	-0.029
	(0.014)	(0.014)	(0.086)	(0.018)	(0.013)	(0.021)
ln*AGE*	0.245 **	0.249 ***	0.248	0.205 **	0.205 **	0.241 **
	(0.106)	(0.092)	(0.219)	(0.093)	(0.090)	(0.108)
D_{IM}	0.648 ***	0.631 ***	1.215	0.812 ***	0.770 ***	0.805 ***
	(0.200)	(0.151)	(0.830)	(0.246)	(0.148)	(0.196)
D_{EX}	0.169	0.179	0.440	0.151	0.116	0.310
	(0.182)	(0.148)	(0.758)	(0.162)	(0.154)	(0.268)
cons	-1.681	-1.878	-21.126	-2.116	-3.730	-153.791
	(3.185)	(1.755)	(41.189)	(6.091)	(5.034)	(186.562)
Obs	554	554	554	554	554	554
Wald chi2	172.62	180.87	31.68	157.26	172.15	122.95
R squared	0.182	0.171		0.080	0.195	
No. of industry dummy variables	4	4	4	4	4	4
Exogeneity test statistics	1.551	18.927 ***	1.286	32.405 ***	4.041 **	24.846 ***
Elasticity at means: $\partial \ln S/\partial \ln CONN$	-0.563	-0.643 **	1.572	0.756 *	0.839	2.030 **
	(0.527)	(0.306)	(2.813)	(0.392)	(0.787)	(0.909)

VI. Discussion

Four scenarios are considered to understand the estimation results in practical terms (Table 4). The first scenario assumes that the total port costs, including fees and waiting time costs, are halved. The current costs are about US$78 and US$96 per ton at the port of Mombasa and Dar es Salaam The second scenario assumes that the border charges, such as customs, are halved. The current border costs range from US$11 to US$16 per ton. The time costs at border points are not significant. The third scenario assumes that the fees and charges paid at the port are halved. Finally, the fourth scenario assumes that the waiting time at the port is halved. These scenarios provide some insight into the priority that should be accorded to different interventions within the port.

Using the elasticity estimated by the last column model in Table 2, the average impacts are calculated for each city (Table 5). The comparison between the first two scenarios indicates that the expected benefits from the port improvements would be much greater than those from the border improvements. This is simply because the port costs are much higher than the border costs. In addition, the results show that the entire region would benefit from port improvements. But for obvious reasons, the expected benefits from border improvements would accrue to the landlocked countries.

Comparing the last two scenarios, it seems that benefits from improved efficiency in port operations (i.e., reduced waiting time) tend to be more significant than those from tariff reductions at the ports. This indicates that *if* the investment costs are the same, the governments prioritize projects that improve operational and spatial efficiency, possibly addressing institutional constraints and expanding port capacity. This would be more inductive to reducing firms’ inventory costs and improving their competitiveness.

Table 4. Scenarios with different transport node improvements

		Mombasa	Dar es Salaam	Border points
Baseline	Current costs	77.99	96.16	10.81-16.26
Scenario 1	Total port costs (both fees and time cost) are halved	38.99	48.08	
Scenario 2	Total border costs (both fees and time cost) are halved			5.41- 8.13
Scenario 3	Port fees are halved	67.96	84.43	
Scenario 4	Time costs at port are halved	49.02	59.82	

Table 5. Predicted impacts on firm inventory

Country	City	Baseline	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
		Days	Days	% change	Days	% change	Days	% change	Days	% change
Burundi	Bujumbura	13.3	10.3	-22.5	12.6	-5.7	12.7	-5.0	11.1	-16.6
Kenya	Kisumu	10.8	7.5	-30.3	10.8	0.0	10.0	-7.8	8.4	-22.5
	Mombasa	22.8	11.7	-48.8	22.8	0.0	19.9	-12.5	14.5	-36.2
	Nairobi	21.6	14.7	-32.0	21.6	0.0	19.8	-8.2	16.5	-23.7
	Nakuru	11.8	7.9	-33.2	11.8	0.0	10.8	-8.5	8.9	-24.7
Rwanda	Butare	8.4	6.6	-21.9	8.0	-5.6	8.0	-4.9	7.1	-16.2
	Kigali	17.3	13.4	-22.8	16.3	-5.8	16.4	-5.1	14.4	-16.8
Tanzania	Arusha	12.3	8.2	-33.6	11.7	-5.1	11.2	-8.6	9.2	-24.9
	Dar es Salaam	16.7	8.6	-48.8	16.7	0.0	14.7	-11.9	10.6	-36.9
	Mbeya	8.8	5.9	-33.2	8.8	0.0	8.1	-8.1	6.6	-25.1
Uganda	Jinja	11.5	8.8	-23.0	11.2	-2.5	10.8	-5.9	9.5	-17.1
	Kampala	13.9	10.6	-23.8	13.2	-5.0	13.0	-6.1	11.4	-17.7
	Lira	6.4	4.9	-23.2	6.1	-4.8	6.0	-6.0	5.3	-17.2
	Mbale	8.2	6.2	-25.2	7.8	-5.3	7.7	-6.5	6.7	-18.7
	Mbarara	8.5	6.6	-21.7	8.1	-4.5	8.0	-5.6	7.1	-16.1

VII. CONCLUSION

Firms normally keep certain inventories, including raw materials, work-in-progress and finished goods, in order to operate seamlessly and not to miss possible business opportunities. The optimal firm inventory differs depending on various economic conditions. Theoretically, transport infrastructure plays an important role to determine the optimal inventory level. If transport infrastructure is unreliable and the costs of ordering and purchasing materials and goods are high, firms are likely to hold more inventories.

The paper examined the firm inventory behavior in East Africa, in which the countries have different transport connectivity to markets. While Kenya and Tanzania have the advantage of having major seaports situated to the Indian Sea, Burundi, Rwanda and Uganda are landlocked countries. Transport costs vary significantly across countries in the region. After the endogeneity of infrastructure placement is controlled by the IV approach, it shows that transport connectivity affects firms' inventory behavior. Particularly, road density and transport costs to the port are important to determine the optimal inventory level. With more roads in a city and/or cheaper access to the port, firms would hold fewer inventories. Given lower transport costs, firms prefer purchasing inputs and goods more frequently to holding large inventories.

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