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Firms' Locational Choice and Infrastructure Development in Rwanda

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Abstract

Agglomeration economies are among the most important factors to increase firm productivity. However, there is little evidence supportive of this in Africa. By applying the conditional and nested logit models, this paper examines the relationship between firm locations and infrastructure accessibility in Rwanda. It is found that agglomeration economies matter to even one of the smallest countries in Africa. It is also found that infrastructure availability has an important role in affecting the firm location decision. Electricity access and transport connectivity to the domestic and international markets are found to be important to attract new investment. In addition, the quality of local labor supplied, measured by educational attainment, is found as an important determinant of firm location, while the effect of labor costs remains inconclusive.

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FIRMS' LOCATIONAL CHOICE AND INFRASTRUCTURE DEVELOPMENT IN RWANDA

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Key words: Agglomeration economies; firm location; conditional logit model; nested logit model.

JEL classification: H54; H41; R32; C24.

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I. INTRODUCTION

The new economic geography literature suggests that agglomeration economies are one of the important factors to increase firm productivity (Krugman, 1991; Fujita et al. 1999). To improve competitiveness of the economy, firms need to be located close to one another in certain places, which are often major urban areas or industrial zones. Given the proximity, firms can expect to receive benefit from sharing the common labor and intermediate input markets and minimizing trade and transaction costs.

Many empirical studies are supportive of this proposition. For instance, Mare and Graham (2013) show that the average agglomeration elasticity in New Zealand is significant and estimated at 0.06. Agglomeration economies among French firms in Europe are also found to be significant. The agglomeration patterns are determined by not only the physical distance but also the cultural similarity between the headquarters and the foreign subsidiaries (Procher, 2011). Lee et al. (2012) find that there are positive externalities to Korean manufacturers in the United States. While consumer goods manufacturers are spatially less concentrated, the assembly industry follows U.S. upstream firms to take advantage of agglomeration economies.

In the literature, nonetheless, there is little evidence to show agglomeration economies in Africa. Many developing countries in other regions, such as China and Vietnam, have been succeeding in promoting firm agglomeration in manufacturing and accelerating industrialization, but there are only a few cases in Africa (e.g., Yusuf et al. 2008; Otsuka and Sonobe, 2011). It is well known that despite its potential, Africa has been lagging behind in the global manufacturing market since the 1960s. Weak agglomeration economies may be a possible reason for this stagnation. Among others, low labor productivity is one issue, and infrastructure connectivity—in both physical and institutional terms—and land access may also be difficult constraints (Dinh et al. 2012).

The current paper aims at examining the firm location decision in the case of Rwanda, which is a landlocked country in East Africa. Infrastructure access is certainly one important factor that influences firm locations. The analysis particularly focuses on transport connectivity, which the literature often finds to be crucial for firm investment. In Hungary, road availability is considered as a significant determinant of firm investment (Boudier-Bensebaa, 2005). Foreign direct investment tends to be concentrated on countries with good transport infrastructure (Cieślik and Ryan, 2004; Milner *et al*., 2006). Access to good port facilities is also essential for private investors (Belderbos and Carree, 2002; Deichmann *et al*., 2005).

The remaining sections are organized as follows: Section II provides an overview of recent economic and infrastructure developments in Rwanda. Section III discusses our empirical models and data. Section IV presents main estimation results and discusses some policy issues. Then Section V concludes.

II. RECENT INFRASTRUCTURE AND INDUSTRIAL DEVELOPMENTS IN RWANDA

Rwanda has been experiencing strong and steady economic growth in recent years (Figure 1). Agricultural production has been boosted by the drastic commercialization of the sector with fertilizer use increased form 18 percent to 38 percent (IMF 2012).[1] Traditional crop exports, such as coffee and tea, were particularly strong given high international commodity prices (Figure 2). Given the government's aggressive capital spending, the industrial sector seems to have been picking up. This particularly contributed to the construction sector (ditto).

However, further industrialization and economic diversification may still be needed to achieve sustainable economic development over the long run. The Government of Rwanda has identified special economic zones (SEZ) as an effective tool for promoting private investment. The Kigali Free Zone (KFZ) and the Kigali Industrial Park were established

[1] "Rwanda: Fourth review under the policy support instrument and request for modification of assessment criteria." 2012. IMF.

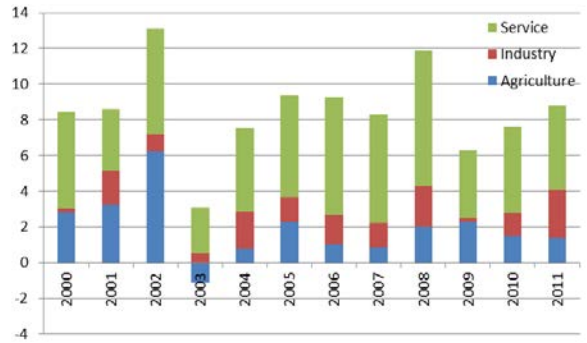
aimed at creating a central distribution point to serve not only the domestic but also regional markets in Burundi, Uganda and western Tanzania (Rwanda MOTI 2009).[2] Agribusiness, information and communications technologies, trade and logistics and mining are among the targeted industries.

In Rwanda, the primary city concentration seems to be increasing in recent years. This may pose a challenge to strengthen international competitiveness of the economy while balancing a growth path to shared prosperity. Many economic activities are historically concentrated on the nation's capital, Kigali, where 1.1 million people or about 10 percent of the total population live (Figures 3). More than 20 percent of the registered businesses are located in the Kigali City (Figure 4).[3] Interestingly, the latest data show that about 75 percent of the newly registered enterprises in 2009-2013 are located at Kigali (Figure 5).[4] Thus, business activities are increasingly becoming concentrated in the capital area.

The geographic distributions of economic and social activities and capital endowments, such as infrastructure, look much different in Rwanda. While the population, agriculture production and social service provision, such as education, are relatively evenly distributed over the country, the distributions of new firms and some infrastructure availability, such as electricity, are more skewed (Figure 6). Among infrastructure services, notably, roads and mobile phone access are much more evenly distributed than electricity access. It is important to ensure a balanced growth path while promoting competitiveness of firms.

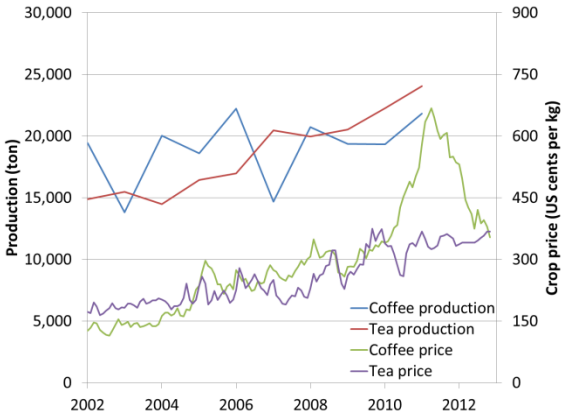
[2] "Rwanda Industrial Master Plan 2009-2020: Achieving global competitiveness." 2009. Ministry of Trade and Industry.
[3] The city is split into three administrative districts: Gasabo, Kicukiro, and Nyarugenge.
[4] In Rwanda, there are a number of informal businesses, which are estimated to account for about 95 percent. For obvious reasons, however, it is difficult to collect detailed data on the informal sector. This paper only focuses on formal enterprises.

Figure 1. Rwanda: Growth contribution by sector



Source: WDI.

Figure 2. Rwanda: Export crop production & prices



Sources: FAOSTAT and IMF.

Figure 3. Distribution of population

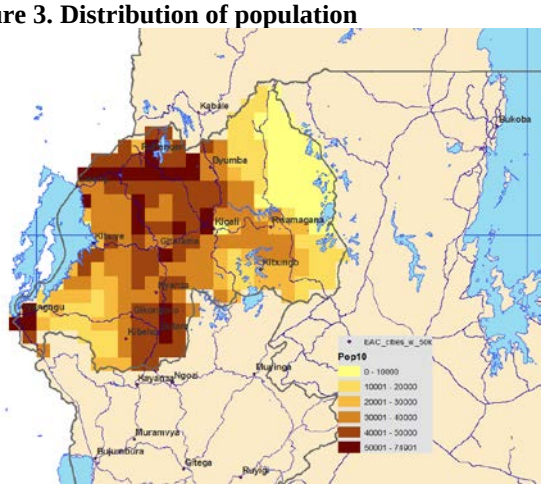


Figure 4. Registered businesses by province, 2011

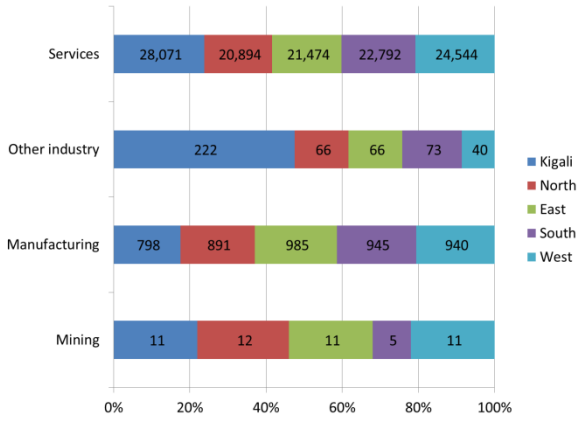


Figure 5. New firms established in 2009-13

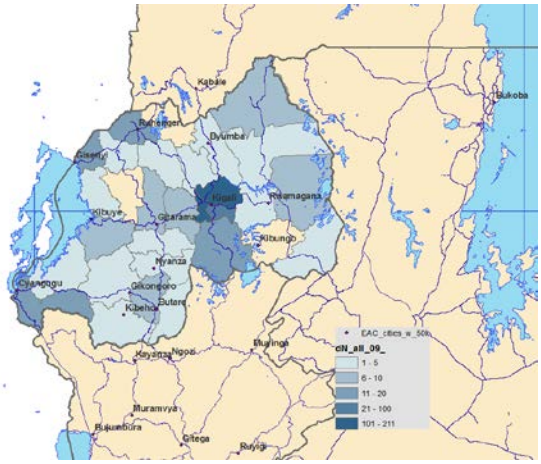
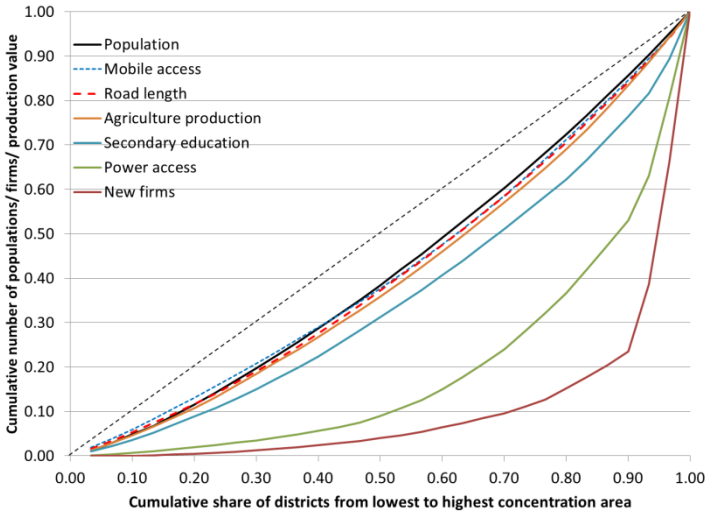


Figure 6. Geographic concentration of economic activities in Rwanda



Source: World Bank calculations based on SPAM, DHS, road network and business register data.

Infrastructure is normally an important determinant of firm location choices. Rwanda has a relatively well developed road network comprised of 1,060 km of paved and 3,500 km of unpaved roads (Figure 7). By regional standard, road density is relatively high at 18.7 km per 100 km^2 of land. Especially around Kigali, road density is high at over 100 km per 100 km^2. Still, rural accessibility is limited and estimated at 35 percent. In addition, the quality of secondary and tertiary roads remains poor (Figure 8). Therefore, transport connectivity within the country, measured by the transport cost to a large city (with more than 50,000 populations), is still an important development agenda (Figure 9).[5]

One of the most significant constraints on the country is access to the international market. Rwanda is located more than 1,400 km away from the nearest seaport, Dar es Salaam (or Mombasa), and therefore, the trade and transport costs must be of necessity significant for the economy. It is estimated that it costs about $190 per ton to convey goods from Kigali to the port (Figure 10). Within the country, it ranges from $177 to $207, depending on the location.

[5] This is also a challenge to explore the country's agricultural potential and accelerate social development further. See the following section for further discussion.

Until recently, electricity used to be identified as one of the most crucial constraints on business (Figure 11). The situation seems to have been improved at least in urban areas, thanks to the government's significant efforts toward increasing the electricity generation capacity, which currently amounts to 96 MW.[6] About half relies on hydropower, and another half use fossil fuels. Nonetheless, the vast majority of the electricity demand is still unmet. Most of people still depend on biomass for primary energy. While electricity accounts for only about 4 percent, biomass contributes to about 85 percent. Approximately 13 percent of households are connected to the grid (Figure 12).[7]

All of these infrastructure factors are potentially affecting the firm location choice. The question is which factor is the most important to foster firm clustering and take advantage of economies of agglomeration. In the following analysis, the conditional logit approach is used with various variables generated from available spatial data in the country.

Figure 7. Road network and road density (km/km^2)

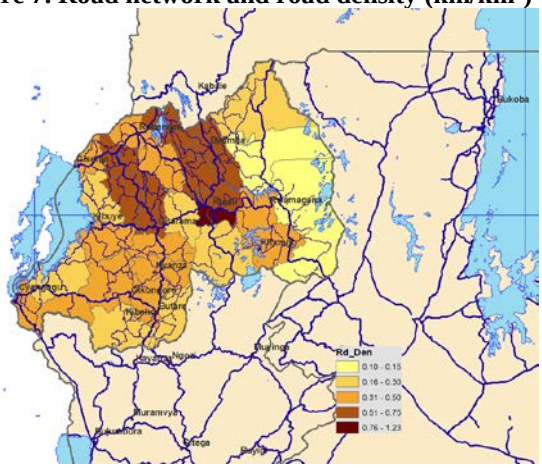
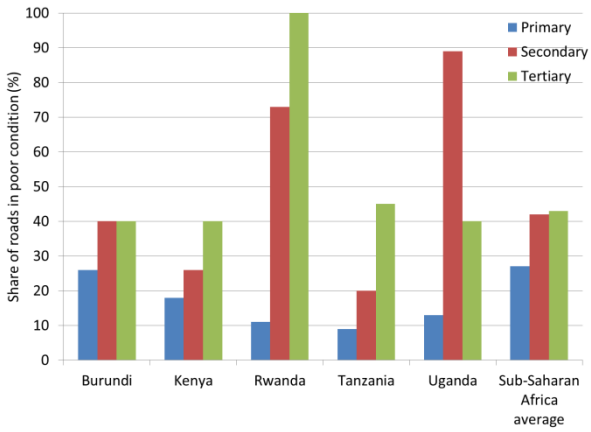


Figure 8. Classified road network in poor condition



[6] The Government's Seven Year Electricity Development Plan (2011-17) aims at developing about 1 GW of new capacity and connecting 1.7 million customers or achieving 70 percent of access rate (Rwanda Energy, Water and Sanitation Authority. "Overview of the energy sector projects" http://www.ewsa.rw/images/pdf/Overview_of_energy_sector_projects.pdf).

[7] Rwanda Development Board at http://www.rdb.rw/investinrwandaenergy/about_forum.html

Figure 9. Access to a large city ($ per ton)

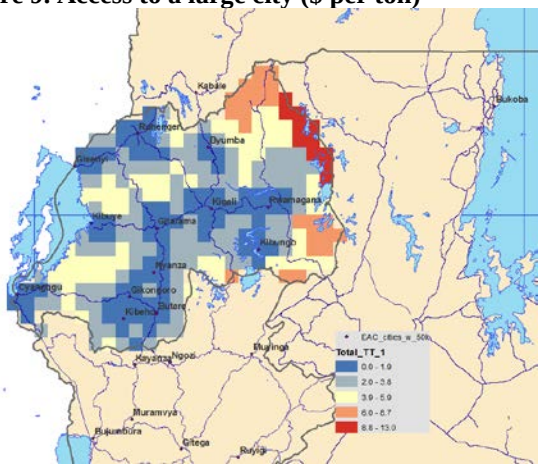


Figure 10. Access to the sea port ($ per ton)

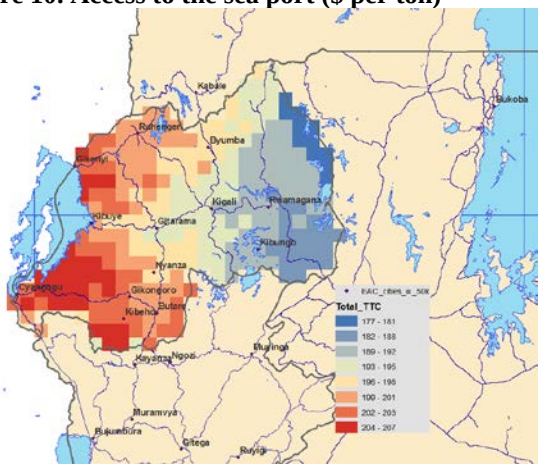
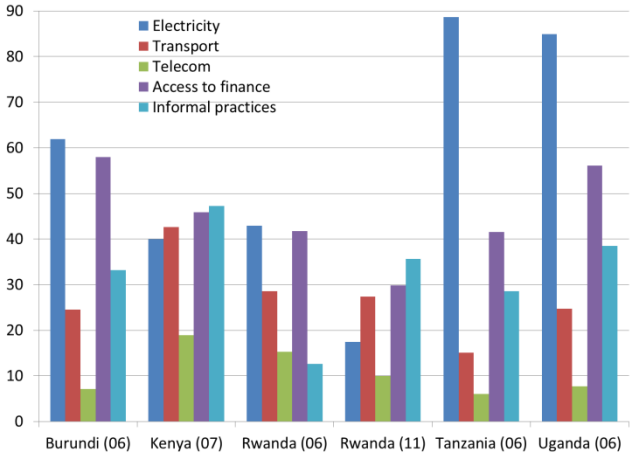


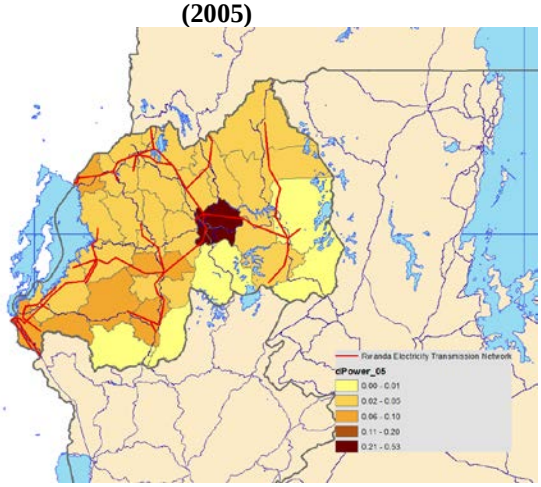
Figure 11. Share of firms that identified each factor as a major constraint (percent)



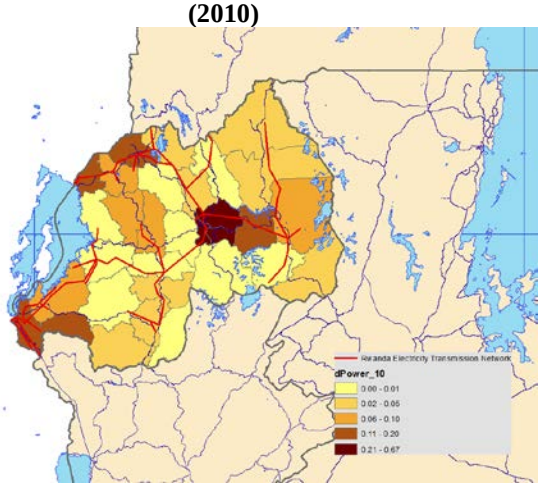
Source: BEEPS.

Figure 12. Electrification rates by region

(2005)



(2010)



Source: Calculated based on DHS 2005 and 2010.

III. METHODOLOGY AND DATA

To examine the infrastructure impacts on firm location, the conventional conditional logit model (e.g., McFadden, 1974) is used, in which the probability of firm *i* choosing a particular location, such as district *j*, can be written by:

$$\Pr(y_i = j) = \frac{\exp(X_j'\beta + Z_{ij}'\gamma)}{\sum_j \exp(X_j'\beta + Z_{ij}'\gamma)} \qquad j = 1, \cdots, J, \quad i = 1, \cdots, N \tag{1}$$

Note that our data include not only alternative specific variables but also case-specific attributes. *X* are a set of location-specific characteristics, such as local market size and infrastructure accessibility. A firm is supposed to choose its location comparing these attributes among districts $\{1, \cdots, J\}$. On the other hand, *Z* includes firm-specific characteristics, such as firm size. The conditional logit model can estimate the equation by interacting the firm characteristics with location-specific dummy variables (e.g., Greene, 1997; Procher, 2011).[8]

One of the major disadvantages of this conditional logit approach is the property of independence of irrelevant alternatives (IIA). It requires that the preferences between any two choices are independent of the third option. This may or may not hold in our context. Particularly in our case, there may exist significant differences between choosing Kigali Province (comprising three districts) and locating at the rest of the country. If this is the case, the substitutability within Kigali is different from that across the provinces.

To partially mitigate this problem, the nested logit model is considered, in which all alternatives $j = 1, \cdots, J$ are exclusively partitioned into *K* subgroups $\{G_1, \cdots, G_K\}$ and the IIA assumption is relaxed at least across the nests *G*'s (e.g., Maddala, 1983; McFadden, 1984). In

[8] It is sometimes called a mixed logit model, which is also used to refer to a random parameter logit model (see Procher, 2011).

Rwanda, there are 30 districts, which are divided into five regions: Kigali, North, South, West, and East. These regions are also used for interacting firm-specific attributes and generating *Z* in the above conditional logit model. As usual, the joint probability of household *i*'s choosing crop *j* in nest G_k is written by (i) the conditional probability of choosing crop *j* given that an alternative in nest G_k is chosen, and (ii) the marginal probability of choosing an alternative in nest G_k:

$$\begin{aligned}\Pr(y_i = j) &= \Pr(y_i = j \mid G_k) \times \Pr(y_i = k) \\ &= \left[\exp(X_j'\beta/\tau_j)/\exp(IV_j)\right] \times \left[\exp(W_i'\gamma_j/\tau_j + IV_j)/\textstyle\sum_k \exp(Z_i'\gamma_k/\tau_k + IV_k)\right]\end{aligned} \tag{2}$$

where the dissimilarity parameter to adjust the scaling effect across subgroups is defined by $\tau_k = \sqrt{1-\rho_k}$. ρ is correlation within nest *k*. The inclusive value is defined by $IV_j = \ln \sum_{j \in G_k} \exp(X_j'\beta/\tau_j)$.

Another potential empirical issue is reverse causality, which has also been argued in the literature (e.g., Mare and Graham, 2013). While firm locations are determined by business conditions surrounding each locality, the business environment is also determined by the firms' locational decisions. For instance, governments may invest more in public infrastructure where firms are concentrated. Therefore, the two factors may be interdependent on one another.

To minimize this endogeneity problem, the time lag approach is used (e.g., Ciccone and Hall, 1996), even though we cannot take long lags because of data availability. This is expected to mitigate the endogeneity risk to a certain extent. While our analysis focuses on Rwanda firms that were established in the last five years (2009-2013), most of the explanatory variables come from the surveys conducted in 2005 or earlier.

Our data on firms come from the 2011 Establishment Census of Rwanda with additional data collected for 2012 and 2013. In the last five years (2009-2013), 642 firms were newly

registered in Rwanda. Note that we only focus on industrial and commercial entities and ignores other types of establishments, such as education entities and public facilities. The following analysis uses data on 568 new firms, because some observations are excluded from the analysis due to missing relevant data, such as firm location. In the sample, the service sector accounts for about half of total firms (Figure 13). This is followed by agribusiness and other manufacturing. By region, the vast majority of firms are based on Kigali Province (also see Figure 5).

For location-specific characteristics *X*, the following variables are used. The summary statistics are shown in Table 1. First, the number of firms that existed in 2005, denoted by *NUM*, is expected to capture the effect of agglomeration economies. Second, transport connectivity is measured by two indicators: (i) transport cost (US$ per ton) to the domestic market—*TCITY*—which is defined by the nearest city with more than 100,000 population, and (ii) transport cost (US$ per ton) to the international market—*TPORT*—which is technically assumed to be the port of Mombasa.[9]

Access to electricity is measured by the share of households using electricity for lighting (*POWR*), based on the 2005 Demographic and Health Survey (DHS) for Rwanda. By definition, this variable may not directly represent firms' accessibility to power. They normally have better access to electricity than residential customers. In addition, firms can choose to install their own generation capacity. Still, the residential electrification rate is a good proxy of local electricity availability (and reliability) for small and medium-sized enterprises. And it is unlikely that firms can expect the reliable grid power provision where residential access is limited: Among others, the supply capacity is a likely constraint on such areas.

[9] Given the current road use costs and waiting time costs at various nodes (such as borders, rail stations and ports), the transport cost calculations (see Figures 9 and 10) indicate that the port of Mombasa is a cheaper option than the port of Dar es Salaam to ship goods from Rwanda to abroad.

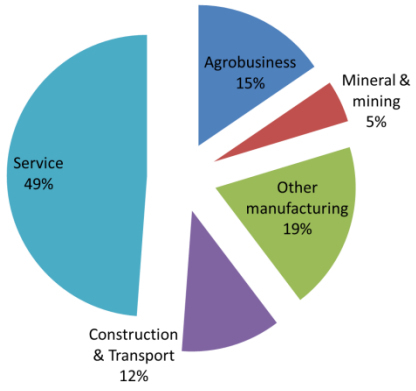
The market demand is usually important for businesses (e.g., Procher, 2011; Brulhart et al. 2012). The size of local market is measured by district population (*POP*): The data come from the 2002 Population Census. The literature also suggests that labor costs are an important determinant of firm location (ditto). The average wage rate (*WAGE*) is calculated based on a household survey carried out in 2005, i.e., Enquête Intégrale sur les Conditions de Vie des Ménages 2 (EICV2). There is a significant variation across districts: While the average monthly wage was more than RWF50,000 around the nation's capital, many employees earned less than RWF10,000 in rural areas (Figure 14).

Since agribusiness is among the most important industries, a variable measuring proximity to agricultural production areas is included in the model. The current potential areas are distributed across districts with different intensity (Figures 15 and 16). Based on the EICV2 data, the total amount of agricultural product sales (in the survey sample) is calculated for each district (*AGVL*).

Finally, to control for firm heterogeneity, the size of firm is measured by the number of employees (*SIZE*). In addition, the share of local stakeholders is also included (*LOCL*). This will allow to examine the potential difference of locational preferences between domestic and foreign investors. Five major sectors are considered: agribusiness, mineral and mining, construction and transport, manufacturing and service. The last is used as a baseline.

Figure 13. Sample firms established in 2009-13

By sector



By region

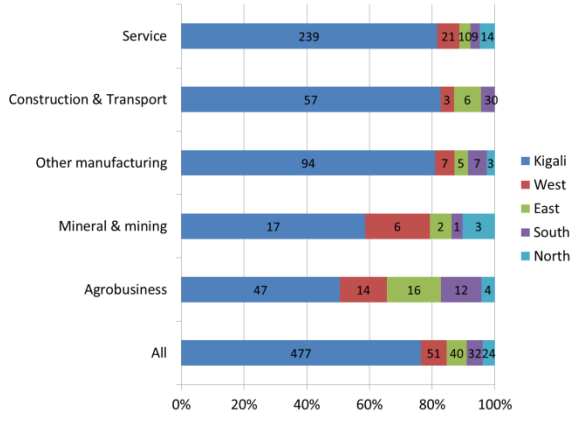
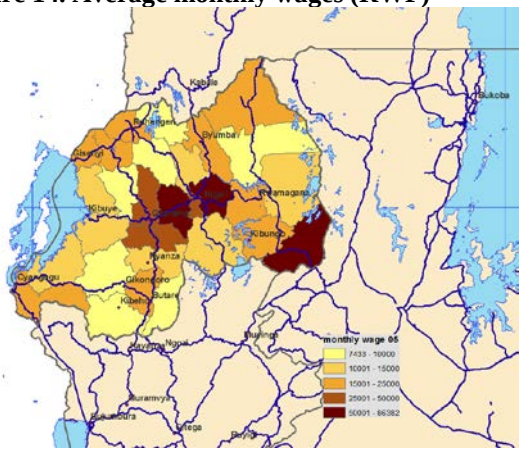


Table 1. Summary statistics

	Abb.	Obs	Mean	Std.Dev.	Min	Max
District-specific attributes:						
Number of firms that existed in district *j* in 2005	*NUM*	568	1199	525	155	1890
Transport cost to the city with more than 100,000 population (US$/ton)	*TCITY*	568	3.0	2.1	0.9	9.5
Transport cost to the port (US$/ton)	*TPORT*	568	194.6	3.2	184.0	206.3
Electricity access rate in 2005	*POWR*	568	0.29	0.18	0.00	0.53
District population in 2002 (thousand)	*POP*	568	271.8	45.3	207.8	359.7
Average monthly wage rate in 2005 (RWF thousand)	*WAGE*	568	45.3	17.6	8.8	86.4
Share of people who completed at least secondary education	*EDU*	568	0.34	0.03	0.23	0.38
Large scale agricultural product sales (RWF thousand)	*AGVL*	568	165.8	144.0	6.2	581.5
Firm-specific characteristics:						
Size of firm (number of employees)	*SIZE*	568	104.3	371.0	2	4000
Share of local stakeholders	*LOCL*	568	0.65	0.46	0.00	1.00
Dummy variable for agribusiness	*dAGRO*	568	0.15	0.36	0	1
Dummy variable for petroleum, chemical and mining industries	*dMINE*	568	0.05	0.21	0	1
Dummy variable for construction and transport	*dCONS*	568	0.11	0.31	0	1
Dummy variable for other manufacturing sectors	*dMANU*	568	0.20	0.40	0	1

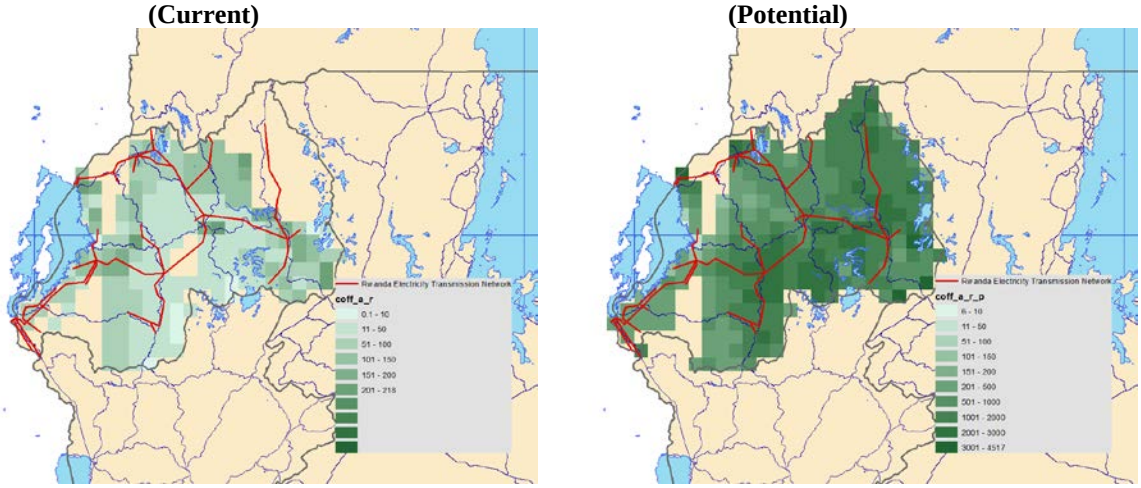
Figure 14. Average monthly wages (RWF)



Source: EICV2.

Figure 15. Distribution of coffee production areas (MT)

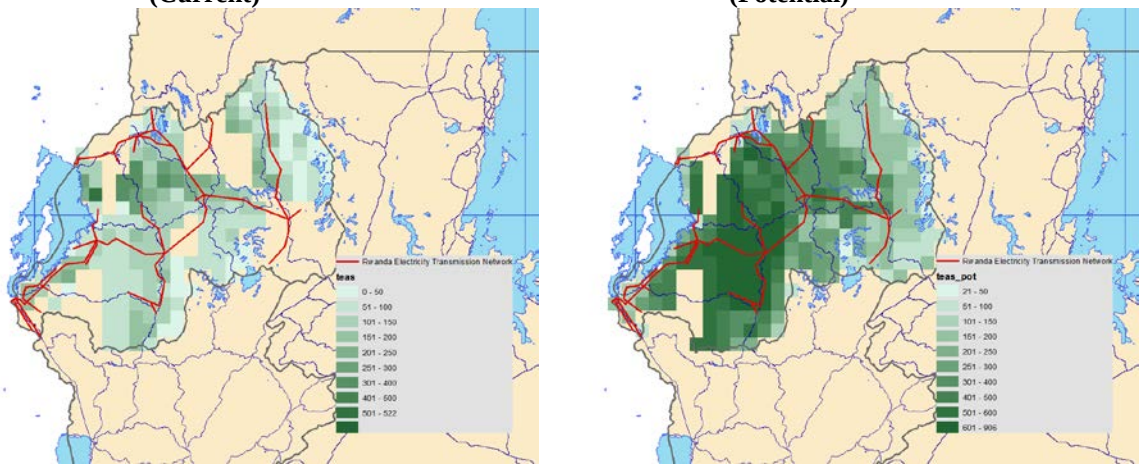
(Current) **(Potential)**



Source: SPAM Update 2010.

Figure 16. Distribution of tea production areas (MT)

(Current) **(Potential)**



IV. MAIN ESTIMATION RESULTS

The conditional logit results are shown in Table 2. The results strongly support the fact that agglomeration economies are important to attract new firms. The coefficient of the number of existing firms is always positive and significant. The implied elasticity can be calculated at 0.68, when the coefficient in the last column model is evaluated at sample means. This is broadly consistent with the literature (e.g., Procher 2011; Mare and Graham0 2013). Although the elasticity is the same across districts given our specification, the expected

agglomeration benefits can vary among locations, depending on the current conditions, and the vast majority of benefits would likely be accrued to Kigali Province (Table 3).

Better transport connectivity is found to be a crucial determinant of firm location. Both market and port access variables have significantly negative coefficients, meaning that a reduction in transport costs to a large city or port could bring in more investment from firms. The port connectivity looks to be of particular importance. For instance, if the transport cost from Kigali to the port of Mombasa declines by 10 percent, the probability of a firm being located at Kigali would increase by 6 to 14 percentage points (Table 3).

The estimation results also show that the firm location decision is crucially dependent on local electricity accessibility. The demand size of the local market is also found to be important, as expected. The positive and significant coefficients of our agriculture variable can be interpreted to mean that firms, presumably, agribusinesses, prefer to be located close to agricultural production areas. This is consistent with the fact that agribusiness accounts for a considerable share of total firms in Rwanda, and it is indeed less concentrated on Kigali Province (see Figure 13).

One unexpected result may be that the district attractiveness could increase, not decrease, with local labor costs according to the first two models, or the labor cost does not seem to affect the firm location choice in the last column model. A plausible reason is that higher labor costs may be associated with the higher quality of labor supply. To see this impact, the wage variable is replaced with the share of adults who completed at least secondary education. Again, there is certain heterogeneity in education outcome across districts (Figure 17). As expected, the coefficient of secondary education is found positive and highly significant (Table 4). Therefore, education is important to provide high quality labor and attract new firms.

Regarding firm-specific characteristics, there are few significant results on the effects of firm size and ownership (see Annex Tables). There is no systematic difference in firms' locational

preferences between small and large enterprises or between domestic and foreign companies. One interesting result is that agribusiness is less likely to be based on Kigali Province.[10] This is consistent with the above finding that some firms prefer to take advantage of proximity to agricultural production areas.

Finally, to check robustness of the estimated results, the nested logit model is performed by interacting firm-specific characteristics with location dummy variables. The results are broadly similar to the above (Table 5): Agglomeration economies matter to the firm location choice. Transport connectivity, especially to large cities, is important to attract more firms. The statistical significance of the port accessibility somehow disappears. But the importance of the market demand and proximity to agricultural production areas is still maintained.

From the policy point of view, our estimation results recast light on several important issues in Rwanda. First, the importance of agglomeration economies cannot be underestimated. The finding is supportive of the government's efforts to create special economic zones. Second, to promote firm agglomeration, good quality infrastructure is essential. Transport connectivity to the markets and electricity access need to be improved to attract more investment. Finally, it is also important to invest in connecting agribusinesses and their markets. Our estimation results indicate that agribusiness companies tend to be located close to production areas—which are mostly in rural regions. They need to be connected effectively to their final markets—either domestic urban areas or the regional ports for export crops. Thus, not only primary roads but also secondary and tertiary roads are important.

[10] There are other sector dummy variables, of which the coefficients are also statistically significant. However, those results are mostly inconsistent with the estimation results from the nested logit model. The unfavorable preferences of Kigali Province are only unchanged for the agribusiness industry.

Table 2. Conditional logit estimation

	(1)			(2)			(3)		
ln*NUM*	0.775	(0.297)	***	1.360	(0.337)	***	1.065	(0.321)	***
ln*TCITY*	-0.405	(0.100)	***				-0.427	(0.098)	***
ln*TPORT*				-11.208	(5.429)	**	-14.954	(5.777)	***
POWR	5.428	(1.283)	***	3.532	(1.273)	***	5.316	(1.261)	***
ln*POP*	3.021	(0.823)	***	2.112	(0.832)	**	3.134	(0.793)	***
ln*WAGE*	0.300	(0.142)	**	0.400	(0.169)	**	-0.029	(0.196)	
ln*AGVL*	0.309	(0.060)	***	0.355	(0.053)	***	0.285	(0.057)	***
Obs	17040			17040			17040		
Wald chi2	17269.8			16843.5			17016.0		
Pseudo R2	0.3993			0.3958			0.4006		

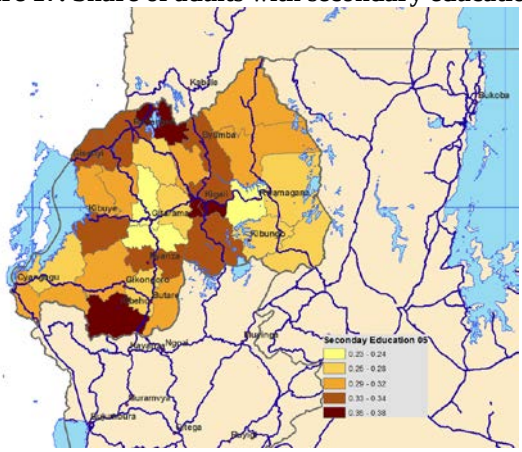
Note: The table contains only parts of the estimation results. See Annex Tables for the full results.

Table 3. Predicted changes in probability of choosing a particular district (%)

Province	District	Scenario1 10% more firms (*NUM*)	Scenario2 10% reduction in *TCITY*	Scenario3 10% reduction in *TPORT*	Scenario4 10 % point increase in *POWR*
Kigali	GASABO	0.254	0.171	14.274	2.391
	KICUKIRO	0.115	0.077	6.455	1.081
	NYARUGENGE	0.207	0.140	11.665	1.954
East	BUGESERA	0.008	0.005	0.454	0.076
	GATSIBO	0.004	0.002	0.205	0.034
	KAYONZA	0.003	0.002	0.152	0.025
	KIREHE	0.004	0.003	0.211	0.035
	NGOMA	0.004	0.003	0.236	0.040
	NYAGATARE	0.006	0.004	0.338	0.057
	RWAMAGANA	0.011	0.008	0.636	0.106
North	BURERA	0.001	0.001	0.043	0.007
	GAKENKE	0.001	0.001	0.074	0.012
	GICUMBI	0.003	0.002	0.146	0.024
	MUSANZE	0.002	0.001	0.110	0.018
	RULINDO	0.001	0.000	0.031	0.005
West	KARONGI	0.003	0.002	0.183	0.031
	NGORORERO	0.002	0.001	0.123	0.021
	NYABIHU	0.004	0.003	0.217	0.036
	NYAMASHEKE	0.003	0.002	0.178	0.030
	RUBAVU	0.026	0.017	1.444	0.242
	RUSIZI	0.026	0.017	1.451	0.243
	RUTSIRO	0.002	0.001	0.103	0.017
South	GISAGARA	0.001	0.001	0.080	0.013
	HUYE	0.009	0.006	0.484	0.081
	KAMONYI	0.012	0.008	0.649	0.109

MUHANGA	0.005	0.004	0.300	0.050
NYAMAGABE	0.006	0.004	0.342	0.057
NYANZA	0.003	0.002	0.174	0.029
NYARUGURU	0.002	0.002	0.126	0.021
RUHANGO	0.002	0.001	0.122	0.020

Figure 17. Share of adults with secondary education



Source: EICV2.

Table 4. Conditional logit estimation with education variable

	(1)			(2)			(3)		
ln*NUM*	0.432	(0.325)		0.885	(0.320)	***	0.746	(0.320)	**
ln*TCITY*	-0.450	(0.101)	***				-0.272	(0.114)	**
ln*TPORT*				-23.863	4.1873	***	-17.499	4.7194	***
POWR	6.572	(1.253)	***	4.507	(1.183)	***	5.353	(1.240)	***
ln*POP*	3.640	(0.765)	***	2.848	(0.730)	***	3.202	(0.754)	***
EDU	5.844	(2.686)	**	12.153	(2.275)	***	7.905	(2.920)	***
ln*AGVL*	0.398	(0.076)	***	0.436	(0.064)	***	0.363	(0.071)	***
Obs	17040			17040			17040		
Wald chi2	17389.2			17040.2			17253.9		
Pseudo R2	0.3994			0.4007			0.4024		

Table 5. Nested logit estimation

	(1)		(2)		(3)	
ln*NUM*	1.322	(0.673) **	1.640	(0.733) **	1.308	(0.770) *
ln*TCITY*	-0.735	(0.212) ***			-0.736	(0.211) ***
ln*TPORT*			-10.581	(9.140)	0.558	(10.038)
POWR	6.051	(1.787) ***	3.600	(1.836) **	6.080	(1.943) ***
ln*POP*	2.256	(0.839) ***	1.090	(0.894)	2.268	(0.898) **
ln*WAGE*	0.346	(0.272)	0.447	(0.340)	0.360	(0.374)
ln*AGVL*	0.410	(0.124) ***	0.444	(0.108) ***	0.409	(0.128) ***
Obs	17040		17040		17040	
No. of cases	568		568		568	
No. of alternatives	30		30		30	
Wald chi2	6797.48		8598.9		6775.0	

Note: The table contains only parts of the estimation results. See Annex Tables for the full results.

V. CONCLUSION

Agglomeration economies are one of the important factors to increase firm productivity. Several empirical studies support this in developed countries. However, there is little evidence for Africa, where industrialization has been stagnant and many countries have been lagging behind in the global manufacturing market in the last four decades. There are many constraints in the region, such as low labor productivity and lack of infrastructure access.

The paper re-examined the relationship between firm location and investment environment, primarily infrastructure endowments. With the detailed establishment census data combined with spatial data representing infrastructure accessibility and other locational attributes, the conditional and nested logit models were applied. It was found that agglomeration economies matter to even small countries, such as Rwanda. Firms prefer to be located close to each other. Both electricity access and transport connectivity to the domestic and international markets (through the regional ports) are also important to foster firm agglomeration. Notably, the electricity supply capacity is still weak in Rwanda, and transport costs to the regional ports are significantly high. More infrastructure investments are called for.

Finally, the analysis also shows the importance of investing in agricultural production areas to stimulate the agribusiness industry. Holding everything else constant, firms are more likely to be based in agricultural production areas. It is important to ensure good connectivity to bring their products to the final destinations in the domestic, regional or global markets.

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ANNEX

Table 6. Conditional logit estimation

	(1)			(2)			(3)		
ln*NUM*	0.775	(0.297)	***	1.360	(0.337)	***	1.065	(0.321)	***
ln*TCITY*	-0.405	(0.100)	***				-0.427	(0.098)	***
ln*TPORT*				-11.208	(5.429)	**	-14.954	(5.777)	***
POWR	5.428	(1.283)	***	3.532	(1.273)	***	5.316	(1.261)	***
ln*POP*	3.021	(0.823)	***	2.112	(0.832)	**	3.134	(0.793)	***
ln*WAGE*	0.300	(0.142)	**	0.400	(0.169)	**	-0.029	(0.196)	
ln*AGVL*	0.309	(0.060)	***	0.355	(0.053)	***	0.285	(0.057)	***
*SIZE*Kigali*	0.370	(0.261)		0.345	(0.261)		0.396	(0.271)	
*SIZE*North*	-2.936	(2.946)		-3.005	(2.996)		-3.230	(3.235)	
*SIZE*West*	0.122	(0.550)		0.155	(0.523)		0.234	(0.506)	
*SIZE*South*	0.402	(0.438)		0.452	(0.409)		0.490	(0.420)	
*LOCL*Kigali*	-0.338	(0.226)		-0.421	(0.228)	*	-0.281	(0.221)	
*LOCL*North*	-0.252	(0.412)		-0.297	(0.409)		-0.241	(0.402)	
*LOCL*West*	-0.167	(0.302)		-0.038	(0.334)		0.231	(0.348)	
*LOCL*South*	0.096	(0.302)		0.378	(0.352)		0.450	(0.344)	
*dAGRO*Kigali*	-1.480	(0.317)	***	-1.531	(0.316)	***	-1.420	(0.311)	***
*dAGRO*North*	-1.067	(0.590)	*	-1.095	(0.586)	*	-1.022	(0.582)	*
*dAGRO*West*	-0.459	(0.409)		-0.396	(0.406)		-0.220	(0.409)	
*dAGRO*South*	0.216	(0.387)		0.395	(0.407)		0.464	(0.401)	
*dMINE*Kigali*	-1.551	(0.531)	***	-1.623	(0.533)	***	-1.472	(0.528)	***
*dMINE*North*	-0.050	(0.727)		-0.091	(0.726)		-0.001	(0.725)	
*dMINE*West*	-0.175	(0.627)		-0.074	(0.627)		0.182	(0.626)	
*dMINE*South*	-1.008	(1.139)		-0.757	(1.157)		-0.663	(1.154)	
*dCONS*Kigali*	-1.006	(0.333)	***	-1.055	(0.334)	***	-0.942	(0.330)	***
*dCONS*North*	-15.137	(0.343)	***	-15.134	(0.342)	***	-15.047	(0.338)	***
*dCONS*West*	-1.560	(0.640)	**	-1.495	(0.645)	**	-1.318	(0.648)	**
*dCONS*South*	-0.805	(0.677)		-0.630	(0.699)		-0.560	(0.695)	
*dMANU*Kigali*	-0.976	(0.273)	***	-1.031	(0.278)	***	-0.909	(0.271)	***
*dMANU*North*	-1.621	(0.652)	**	-1.652	(0.654)	**	-1.578	(0.650)	**
*dMANU*West*	-1.257	(0.465)	***	-1.184	(0.480)	**	-0.988	(0.485)	**
*dMANU*South*	-0.466	(0.465)		-0.271	(0.500)		-0.196	(0.494)	
Obs	17040			17040			17040		
Wald chi2	17269.8			16843.5			17016.0		
Pseudo R2	0.3993			0.3958			0.4006		

Table 7. Conditional logit estimation with education variable

	(1)			(2)			(3)		
ln*NUM*	0.432	(0.325)		0.885	(0.320)	***	0.746	(0.320)	**
ln*TCITY*	-0.450	(0.101)	***				-0.272	(0.114)	**
ln*TPORT*				-23.863	4.1873	***	-17.499	4.7194	***
POWR	6.572	(1.253)	***	4.507	(1.183)	***	5.353	(1.240)	***
ln*POP*	3.640	(0.765)	***	2.848	(0.730)	***	3.202	(0.754)	***
EDU	5.844	(2.686)	**	12.153	(2.275)	***	7.905	(2.920)	***
ln*AGVL*	0.398	(0.076)	***	0.436	(0.064)	***	0.363	(0.071)	***
*SIZE*Kigali*	0.372	(0.263)		0.417	(0.282)		0.426	(0.281)	
*SIZE*North*	-2.892	(2.909)		-2.930	(2.998)		-2.918	(2.987)	
*SIZE*West*	0.111	(0.560)		0.294	(0.495)		0.282	(0.503)	
*SIZE*South*	0.426	(0.430)		0.574	(0.404)		0.545	(0.416)	
*LOCL*Kigali*	-0.332	(0.223)		-0.238	(0.215)		-0.209	(0.216)	
*LOCL*North*	-0.235	(0.409)		-0.106	(0.404)		-0.096	(0.402)	
*LOCL*West*	-0.203	(0.295)		0.453	(0.353)		0.386	(0.350)	
*LOCL*South*	0.202	(0.297)		0.876	(0.361)	**	0.667	(0.344)	*
*dAGRO*Kigali*	-1.474	(0.315)	***	-1.375	(0.305)	***	-1.359	(0.307)	***
*dAGRO*North*	-1.056	(0.589)	*	-0.938	(0.582)		-0.934	(0.584)	
*dAGRO*West*	-0.476	(0.406)		-0.084	(0.418)		-0.117	(0.416)	
*dAGRO*South*	0.287	(0.390)		0.743	(0.431)	*	0.616	(0.418)	
*dMINE*Kigali*	-1.543	(0.533)	***	-1.413	(0.526)	***	-1.389	(0.526)	***
*dMINE*North*	-0.034	(0.733)		0.123	(0.724)		0.130	(0.722)	
*dMINE*West*	-0.203	(0.632)		0.383	(0.622)		0.330	(0.621)	
*dMINE*South*	-0.909	(1.142)		-0.271	(1.188)		-0.452	(1.170)	
*dCONS*Kigali*	-0.999	(0.331)	***	-0.895	(0.326)	***	-0.880	(0.327)	***
*dCONS*North*	-15.147	(0.346)	***	-15.006	(0.340)	***	-15.005	(0.340)	***
*dCONS*West*	-1.578	(0.638)	**	-1.185	(0.651)	*	-1.216	(0.648)	*
*dCONS*South*	-0.733	(0.677)		-0.291	(0.726)		-0.411	(0.705)	
*dMANU*Kigali*	-0.969	(0.271)	***	-0.859	(0.267)	***	-0.842	(0.267)	***
*dMANU*North*	-1.608	(0.649)	**	-1.480	(0.652)	**	-1.474	(0.652)	**
*dMANU*West*	-1.278	(0.462)	***	-0.841	(0.485)	*	-0.876	(0.482)	*
*dMANU*South*	-0.387	(0.463)		0.101	(0.524)		-0.032	(0.505)	
Obs	17040			17040			17040		
Wald chi2	17389.2			17040.2			17253.9		
Pseudo R2	0.3994			0.4007			0.4024		

Table 8. Nested logit estimation

	(1)		(2)		(3)	
ln*NUM*	1.322	(0.673) **	1.640	(0.733) **	1.308	(0.770) *
ln*TCITY*	-0.735	(0.212) ***			-0.736	(0.211) ***
ln*TPORT*			-10.581	(9.140)	0.558	(10.038)
POWR	6.051	(1.787) ***	3.600	(1.836) **	6.080	(1.943) ***
ln*POP*	2.256	(0.839) ***	1.090	(0.894)	2.268	(0.898) **
ln*WAGE*	0.346	(0.272)	0.447	(0.340)	0.360	(0.374)
ln*AGVL*	0.410	(0.124) ***	0.444	(0.108) ***	0.409	(0.128) ***
Gasabo: *SIZE*	0.038	(0.282)	0.106	(0.274)	0.038	(0.282)
LOCL	-0.024	(0.418)	0.264	(0.366)	-0.025	(0.418)
dAGRO	-2.214	(0.476) ***	-1.998	(0.440) ***	-2.215	(0.477) ***
dMINE	-2.016	(0.925) **	-1.729	(0.895) *	-2.017	(0.925) **
dCONS	-1.299	(0.575) **	-1.087	(0.544)	-1.300	(0.576) **
dMANU	-0.347	(0.637)	-0.108	(0.596)	-0.348	(0.638)
Kicuriro: *SIZE*	-1.593	(0.878) *	-1.224	(0.687) *	-1.591	(0.876) *
LOCL	0.002	(0.429)	0.418	(0.379)	0.002	(0.429)
dAGRO	-1.239	(0.534) **	-0.894	(0.512) *	-1.239	(0.535) **
dMINE	0.151	(0.831)	0.618	(0.812)	0.152	(0.832)
dCONS	-0.239	(0.611)	0.108	(0.578)	-0.239	(0.611)
dMANU	0.911	(0.651)	1.294	(0.605) **	0.911	(0.652)
Nyarugenge: *SIZE*	-0.228	(0.283)	-0.226	(0.299)	-0.229	(0.282)
LOCL	-0.513	(0.410)	-0.419	(0.372)	-0.514	(0.414)
dAGRO	-2.005	(0.493) ***	-1.898	(0.460) ***	-2.007	(0.495) ***
dMINE	-0.861	(0.837)	-0.724	(0.811)	-0.863	(0.839)
dCONS	-0.842	(0.577)	-0.743	(0.549)	-0.844	(0.580)
dMANU	0.092	(0.635)	0.197	(0.603)	0.090	(0.639)
North: *SIZE*	-1.187	(0.795)	-1.401	(1.080)	-1.186	(0.795)
LOCL	1.236	(0.989)	1.083	(0.714)	1.236	(0.989)
dAGRO	-1.253	(0.693) *	-1.172	(0.685) *	-1.254	(0.695) *
dMINE	1.013	(0.973)	1.053	(0.901)	1.013	(0.973)
dCONS	-14.107	(0.592) ***	-14.108	(0.559) ***	-14.108	(0.594) ***
dMANU	-0.235	(0.886)	-0.144	(0.864)	-0.236	(0.888)
West: *SIZE*	-0.250	(0.511)	-0.241	(0.531)	-0.251	(0.512)
LOCL	0.222	(0.477)	0.282	(0.442)	0.218	(0.484)
dAGRO	-0.949	(0.518) *	-0.841	(0.485) *	-0.951	(0.521) *
dMINE	0.263	(0.872)	0.384	(0.843)	0.260	(0.872)
dCONS	-1.496	(0.793) *	-1.388	(0.766) *	-1.499	(0.793) *
dMANU	-0.254	(0.740)	-0.138	(0.712)	-0.257	(0.743)
South: *SIZE*	0.089	(0.388)	0.126	(0.389)	0.088	(0.390)
LOCL	0.852	(0.519) *	1.022	(0.499) **	0.847	(0.538)
dAGRO	-0.016	(0.549)	0.144	(0.531)	-0.019	(0.558)
dMINE	-0.227	(1.328)	-0.025	(1.333)	-0.231	(1.323)
dCONS	-0.503	(0.844)	-0.338	(0.836)	-0.507	(0.843)
dMANU	0.804	(0.779)	0.987	(0.761)	0.800	(0.782)
Obs	17040		17040		17040	
No. of cases	568		568		568	
No. of alternatives	30		30		30	

Wald chi2	6797.48	8598.9	6775.0