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Abstract. To transport food aid, the World Food Programme (WFP) primarily contracts with third-party transport carriers in markets that are not well understood. We analyze historical contracts between the WFP in Ethiopia and private carriers using multiple linear regression to gain insights in these markets. Analyses of bids and contracts in Ethiopia show that distance alone explains less than 20% of the variability in effective transportation tariffs. By incorporating additional variables for linehaul costs, market structure measures and socio-economics factors, we obtain a model that explains more than 84% of the variability for the international corridors and 78% for the domestic lanes. Analyses of the various factors provide insights for shippers to improve procurement processes, for carriers to devise competitive business models, and for government authorities to define effective investments and policies. Econometric research to characterize transportation markets in developing countries is scarce, and our study provides an initial basis for further work in other countries.

Keywords: Transportation procurement, multiple linear regression, road infrastructure, market structure, humanitarian logistics, food aid.

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1 Introduction

In Africa, freight transportation can be a costly and time-consuming component of the supply chain due to issues such as poor infrastructure, security risks, complex regulations, and lack of available information. For basic goods and commodities, transportation can represent a significant portion of the overall cost to the consumer. In humanitarian supply chains, high transportation costs reduce the number of beneficiaries that aid organizations can reach with the funding they receive. In the private sector, uncertain transportation markets are seen as a challenge for multinational companies looking to Africa as a key region for growth. Increasing the competitiveness and transparency of transportation markets should enable many African countries to better meet the needs of their citizens and be positioned for economic investment.

The markets for freight transportation in African countries are not well understood. Few studies have been conducted, in part due to the lack of available data. Previous studies are based on surveys which may be unreliable, especially when carriers are asked about their cost structures. In this study, we analyze shipper data that include bids from numerous carriers and the subsequent contracted tariffs that were effective in the market. Data were provided by the World Food Programme (WFP) in Ethiopia, one of the largest shippers in the country. We have collected over 10,000 data points from over 75 carriers that span numerous origin-destination lanes within Ethiopia as well as international corridors from nearby seaports. To our knowledge, this study is the first to analyze carrier bids and effective transportation tariffs for the understanding of the transportation market in an African country.

We use multiple linear regression to determine which factors influence the linehaul truck transportation tariffs, our dependent variable. The tariffs are specified in cost per tonne for transportation service by lane, which is the route between the origin and destination points for the cargo. Our model considers a number of independent variables grouped into three broad sets: cost driven factors, market structure measures, and socio-economic variables. The cost driven factors are composed of linehaul cost drivers, such as distance, road conditions and risk, as well as variables related to economies of scale and scope in the transportation sector. The market structure measures incorporate the full set of carrier bids, and not only the effective transportation tariff. Socio-economics factors are based on regional statistics, such as population and economic activity.

Our results show that market structure, particularly competition intensity, is a good predictor of the tariffs paid by the WFP in Ethiopia. The market structure measures are also correlated with other variables such as road quality and socio-economic factors, which indicate that the carrier's bidding is influenced by these factors. Taking out the market structure measures, we gain a truer sense of the underlying cost structure and carrier economies. Contrary to similar studies of transportation markets in developed countries, which generally find very little variation in prices per kilometer across lanes, our results show that road conditions and competition levels explain significant levels of the variability observed in transportation tariffs for Ethiopia. At a macro-level, we are able to quantify the causes for the generally poor development of transportation in East Africa. Simple reduced form counterfactual exercises show that better road conditions should reduce shipping costs by 18% and increase competition by up to 44% on the international corridors. Similarly for the domestic routes, better road conditions would reduce shipping costs by 12% and increase competition should reduce them by 39%.

Insights from the econometric models can serve several purposes. First, shippers, like the WFP, can improve procurement processes. By understanding the cost drivers and estimating fair pricing for transportation services, shippers can identify opportunities for costs savings and facilitate better contracting processes. For example, the lanes for which there is an objective need for negotiations can easily be indentified based on the difference between predicted and actual tariffs. Second, accurate cost estimates improve broad supply chain decisions for shippers, such as selecting the best corridors and stocking locations, and evaluating expansion into new markets. For carriers, better information about the cost drivers and competitive landscape help them identify market opportunities and refine their business model. Finally, government authorities can use model insights to guide investment strategies in infrastructure and policy decisions. As such, the study aims to provide general insights and introduce useful information for developing competitive logistics capacity in Ethiopia.

The paper is organized as follows. Section 2 reviews the literature on transportation market analysis, focusing on truckload and less-than-truckload sectors in both Africa and more mature markets. Section 3 describes the WFP operations in Ethiopia and outlines its transportation procurement process. Section 4 describes the data collected for this study and the variables used in the regression models. Section 5 discusses the model building process and presents the results as well as their interpretations. This is followed by conclusions in Section 6.

2 Literature Review

Very few empirical studies have attempted to understand transportation costs or prices in Africa. One reason is likely due to the absence of computerized archived data and to the difficulty of accessing them. Empirical studies based on surveys of the trucking industry carried out in the last 20 years show that transportation prices were higher in Africa than in developed countries and most developing countries. Rizet and Hine (1993) have found freight tariffs to be four to six times higher in three African countries (Cameroon, Ivory Coast and Mali) than in Pakistan during the late 1980s. These authors also present an analysis of the main factors behind these differences in tariffs, such as transportation costs, taxes, profitability and vehicle productivity. Teravaninthorn and Raballand (2010) have extensively studied four main international corridors in four African sub-regions (West, Central, East and Southern Africa). In order to analyze the differences in transportation cost and price structures, the potential explaining factors were disaggregated into three categories: the vehicle operating costs, the overall commercial providers' costs and the transportation prices paid by end users. The authors observe that market organization and strict regulations lead to low transportation service quality and high profit margins in West and Central Africa, while the trucking market is more mature and competitive in East Africa. Southern African corridors are found to be the most efficient in terms of price competiveness and service quality.

Lall et al. (2009) aim to explain high transportation prices in Malawi, based on trucking surveys designed according to the methodology developed by Teravaninthorn and Raballand (2010). They perform two sets of empirical analyses: farmers' costs for transporting tobacco to markets, and carriers' prices for transporting commodities on routes both within the country and on specific international corridors. Their analyses reveal that both the infrastructure quality and the market structure of the trucking industry are important contributors to transport prices. The quality of the trunk road network is not a major constraint, but differences in the quality of the feeder roads that connect villages to the main roads have a significant bearing on transport prices. These findings are consistent with those of Pedersen (2001) who shows that transportation costs depend on the availability of infrastructure and on the density of demand on specific links, which implies that Africa is especially disadvantaged with low and dispersed demand and many landlocked countries which are difficult to serve. On a macroeconomic level, some studies have shown that the cost of transporting goods and getting them across borders is a major obstacle to African trade performance. Limão and Venables (2001) found that the relatively low level of African trade flows is largely due to poor infrastructures which also affect transportation costs. Portugal-Perez and Wilson (2008) provide estimates suggesting that improvements in logistics are more important in terms of trade expansion than are reductions of barrier tariffs.

In contrast to most African markets, the United States (US) transportation market is mature and well-studied, especially since the deregulation of the trucking industry in 1980 which contributed to open up competition. Caplice (2007) and Nandiraju and Regan (2008) describe the American truckload (TL) transportation market in detail and explain how the procurement of transportation services is managed in the context of electronic marketplace formats. Combinatorial auction mechanisms, by which carriers can bid on bundles of items for more economically efficient allocations, are commonly used for TL transportation procurement in practice (see Caplice and Sheffi, 2003; Elmaghraby and Keskinocak, 2003). In transportation procurement, the savings that can be generated by the use of combinatorial auctions are based on the principle of economies of scope, which strongly influence transportation costs. Shippers commonly use sophisticated transportation management systems to manage their TL operations, but determining the auction's winners is an NP-hard problem for which optimization algorithms must be implemented (see Sandholm et al., 2005, and Ma et al., 2010, for examples). Powell et al. (1988) and Ergun et al. (2007) have studied TL operations and pricing strategies from the carrier's perspective considering uncertainty. For food aid procurement and ocean transportation services, Trestrail et al. (2009) have proposed a mixed-integer programming decision tool that reproduces the United States Department of Agriculture bidding process in order to improve the bidder pricing strategies. Bagchi et al. (2011) have shown that the current bid process for American food aid does not enable the capture of potential synergies between suppliers and carriers. They have thus presented recommendations for optimal award allocation.

The American TL market is probably best suited for using combinatorial auctions since the North American TL network is well developed and state-of-the-art technologies are accessible. However, this is not the case in developing countries like Ethiopia where backhaul opportunities are almost inexistent and where TL operations are not managed through the use of electronic catalogs but mostly manually. As mentioned by Kunaka (2011), one fundamental factor preventing good quality of logistics infrastructure and services in lagging regions is the low demand spread both spatially and temporally in large areas, which prevents economies of scale. Long distances and dispersed economic activity inhibit access to information on market conditions and lead to erratic freight flows. In such a context, tools similar to the ones that have been developed for less-than-truckload (LTL) services in the US are more appropriate to better understand the transportation market in Ethiopia than those based on combinatorial auctions.

Smith et al. (2007) and Ozkaya et al. (2010) have presented a regression-based methodology to estimate the LTL market tariffs in the US. These studies aim to identify the significant drivers of LTL pricing and produce tariff estimates that can be useful for negotiation and contracting practices. Smith et al. (2007) have relied on data from a single US motor carrier to construct statistical models which focus on quantitative factors such as distances, weight and number of shipments. To produce better tariff predictions, Ozkaya et al. (2010) have improved this methodology by quantifying intangible qualitative factors through a scorecard process. They also used an extensive dataset in terms of lane coverage and transaction diversity for freight classes as well as carrier-shipper combinations.

To our knowledge, our study is the first to use observed market tariffs as opposed to survey data for a developing country. It is also the first contribution to provide empirical results on the Ethiopian transportation market. The methodology used to support our findings is similar to that used by Smith et al. (2007) and Ozkaya et al. (2010) for the LTL US markets, but it is applied in the context of an emerging country as was done by Lall et al. (2009) in Malawi.

3 The WFP transportation management in Ethiopia

The WFP is the United Nations' core agency for food security. The organization aims to "improve the lives of the poorest people who, either permanently or during crisis periods, are unable to produce enough food or do not have the resources to otherwise obtain the food that they and their households require for active and healthy lives" (see WFP, 2012).

Ranked 174th out of 187 in the 2011 Human Development Index of the United Nations Development Programme, Ethiopia is one of the least developed countries in the world. The 2005 Demographic Health Survey (2005) highlights the underlying vulnerability of Ethiopians to nutrition crises. A case study on Ethiopia (2004) notes that an estimated 50% of the population is food-insecure and approximately 22% of the total population receives food aid, although not on a regular basis. The WFP has maintained a continuous presence in Ethiopia since 1974. In 2011, it assisted over 3.8 million people in this country of about 80 million people, distributing over 425,000 tonnes of food aid (WFP, 2011). For 2013, the WFP estimates it will assist about 7.2 million people and will distribute 846,000 tonnes of food (WFP, 2013).

Ethiopia is a landlocked country located between Djibouti, Kenya, Somalia, Sudan and Eritrea in East Africa (see Figure 1). There are four classes of administrative divisions in the country: kebele, woreda, zone and region (ethnically-based regions and governing administrative cities). The kebeles are the smallest administrative divisions while the regional divisions are the largest. As in other emerging nations, the infrastructure in Ethiopia is underdeveloped. Railways are inoperable and less than 20% of roadways are paved. Because of the landlocked geographical location, limited railway capacity and costly air transportation of this country, shippers largely depend on ground transportation to move commodities in Ethiopia. The Ethiopian Government and the WFP share responsibility for food aid transportation within the country. Ground transportation is shared between two phases: international and domestic transportation. The WFP Ethiopia's logistics division is completely in charge of the international transportation movements, which are primarily controlled by commercial providers. The Ethiopian government manages most of the domestic transportation movements as well as the food aid distribution (hand-out to beneficiaries), except in the Somali region where it has handed responsibility to the WFP due to challenges in meeting food demand amidst security concerns.

3.1 Transportation procurement

In Ethiopia, the WFP contracts third-party carriers instead of relying on a private fleet. The organization procures transportation services in a similar way as is done in the commercial sector of developed economies, using a request for quotation (RFQ) mechanism which allows carriers to gain business through competitive bidding. The WFP first sends out questionnaires asking about transportation companies' profiles and launches tenders only to those carriers whose profiles match their standards (core set of carriers). Every six months, the WFP invites its core set of carriers to submit rate proposals (bids) on lanes that may require transportation services. It is through this RFQ mechanism that tariffs are established and carriers awarded transportation services are specified for each network segment. Carriers receive loading orders when the WFP needs to move cargo, and waybills are used to track shipments. Carriers are monitored according to the contract and may be blacklisted if they do not perform up to the stipulated standards. The WFP actively utilizes its contracts established for international transportation. While only providing backup capacity for most domestic transportation, it still conducts RFQs and establishes contracts for an extensive domestic transportation network to supplement government capacity when necessary.

Figure 1: Map of Ethiopia (Logistics Cluster, 2012).

3.2 International versus domestic transportation operations

The first phase of transportation, movements on international corridors, consists in transporting food aid from ports to main warehouses, which are known as Extended Delivery Points (EDPs). Because Ethiopia is landlocked, transportation from seaports necessarily involves international movements. Port of Djibouti is the main port of operation for Ethiopia, and 90% of WFP's food aid is routed through it. Because of delays at Djibouti, food aid is also received at Berbera and Sudan since 2009. In this study, we concentrate our analysis on the ports of Djibouti and Berbera for international transportation. The EDPs are located in strategic regions in the country where primary storage infrastructure is available, and act as transshipment hubs for the second transportation phase. This phase is the movement of food aid on domestic roads from the EDPs to the Final Delivery Points (FDPs), where the food is stored and directly distributed to the beneficiaries. The FDPs are temporary deposits such as shelters, schools and community centers which can be located in remote regions depending on the needs of the beneficiaries.

The international and domestic transportation markets differ in several ways. Trucks operating on international corridors, typically having a 40-tonne capacity, are uncommon on domestic lanes which tend to use smaller trucks that can handle poor road conditions. Larger quantities of food are moved within a short period of time over international corridors, especially when a ship is docked. The loading and offloading operations are usually faster and easier at ports and at EDPs, which are located in major cities with better infrastructure as opposed to FDPs. International transportation also requires carriers to have special permits to operate in multiple countries. They can be subject to delays at ports and borders, which are not common on domestic lanes.

4 Data sources and variable description

Data from two different sources were gathered to conduct our analysis. We have compiled data from a specific RFQ executed by the WFP in Ethiopia as well as from different reports of the Central Statistical Agency of Ethiopia (CSAE). In this section, we present and discuss these two sources of data. We also present the variables derived from these data sets and used later in the statistical analyses. We first describe the effective transportation tariffs, which will account for the dependent variable of our statistical models. We then describe the independent variables grouped in three categories: cost driven factors (linehaul cost and carrier economies), market structure measures and socio-economic variables.

4.1 Variables extracted from the data provided by the WFP

Data were gathered from an RFQ executed by the WFP in Ethiopia. An RFQ is an efficient competitive mechanism (reverse auction) used to aggregate and reveal scattered information about the market participant valuations of a service in order to dynamically set a price. The contracts derived from this specific RFQ were valid for the planning period from September 2010 to March 2011. The data describe carriers who participated in the RFQ, the lanes of the WFP network and the set of bids offered on each lane. Table 1 illustrates the compiled information of the RFQ for a given origin ($orig_1$).

Table 1: Illustrative RFQ data table for one specific origin ($orig_1$)

Lane		Tariff	Lane characteristics					Carrier rate offers (bids)			
Origin (port or EDP)	Destination (EDP or woreda)	Tariff (Birr/tonne)	Distances			Tonnage estimate (tonne)	Risk (scale)	Carrier (Birr/tonne)			
			Total (km)	Paved (km)	Unpaved (km)			1	2	...	m
$orig_1$	$dest_1$	$tariff_1$	$dist_1$	$paved_1$	$unpaved_1$	ton_1	$risk_1$	bid_{11}	bid_{12}	...	bid_{1m}
$orig_1$	$dest_2$	$tariff_2$	$dist_2$	$paved_2$	$unpaved_2$	–	$risk_2$	bid_{21}	–	...	bid_{2m}
$orig_1$	$dest_3$	$tariff_3$	$dist_3$	$paved_3$	$unpaved_3$	ton_3	$risk_3$	–	bid_{32}	...	bid_{3m}
$orig_1$	$dest_4$	$tariff_4$	$dist_4$	–	–	ton_4	–	bid_{41}	bid_{42}	...	–
$orig_1$	$dest_5$	$tariff_5$	–	–	–	–	–	bid_{51}	–	...	bid_{5m}
...	...	...	...	...	...	...	...	...	...	...	
$orig_1$	$dest_{n_1}$	$tariff_{n_1}$	$dist_{n_1}$	$paved_{n_1}$	$unpaved_{n_1}$	ton_{n_1}	$risk_{n_1}$	$bid_{n_1 1}$	$bid_{n_1 2}$	...	$bid_{n_1 m}$

This data set provides a unique description of the Ethiopian transportation market. The access to accurate and up-to-date information in Africa is often limited. As mentioned by Teravaninthorn and Raballand (2010), trucking data collection is largely inadequate in most countries of Sub-Saharan Africa. The data provided by the WFP are sourced from only one shipper which conducts business with several carriers, and we are thus essentially only looking at the supply side of the transportation market. However, the WFP is one of the most important purchasers of transport services in the country (alongside the Ethiopian Government) and we therefore consider the data to adequately represent the overall transportation market and the costs of transport. We make the assumption that the WFP faces similar costs as other buyers and does not profit from monopsony power. In the following, we describe the variables based on the WFP RFQ data. We first describe the determination of the effective transportation tariffs for the international and domestic transportation markets, which will define the dependent variable of our statistical models. We then describe the independent variables grouped in two categories: cost driven factors (linehaul cost and carrier economies) and market structure measures.

4.1.1 Effective transportation tariffs

The dependent variable in our regression models represents the tariffs in Birr per tonne (Birr/tonne) paid by the WFP from September 2010 to March 2011 for transportation services on a specific lane. These effective transportation tariffs (*tariff*) are determined by the WFP through the bidding process (RFQ). For domestic transport, the tariff determined by the WFP for a lane corresponds to the lowest bid made on that lane in the RFQ. The carrier who made this lowest offer is awarded the transportation contract on that lane although there is no commitment to execute shipments when they will occur. For international transportation, since no carrier has the capacity to handle alone all the transportation services required on a corridor, a tariff is determined by the WFP in order to capture enough capacity. There is no formal procedure for fixing the effective transportation tariffs on the international corridors. The WFP determines international tariffs in order to capture enough transportation capacity based on their judgement, the received offers in the RFQ and market prices for transporting commodities such as sugar, fertilizers or cement. This tariff is sent as a counter offer to the carriers who participated in the RFQ and will correspond to the effective transportation tariff during the planning period of the RFQ. The carriers that accept the WFP counter offer and conditions are awarded transportation services proportionally to their total dedicated fleet capacity. The dependent variable in our regression models corresponds to the natural logarithm of these tariffs ($\ln(tariff)$). As explained in Section 5.1, regressing *tariff* yielded heteroscedasticity which was eliminated when regressing $\ln(tariff)$.

4.1.2 Cost driven factors

The transportation tariffs should partially reflect the carrier operating costs. We define as cost driven factors the variables recognized to directly affect carrier operating costs. We separate these variables in two classes: linehaul cost drivers and carrier economies. Using cost driven factors to estimate the transportation tariff will thus enable us to determine the significant variables of the cost-based pricing structure in Ethiopia.

Linehaul cost drivers

The linehaul costs are the costs related to freight movements including fuel, maintenance, depreciation, driver wages and others (Liu, 2006). In particular, we include lane-specific cost drivers that are unique to the context of developing countries: measures of road infrastructure quality and perception of operational risks.

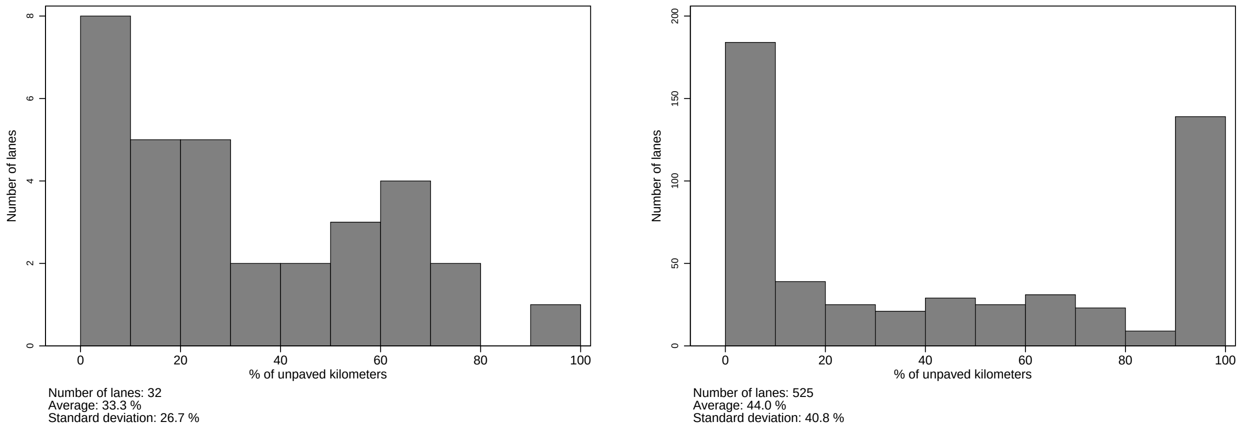
Distance and road conditions

Distance is the primary cost factor in linehaul movements since the main trucking operating costs (fuel, tires, maintenance, and driver wage) vary directly according to it (see Caplice, 1996; Daganzo, 2005). However, in developing countries road quality also matters. At the macro-level, an analysis of bilateral trade data by Limão and Venables (2001) shows the influence of road infrastructure on transportation costs. To account for road quality, the total length of the lanes was decomposed into their paved (*paved*) and unpaved (*unpaved*) distances in kilometers, using Geographical Information System (GIS) data.

The disaggregation into paved and unpaved distances is available for all the lanes of the international corridors, but for only 72% of the domestic transportation lanes. In order to discard as few observations as possible on the domestic transportation market, we have created a road condition indicator based on the percentage of unpaved kilometers per lane with the four following categories: good (less than 10% unpaved), intermediate (between 10% and 70% unpaved), poor (70% or more unpaved) and unknown. These bounds were chosen in order to ensure that the number of observations in each category was fairly distributed (see Figure 2). To capture the effect of the total length of the lanes, we also consider a continuous variable for the total distance (*distance*) in addition to the road condition indicator.

Risk perception

Chander and Shear (2009) suggested that carrier rates are likely to reflect the risks involved in providing transportation services in conflict areas of Ethiopia. A risk level was associated to some lanes within the Somali region by the WFP, while the other lanes were not graded in terms of risk. Note that the Somali region is recognized as the most underdeveloped and conflict-impacted region of Ethiopia. In order to account for the security issues occurring in this particular region, a risk level has been integrated according to the following four WFP



(a) International corridors. (b) Domestic lanes.

Figure 2: Histograms of the corridor and lane unpaved kilometer percentages.

categories: no security issue, low risk, high risk and unspecified risk for the lanes within the Somali region. The fifth category of this risk scale is unknown risk for regions other than Somali. The international corridors with a non-zero specified risk by the WFP were all put in the high level category, which is not the case for the domestic lanes. It is important to mention that when no risk level has been specified by the WFP, this does not imply that the risk is zero but only that the information is unknown.

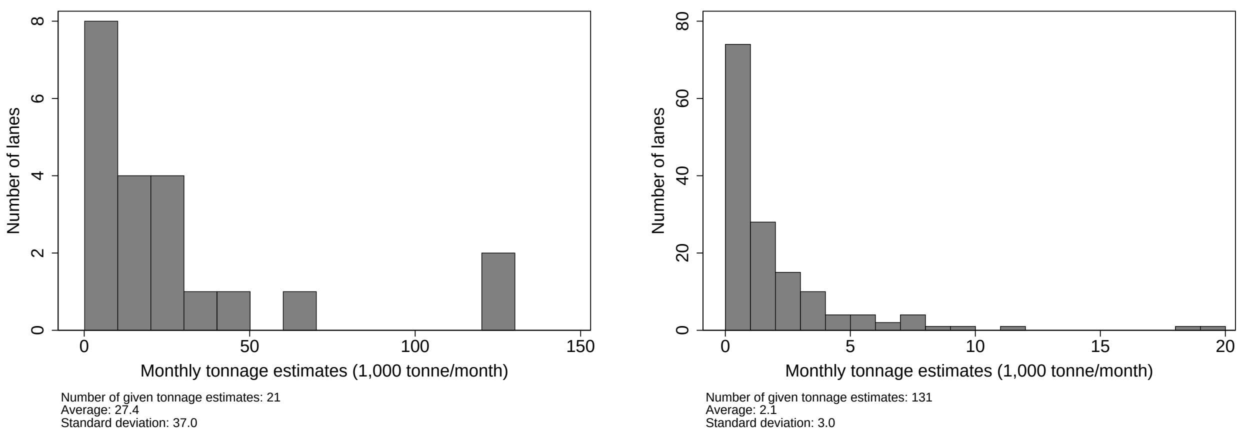
Carrier economies

Economies of *scale* occur when the average cost per unit decreases as the scale of output increases. In truckload services, fixed costs could be allocated over a larger base unit (tonnes shipped) with more quantities transported on the linehaul or the backhaul. For the linehaul, this means that larger loads per shipment result in economies of scale by reducing the cost per tonne. The cost of serving a lane is also affected by the probability of finding a backhaul load at the destination, which translates into economies of scope for the carriers (Sheffi, 2004). Data that indicate, but do not guarantee, shipping volumes are available for a limited number of lanes. Data that systematically measure the backhaul opportunities are unavailable; however, we can test for the potential effects of economies of *scope* using different indicator variables, as described below.

Economies of scale

A higher estimated tonnage to be transported per month can lead to lower unit costs through economies of scale. In the RFQ, the WFP provides estimates of the monthly tonnage to be transported for 66% of the international corridors and 17.9% of the domestic lanes. These estimates are based on historical data, projected demands and requirements. However, the lack of an estimate does not imply that no transportation service will be required on the lane, nor does a given estimate guarantee business on the lane. Carriers are invited to bid on all lanes considering the information provided. We have included estimated tonnage indicators in order to test for potential economies of scale reflected in transportation tariffs.

Because of missing data, we have generated an indicator for the estimated tonnage to be transported monthly. The indicator variable designate low or high tonnage estimates depending on a threshold $\bar{t}$, with $\bar{t} = 20,000$ tonnes/month for the international corridors and $\bar{t} = 1,000$ tonnes/month for the domestic lanes. The thresholds were determined to ensure that the number of observations in each category was fairly distributed (see Figure 3). The third category of this indicator represents missing data on tonnage estimates.



(a) International corridors. (b) Domestic lanes.

Figure 3: Histograms of monthly tonnage estimates by transportation network segment.

Economies of scope

Backhaul opportunities can also reduce costs and affect transportation tariffs. However, we do not have the data required to observe backhaul opportunities directly. One way of identifying their potential impact is to investigate variations at the regional level, i.e. unobserved factors either at the region of origin or at the region of destination which may indicate backhaul opportunities. In order to remain agnostic about which factors determine backhaul opportunities, we include region-specific indicator variables for both the origin and the destination to account for all residual cross-regional variability not captured by our other explanatory variables. Note that regional indicators were successfully used to identify economies of scope in truckload transportation markets in the US. For all the domestic lanes, we have defined a regional indicator for the origin and the destination regions, as well as an indicator for the destination region of the international corridors. These correspond to the 11 regions of Ethiopia: Addis Ababa, Affar, Amhara, Benishangul-Gumuz, Dire Dawa, Gambella, Harari, Oromia, SNNP, Somali and Tigray.

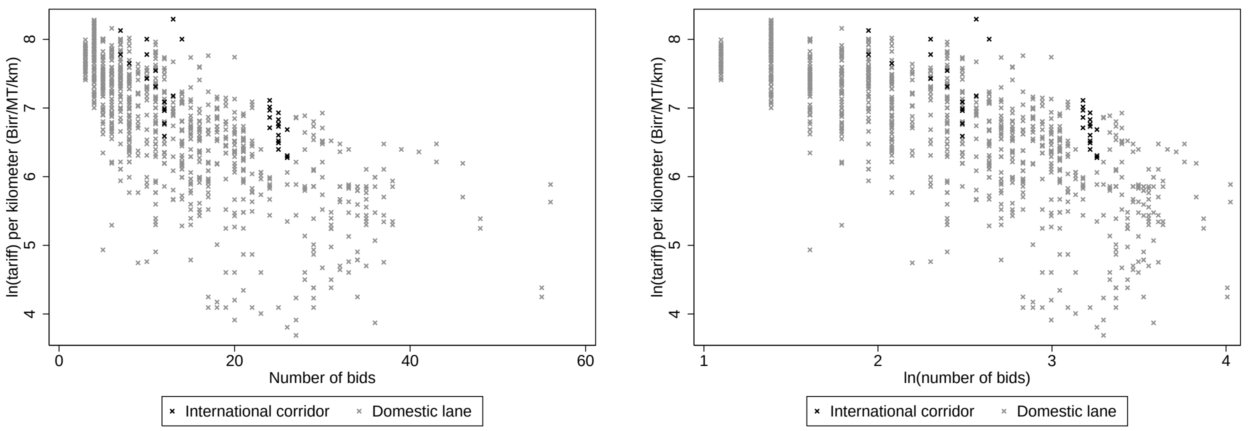
When no significant differences between regions are found, we can rule out the possibility for backhaul opportunities to explain variability in tariffs, at least at the regional level. However, we cannot claim that economies of scope alone explain any cross-regional variability observed; other unobserved factors could also explain them. One of these is related to the market structure. Indeed, we will see that the characteristics of the marketplace are an essential factor in establishing transportation tariffs. Moreover, this dimension might encompass the effect of economies of scope described above.

4.1.3 Market structure measures

The second group of explanatory variables concerns the structure of the trucking market. Truckload transportation markets in developing countries such as Ethiopia are unlikely to resemble the competitive markets found in developed countries. If competition is low, monopoly power will allow carriers to include a higher markup over marginal cost in their pricing structure. Exploiting the unique nature of our data, we use information from the bid distribution as a proxy to measure the impact of market structure on transportation tariffs. To this end, proxies associated with competition intensity, market dispersion and market concentration were included in the regression models. These variables were computed from information extracted from the internal supply chain of the WFP derived from the RFQ.

Competition intensity

We hypothesize that the competition intensity on a network segment is related to the number of bids made on the corresponding international corridor or domestic lane. Figure 4a depicts the tendency for the natural logarithm of tariffs per kilometer per tonne to decline as the number of carriers bidding on a lane increases. It also shows this relationship to be non-linear: each additional bidder reduces the tariffs, but this effect decreases with the number of bidders. Thus, competition appears to considerably affect transportation tariffs, but adding players in the bidding process becomes less influential when the competition intensity has reached a certain level. This non-linear relationship is estimated in the regression models by including the natural logarithm of the number of bids per lane, ln(#*bids*), as a proxy for competition intensity. Figure 4b shows the relationship between the logarithm of the transportation tariffs and the logarithm of the number of bids to be linear.



(a) Effect of the number of bids on ln tariff rates per kilometer.

(b) Effect of ln(number of bids) on ln tariff rates per kilometer.

Figure 4: Tariffs per kilometer as function of the competition intensity.

Market dispersion

In a mature and efficient market, information about prices should be known by all participating actors, and the dispersion in bids for each transportation network segment should be small. We hypothesize that a large dispersion in bids reveals a disorganized market in which information does not circulate well between the carriers. Therefore, the difference between the third and the first quartiles of the bids on each lane have been computed to measure the variation in bids without considering the extreme bids. To standardize this measure, the difference between the third and the first quartiles has been divided by the median. The ensuing variable is called *bid dispersion*.

Market concentration

To reflect the market concentration at the shipping origins and destinations, we have created two types of predictors: the number of active carriers and bid-related Herfindahl-Hirschmann indices (Herfindahl, 1950; Hirschman, 1945). The number of active carriers (*carrier*) is the number of carriers that are willing to provide services from an origin or to a destination, i.e. the number of distinct carriers who have bid on a lane originating from a specific origin or ending at a specific destination in the RFQ.

The Herfindahl index is equal to the sum of the squared market share s_t of carrier t ($t = 1, ..., m$): $hhi = \sum_{t=1}^{m} s_t^2$. Lacking information on carriers' market shares, we have used the number of bids by carriers as a proxy. Let b_t be the number of bids made by carrier t, and let B be the total number of bids that have been made at the origin or at the destination. Market shares s_t are estimated by b_t/B. The Herfindahl index measures the amount of market power from which firms profit from. An industry with few large competitors will have a high level of concentration (*hhi* close to one), while a fragmented market with many small competitors results in low concentration (*hhi* close to zero). We have evaluated the transportation market concentration *hhi* both at the origin and at the destination of each network segment.

4.2 Variables extracted from data published by the Central Statistical Agency of Ethiopia

The last group of explanatory variables consists of regional demographic and economic factors. These data are external to the WFP supply chain, so they can be used in conjunction with the cost driven factors to predict transportation tariffs when extensive RFQ data are not available or not representative of the global market. This situation could also occur for the prediction of the transportation tariff of a new lane without information on the competition environment. Thus, the geographic concentration of population and economic activities at the origins and at the destinations could be used as a substitute for market predictors.

Data on economic activities were compiled from the latest reports published by the Central Statistical Agency of Ethiopia (CSAE). The CSAE is a government agency designated to supervise and provide all survey and census reports in Ethiopia in order to monitor economic and social indicators. For the 11 regional states of Ethiopia, we have extracted data on the following three categories: the number of manufactures of the major industrial groups (CSAE (2010)), the agricultural production (CSAE (2009)), and major livestock types (CSAE (2008)). We have also extracted data on the population from the latest Population and Housing Census of Ethiopia conducted by the Ethiopian Population Census Commision (Population Census Commission (2008)). We use the socio-economic data at the regional administrative level because this information is not available for the smallest administrative levels such as woreda or kebele. Note that there are no regional socio-economic indicators associated with the origins of the international corridors since these correspond to foreign ports.

The compiled socio-economic statistics for Ethiopia are presented in Table 5 of Appendix 1. Brief descriptions of the considered elements are given in the first column of this table, while their values together with their relative percentages are presented in the last two columns. Although we have used data at the regional level in the regression models, note that we only provide the statistics applicable to the whole country. Information at the regional level can be found in the CSAE public reports.

The variable *population* represents the total population, and the variable $manufacture$ corresponds to the total number of manufactures (the sum of all types of manufactures) in the region of origin or destination. The variables *grain*, *vegetable* and *coffee* are the total quintals of crop grains, vegetable and coffee produced in all regions. The variable *agriculture* is the total output of agriculture production, which corresponds to the sum of the three previous variables. The variables *cattle*, *sheep*, *goat* are the number of registered animals of each type. The variable *livestock* is the total number of animals (the sum of the number of cattle, sheep and goats). Note that for the agricultural production and the livestock, we have only considered the three more important and significant elements regarding the Ethiopian actual economic situation.

Table 6 of Appendix 1 shows the correlation coefficients between socio-economic variables. We note that all the agricultural production variables (*grain*, *vegetable*, *coffee* and *agriculture*) and all the livestock variables (*cattle*, *sheep* and *goat*) are strongly correlated to each other. This implies that the different agricultural activities are concentrated in the same regions. Moreover, when comparing the correlation coefficients of *agriculture*, *livestock* and *population*, we observe that these three variables are positively correlated. This indicates that the more populated regions are also more active in terms of agricultural production, which is not necessarily the case for the manufacturing activities having no strong significant correlation with *population* nor *agriculture*. Indeed, more than 85% of the Ethiopian population lives in rural areas where agriculture is the main economic activity.

4.3 Descriptive statistics

Table 2 contains descriptive statistics for the main variables of interest for the two markets. This table clearly shows that the international transportation network is denser than the domestic network, with fewer lanes to cover but more tonnage to transport per lane. The average distance of the international corridors is greater than that of the domestic lanes, but both domestic and international markets are considered to be long-haul transportation. The last row of Table 2 shows that the tariffs per kilometer are lower on average for the international corridors than for the domestic lanes. Moreover, the standard deviation of the tariffs per kilometer is smaller for the international corridors than for the domestic lanes. The international market seems more competitive since it generates on average more bids per lane than the domestic market. Note that in the remainder of this paper the information on the carriers is not used to explain the effective transportation tariffs, but only to analyze the bids.

Table 2: Descriptive statistics

Market	International market			Domestic market		
Network	2 origins (ports) 24 destinations (EDPs) 32 lanes 46 carriers			33 origins (EDPs) 98 destinations (FDPs) 731 lanes 59 carriers		
Descriptive statistics	n	mean	standard deviation	n	mean	standard deviation
Distance (km)	32	756.1	289.7	731	589.8	356.3
Estimated tonnage per lane (tonne/month)	21	27,426.9	36,969.3	131	2,055.4	3,028.2
Number of bids per lane	32	17.9	7.3	731	14.9	10.3
Number of bids per carrier	46	14.4	5.5	59	212.3	190.5
Bids (Birr/tonne)	572	1,317.6	1,016.1	12,231	1,322.1	1,286.7
Tariff (Birr/tonne)	32	1,405.3	902.5	731	1,138.8	844.6
Tariff per km (Birr/tonne·km)	32	2.0	1.2	731	2.4	2.1

More detailed descriptive statistics about the WFP data for all variables in both the international and domestic markets are reported in Tables 7 and 8 of Appendix 1. These tables contain information describing the distribution of each variable including the mean, median, standard deviation, as well as the minimum and maximum values.

5 Results

We have used multiple linear regression models to determine which of the factors have a significant impact on transportation tariffs in Ethiopia. Separate analyses are conducted for the international and domestic Ethiopian transportation markets since, as discussed above, these are two distinct markets. We now explain the process implemented to determine our best regression models before presenting and describing them. Note that all statistical analyses were executed using Stata 11.

5.1 Methodology

For each transportation market, we have constructed two distinct type of models which both include the cost driven factors (C): one with the market structure measures (M) and the other with regional socio-economic variables (E). There are different reasons for this choice. The socio-economic variables are derived from public information independent of the WFP operations. Because the socio-economic variables partly explain the market structure, they can thus be considered as proxies for it when specific data, such as the WFP data in this case, are not available. These two models can be compared to better understand the effects of the market structure on transportation tariffs, measured from the WFP information or from socio-economic statistics.

For the international and the domestic transportation markets we aim to define multiple linear regression models explaining ln(*tariff*), i.e. ln(*tariff*)= $f_1(C, M) + \epsilon_1$ and ln(*tariff*)= $f_2(C, S) + \epsilon_2$, where ϵ_1 and ϵ_2 are random errors due to unobservable factors. Heteroscedasticity has been identified with Breusch-Pagan/Cook-Weisberg and White tests (Baum, 2006) when using *tariff* as dependent variable. This problem is removed by using ln(*tariff*) (see Appendix 2).

We have constructed various model specifications by using different sets of independent variables. For each market, we have first regressed ln(*tariff*) on the variables related to the road attributes and we have then added the competition intensity to this specification. We now explain how the variables were selected to build our final regression models. For the models with the market structure measures, the HHI indices (*hhi*) were omitted because they were highly correlated with other market structure measures (see Tables 9 and 10 of Appendix 1) and were not effective predictors. For the models with the regional socio-economic variables, the variables associated with agricultural activities (*agriculture* and *livestock*) at the origin and destination were discarded because of their correlation with the population (*population*). Only the remaining suitable variables were used into the statistical models ln(*tariff*)= $f_1(C, M) + \epsilon_1$ and ln(*tariff*)= $f_2(C, S) + \epsilon_2$. Lastly, backward regressions allowed us to determine our final statistical models for the (1) international and (2) domestic transportation markets.

5.2 Multiple regression models

Tables 3 and 4 display the results obtained for six different specifications for the international corridors and for the domestic lanes. In each table, the first specification corresponds to a regression of the natural logarithm of transportation tariffs (ln(*tariff*)) on variables associated with the distance and road conditions measures only. The second specification adds variables describing competition intensity. The third specification considers all the explanatory variables, except for the regional socio-economic factors, and the fourth specification results from a backward regression which initially considered the same independent variables. The last two specifications include the regional population and the manufacturing activity variables instead of the market structure measures. The fifth specification includes all the explaining variables, and the sixth model was obtained by applying a backward regression.

The number of observation considered (n), the R-squared, the adjusted R-squared and the maximum variance inflation factor (VIF) values are given for each specification presented in Tables 3 and 4. VIF statistics were estimated for the different models to detect multi-collinearity issues. There is no theoretical threshold value for recognizing multi-collinearity, but a common rule of thumb suggests that variables with a VIF value greater than five or ten should be discarded, five being more restrictive than ten (see O'Brien, 2007, and Haan, 2002). The highest VIF values obtained are 3.36 and 3.07 for our final international and domestic models, respectively. In Tables 3 and 4, we provide the robust standard errors associated with the regression coefficients, as suggested by Berry and Feldman (1985). For each model, in order to validate the coefficients, we ensured that their signs and their magnitudes were the same as those obtained when regressing the transportation tariff on each individual variable separately. We thus consider that there are no multi-collinearity problems.

From the results presented in Tables 3 and 4, we note that including the market structure measures as explanatory factors leads to statistical models that explain more variability in transportation tariffs than those including the socio-economic factors, this being true for both international and domestic markets: the adjusted R-squared associated with Models 1.4 and 2.4 are indeed 21.7% and 8.9% higher than those of Models 1.6 and 2.6. In the remainder of this paper, we will therefore consider Models 1.4 and 2.4 presented in Tables 3 and 4 as our best models to explain the international and domestic transportation markets, respectively.

Table 3: Regression models for ln(*tariff*) (Birr/tonne) for the international transportation market

	Models					
Variables	(1.1)	(1.2)	(1.3)	(1.4)[a]	(1.5)	(1.6)[b]
Cost driven						
Road conditions						
paved (km)	0.000137	0.000580***	0.000392**	0.000497**	0.000874**	0.000859**
	(0.000335)	(0.000180)	(0.000184)	(0.000194)	(0.000352)	(0.000338)
unpaved (km)	0.00160***	0.00103**	0.00109***	0.00116***	0.000940***	0.000927***
	(0.000408)	(0.000389)	(0.000302)	(0.000318)	(0.000310)	(0.000299)
Risk perception[c]						
high			0.552***	0.607***	0.549**	0.590**
			(0.170)	(0.161)	(0.262)	(0.251)
not specified			0.0131	0.0604	0.290	0.325*
			(0.108)	(0.119)	(0.190)	(0.175)
Tonnage estimates[d]						
low			–0.102		–0.0816	–0.0954
			(0.128)		(0.168)	(0.162)
high			–0.227		–0.378*	–0.379*
			(0.152)		(0.191)	(0.187)
Market structure						
Competition intensity						
ln(#*bids*)		–0.823***	–0.881***	–0.888***		
		(0.0863)	(0.0809)	(0.105)		
Market dispersion						
bid dispersion			–1.662***	–1.510***		
			(0.406)	(0.282)		
Market concentration						
carrier destination			–0.00335	–0.00525*		
			(0.00307)	(0.00272)		
Socio-economic						
population destination					–4.46e-05	
					(7.71e-05)	
manufacture destination					–0.000847**	–0.000868**
					(0.000345)	(0.000416)
Constant	6.618***	8.829***	9.661***	9.561***	6.550***	6.508***
	(0.250)	(0.328)	(0.398)	(0.453)	(0.341)	(0.330)
n	32	32	32	32	32	32
R-squared	0.442	0.738	0.890	0.878	0.713	0.710
Adj. R-squared	0.404	0.710	0.845	0.842	0.612	0.625
Max. VIF value	1.19	1.53	3.71	3.31	3.52	3.36

Robust standard errors in parentheses, *** p<0.01, ** p<0.05 and * p<0.1

[a] This model corresponds to Model 1.3 after backward elimination of non-significant variables.
[b] This model corresponds to Model 1.5 after backward elimination of non-significant variables.
[c] The category of reference is “not specified” for regions other than Somali.
[d] The category of reference is “not specified”.

Table 4: Regression models for ln(*tariff*) (Birr/tonne) for the domestic transportation market

	Models					
Variables	(2.1)	(2.2)	(2.3)	(2.4)[e]	(2.5)	(2.6)[f]
Cost driven						
distance (km)	0.00164***	0.00123***	0.00109***	0.00112***	0.00138***	0.00138***
	(7.32e-05)	(6.42e-05)	(6.73e-05)	(6.14e-05)	(7.61e-05)	(7.54e-05)
Road conditions[g]						
poor	1.102***	0.258***	0.219***	0.204***	0.441***	0.441***
	(0.0685)	(0.0687)	(0.0616)	(0.0604)	(0.0783)	(0.0781)
intermediate	0.310***	–0.0573	–0.0761	–0.0838	–0.0867	–0.0867
	(0.0701)	(0.0583)	(0.0539)	(0.0535)	(0.0658)	(0.0658)
good	–0.325***	–0.256***	–0.137**	–0.149***	–0.376***	–0.378***
	(0.0634)	(0.0517)	(0.0545)	(0.0495)	(0.0632)	(0.0631)
Risk perception[h]						
none			–0.112	–0.145	–0.0507	–0.0478
			(0.109)	(0.0999)	(0.139)	(0.136)
low			0.468***	0.431***	0.575***	0.577***
			(0.0799)	(0.0771)	(0.0969)	(0.0943)
high			0.647***	0.644***	0.611***	0.613***
			(0.0725)	(0.0701)	(0.0977)	(0.0957)
not specified			0.216***	0.232***	0.349***	0.351***
			(0.0574)	(0.0527)	(0.0647)	(0.0626)
Tonnage estimates[i]						
low			–0.0213		–0.0967	–0.0961
			(0.0622)		(0.0799)	(0.0800)
high			–0.111		–0.310***	–0.310***
			(0.0717)		(0.0773)	(0.0774)
Market structure						
Competition intensity						
ln(#bids)		–0.717***	–0.605***	–0.564***		
		(0.0359)	(0.0610)	(0.0402)		
Market dispersion						
bid dispersion			–0.724***	–0.718***		
			(0.0924)	(0.0891)		
Origin						
Market concentration						
carrier origin			0.00269			
			(0.00248)			
carrier destination			–0.00530***	–0.00557***		
			(0.00110)	(0.00107)		
Socio-economic						
population origin					–6.08e-05**	–6.10e-05**
					(2.39e-05)	(2.39e-05)
population destination					–7.72e-06	
					(3.32e-05)	
manufacture origin					–0.000616***	–0.000617***
					(0.000118)	(0.000118)
manufacture destination					–0.000831***	–0.000848***
					(0.000138)	(0.000144)
Constant	5.471***	7.737***	7.855***	7.806***	5.977***	5.971***
	(0.0716)	(0.120)	(0.158)	(0.140)	(0.116)	(0.107)
n	731	731	731	731	731	731
R-squared	0.564	0.727	0.780	0.778	0.689	0.689
Adj. R-squared	0.561	0.725	0.775	0.775	0.683	0.683
Max. VIF value	1.38	2.23	6.11	3.07	2.82	2.77

Robust standard errors in parentheses, *** p<0.01, ** p<0.05 and * p<0.1

[e] This model corresponds to Model 2.3 after backward elimination of non-significant variables.

[f] This model corresponds to Model 2.5 after backward elimination of non-significant variables.

[g] The category of reference is "unknown"

[h] The category of reference is "not specified" for regions other than Somali.

[i] The category of reference is "not specified".

5.3 Insights

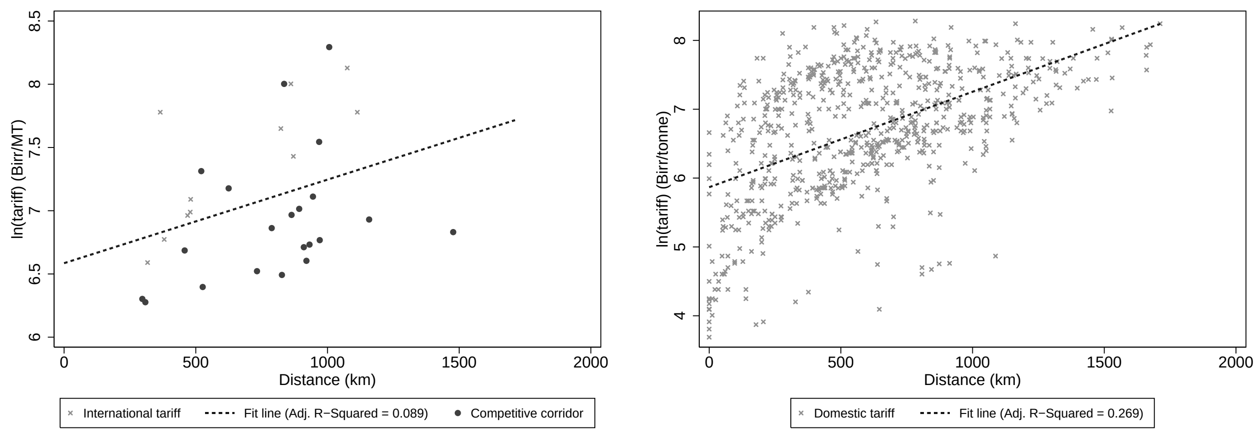
In this section, we highlight the significant determinants of transportation tariffs and quantify their impact. We aim to discuss the ability of the different variables to predict Ethiopian transportation tariffs by putting a particular emphasis on factors which are specific to emerging markets. We first look at the cost driven factors and then at the measures associated with market structure before discussing the results of the models considering the socio-economic variables. Note that Kennedy (1981) suggested the following estimator for the percentage impact of a dummy variable on the variable being explained in semi-logarithmic equations:

$$100\left[\exp\left(\hat{\beta} - \frac{1}{2}\widehat{V}(\widehat{\beta})\right) - 1\right],$$

with $\widehat{\beta}$ being the dummy variable coefficient and $\widehat{V}(\widehat{\beta})$ being an estimate of the variance for $\widehat{\beta}$. We will thus use this estimator with $\widehat{V}(\widehat{\beta})$ equal to the squared robust error of a coefficient β, in order to analyze the impact of our indicator variables on *tariff*.

5.3.1 Analysis of the linehaul cost drivers

In linehaul movements, distance is recognized to be an important contributor to the cost of doing business for freight carriers (Kirkeby, 2012, and Rodrigue et al. 2009). Figure 5 illustrates the relationship between the natural logarithm of transportation tariffs and distance. This figure reveals that, despite a certain linear tendency, a large amount of variability in tariffs remains. The transaction prices are not tightly concentrated along the fitted line and distance alone only explains 9% and 27% of the variability in tariffs for international and domestic transportation. This is a striking fact, especially considering that transport prices are known to increase almost directly proportionally to distance in mature transportation markets. In the US for instance, a fixed price and a constant variable price per kilometer alone explain about 80% of the variability in tariffs. Thus, the need to take into account factors other than distance to explain the Ethiopian transportation market is obvious. In Figure 5, the international corridors and the domestic lanes where the number of bids is larger than the average (16.3 for corridors and 11.6 for lanes) are distinguished with dark grey dots. We note that the transportation tariffs tend to be lower on these more competitive network segments.



(a) International corridors

(b) Domestic lanes

Figure 5: Natural logarithm of transportation tariffs as a function of distance.

The first specifications presented in Tables 3 and 4 emphasize the importance of incorporating road conditions to better explain transportation tariffs. When comparing the adjusted R-squared of Models 1.1 with the simple univariate model displayed in Figure 5, we note that 31.5% more variability in tariffs can be explained only by decomposing the total distance of the lanes into their paved and unpaved distances for the international corridors. We can also observe in Model 1.4 that the coefficient of unpaved kilometer is highly significant while the coefficient of paved kilometer is less significant. This indicates that carriers tend to set their tariffs proportionally to the unpaved distance. A small change in unpaved and paved distance increases tariffs by 0.116% and 0.0497% on average when controlling for significant factors including the market structure, as in Model 1.4. For the domestic market, we note that adding road condition to distance in the regression model increases its predicting power by 34.1% (comparing the adjusted R-squared of Models 2.1 and the one of the basic regression shown in Figure 5). We can also observe from the statistical models of Table 4 that the transportation cost on the lanes with poor road conditions is much more expensive than on the lanes with intermediate or good conditions. Indeed, based on the coefficients of Model 2.4, and compared with lanes without available information on road conditions, poor road conditions increase the tariffs by 22.4%, while good conditions decrease the tariff by 13.9%.

Carriers operating in the Somali region are vulnerable to various risks such as hijacking or delays caused by escorting processes or expected disruptions. It is likely that they will take these factors into account in their tariff structures. The coefficients of risk perception in

Models 1.4 and 2.4 confirm that the lanes with a higher or unknown risk have significantly greater tariffs. For the international market, the transportation tariffs are 81.1% higher on corridors in which risk is specified. For the domestic lanes, the transportation tariffs are not significantly lower when it is specified that the lanes are not risky. For low and high specified risk, the transportation tariffs are 53.4% and 89.9% higher, compared to lanes with non-specified risk for regions other than Somali. Transportation in the Somali region also tends to increase the transportation tariff significantly. Even if the risk is not specified, it is 25.9% more expensive to transport food aid within the Somali region than on the other domestic lanes.

5.3.2 Analysis of the carrier economies

The indicator variables associated with the estimated quantity of aid food to be transported monthly (*low* and *high* tonnage) are not significant at the 90% level in Models 1.3 and 2.3 and do not appear in Models 1.4 and 2.4. Even by regressing on a smaller sample, where only the lanes with a specified tonnage value are taken into account, the estimated tonnage does not significantly explain transportation tariffs, and the regression coefficients remain similar to those of Models 1.3 and 2.3. This implies that, with respect to estimated tonnage data we have, there is no clear evidence of economies of scale for transportation services in Ethiopia when controlling for the market structure. This is surprising since decreasing unit transport costs for grains can generally be expected (Rodrigue et al., 2009) and larger regional volumes of trade usually correspond to lower freight tariffs (Skiba, 2007).

To further test for economies of scale at the level of carriers, we also consider the bid as a dependent variable. We add indicator dummies per carrier uniquely to identify the carriers across lanes, allowing control for any carrier-specific characteristics that might influence their bids. The international and domestic specifications obtained from this regression are presented in Table 11 of Appendix 3. Results show that the tonnage indicators have a statistically significant impact in lowering the bids, regardless of whether the estimate is low or high. Carriers perhaps bid more competitively when tonnage estimates are provided, regardless of the volume level, since even a low estimate indicates some degree of certainty about volumes, although it is not a tonnage guarantee by the WFP. The decrease in bids when the estimated tonnage moves from low to high for both markets indicates that this aspect of bidding behavior could be related to economies of scale. There is therefore some evidence regarding the influence of economies of scale at the level of carriers among these sets of bids. Since Jara-Díaz and Basso (2003) indicate that economies of scale and scope are the main determinants of the transportation industry structure, we must look further into economies of scope.

To investigate potential for economies of scope to determine the variability in tariffs on the Ethiopian transportation network, we have tested the relevance of including the regional indicators in the regression models 1.4 and 2.4. For the international market, we have conducted an F-test of joint significance for the inclusion of the regional destination indicator cluster into Model 1.4. The F statistic shows that the destination regions do not add significant explanatory power to the model (the p-value is 0.696). This result implies that there is no significant variability in tariffs between the destination regions, which is not already accounted for in the model, and we conclude that there is no clear evidence of backhaul opportunities or economies of scope to explain variability in tariffs at the regional level. This finding is consistent with the observed practice of carriers. The time required to find and manage a backhaul load is usually rather long in Ethiopia. Carriers cannot afford to waste time and hold back their resources in the hope of obtaining backhaul loads when large quantities of food should be cleaned out at the ports as quickly as possible. As a result, returning to port locations for the next load is usually done with empty trucks.

As for the domestic market, we have conducted an F-test on the significance of the destination indicators and the origin indicators in Model 2.4. The F statistics show that the regional indicators for the destination regions add some explanatory power to the model, but that the increase in R-squared is less than 1.35% when the origin and destination regions are added in separate clusters and only 1.64% when they are added in one cluster. The inclusion of the regional destination indicator cluster do not add significant explanatory power to the model (the p-value is 0.226 and the change in R-squared is less than 0.3%). Some of the coefficients on the regional indicators are significant at the 5% significance level. These results imply that there are differences between the origin and destination regions, and we cannot rule out the impact of backhaul opportunities on transportation tariffs. We cannot assume that backhaul opportunities are the only factor explaining the differences between regions, but we can state that they can explain at most 1.64% of the variability in tariffs in a model that controls for competition intensity. We conclude that the economies of scope are not major determinants of the transportation tariffs, which makes sense since there are only few backhaul opportunities in Ethiopia.

5.3.3 Analysis of the market structure

Beyond carrier cost structures and economies, transportation tariffs may also be affected by the level of competition. Simple univariate regressions reveal that the number of carriers submitting rate offers in the RFQ for a specific lane has an impact on the effective market tariff. A regression of the transportation tariffs on $\ln(\#bids)$ and a constant explains about 55% of the variability in tariffs for both the international corridors and the domestic lanes, which suggests that competition intensity has a considerable influence on transportation tariffs.

Models 1.4 and 2.4 further indicate that the intensity of competition, measured by $\ln(\#bids)$, has a significant impact on transportation tariffs for both international and domestic transportation markets. Indeed, a one percent increase in $\#bids$, all other variables being held constant, generates a 0.888% and 0.564% decreases (elasticities) in the transportation tariff for the international corridors and domestic lanes. The importance and consequences of the competition intensity in the transportation market will be further analyzed in the following sub-section.

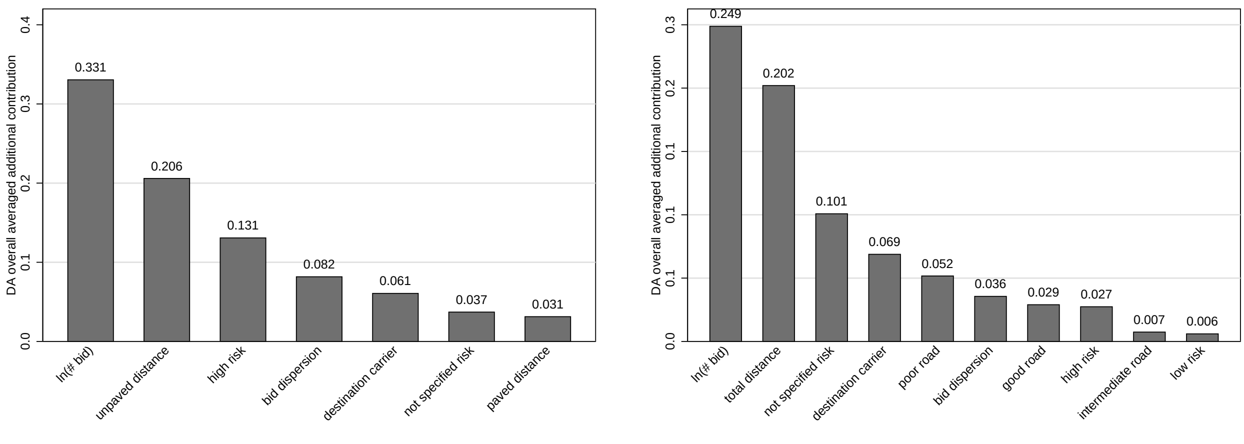
An alternate way to test the importance of competition is to regress not only the effective transportation tariffs but also the complete distribution of bids. Since we are able to uniquely identify the carriers across lanes, we can add indicator dummies per carrier to control for systematic differences in the average bid submitted by each carrier. Results from this regression show that the number of bids per lane also has a statistically significant and negative impact on the bids. The intensity of competition not only has an impact on the effective transportation tariffs but also on the carrier bids in general (see Table 11 in Appendix 3).

From Models 1.4 and 2.4, we also note that transportation tariffs tend to decrease when there are more active carriers at the network segment destination (variable *carrier destination* for the corridor and lane destinations), for both international and domestic markets. The number of active carriers at a location is an indicator of business attractiveness, and transportation tariffs tend to be lower for a lane ending at an attractive destination.

Although the international data do not have an indicator variable for the number of carriers at the origin, the coefficient of the number of carriers at the lane origin (*carrier*) is not significant for the domestic market. (Behrens and Picard, 2011) show that the opportunity costs of returning empty increase freight rates, and that transport costs should be higher from destinations that are net exporters than from regions that are net importers. Our findings can be reconciled with this theory by making the hypothesis that carriers tend to locate in net exporting regions rather than in net importing regions. However, given the limited data, this hypothesis cannot be tested. If true, a relatively higher number of carriers at origin indicates a net exporting location, for which there will exist relatively fewer backhaul opportunities. In addition, a destination location with more carriers is a net exporter, with more business activities and lower tariffs, which is what we observe.

We also observe in Models 1.4 and 2.4 that the coefficients of the standardized dispersion in bids (*bid dispersion*) are negative and significant, which implies that the disparity between bids leads to lower transportation tariffs and that prices are not necessarily higher in disorganized markets. Having a wide dispersion between bids on a lane increases the chance of having a lower bid, resulting in a lower effective transportation tariff. This may mean that some carriers are bidding below the cost drivers to be competitive or that they do not understand their cost structure well. Informal discussions with shippers in Ethiopia indicated that they feel that some carriers are bidding at levels that do not support their operations, which may provide short term cost savings but not sustainable capacity. Another explanation is that this could constitute an evidence for collusion. If carriers collude to set prices on certain lanes as in a cartel, there will be less variability in bids on those lanes, and the effective transportation tariff will be higher. However, further analyses would need to be conducted in order to identify cartels and analyze their impact.

In order to compare the relative importance of the cost driven and the market structure predictors of Model 1.4 and Model 2.4, we have implemented the dominance analysis (DA) proposed by Azen and Budescu (2003). These authors have introduced several quantitative measures of dominance for predictors in multiple regression, based on an examination of the R-squared values for all possible subset models of the independent variables. Figure 6 illustrates the overall averaged additional contribution to the proportion of variance in $\ln(\textit{tariff})$ accounted for by each predictor in the subset models. When the DA overall averaged additional contribution of a predictor is greater than another, this predictor is said to generally dominate it and, therefore, we can state that this predictor is relatively more important than the other. These values thus provide an idea on the magnitude of importance of the different explaining factors considered in our models. For the international corridors (Figure 6a), the competition intensity and the unpaved distance appear to be the major determinants of transportation tariffs, followed by the high risk perception to go in Somali. For the domestic lanes (Figure 6b), competition intensity appears to be the dominant determinant of tariffs, followed by distance. Providing transportation services in the region of Somali and the number of active carriers at destination also have an impact on the tariffs, but their importance drops significantly compared with distance. The results of Models 1.4 and 2.4, as well as the bar charts of Figure 6, show the importance of the competition intensity on the transportation tariffs in Ethiopia. Note that for the international corridors, the competition intensity completely dominates all the other predictors (Azen and Budescu, 2003).



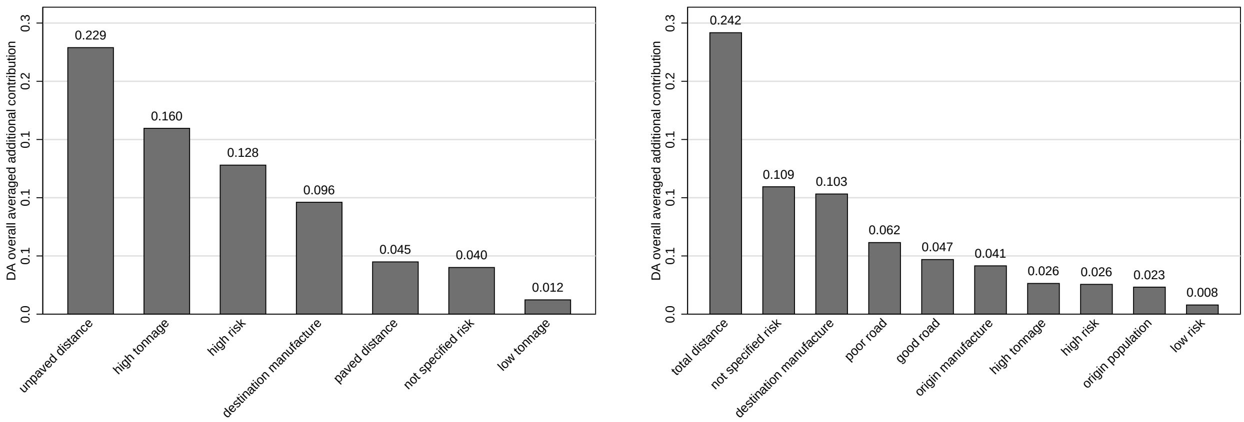
(a) International market, Model 1.4.

(b) Domestic market, Model 2.4.

Figure 6: Dominance analysis overall additional contributions for the models considering the market factors.

5.3.4 Analysis of the socio-economic factors

Comparing the adjusted R-squared values of Models 1.4 and 2.4 with the ones of Models 1.6 and 2.6, we observe that the socio-economic factors do not explain the variability in tariffs as well as the market structure measures. However, they make use of variables derived from public information, independent of the WFP operations, which are generally available to shippers. As above, in order to assess the relative importance of the combined cost and socio-economic factors in Models 1.6 and 2.6, we have considered the DA overall averaged additional contribution of each predictor shown in Figure 7. Unpaved distance is the most important explaining factor for the transportation tariffs, followed by high tonnage and risk for the international corridors (Figure 7a). When using the socio-economic factors instead of the market structure variables, the high estimated tonnage indicator becomes a significant variable. This indicates that the market structures variables may encompass the effect of this variable in the other model. However, the paved distance remains one of the least important predictor of transportation tariffs on the international corridors. For the domestic lanes (Figure 7b), distance has a major impact on the transportation tariffs, followed by non-specified risk in the region of Somali and the number of manufactures at destination. For both markets, international and domestic, regions with more manufacturing activities appear to be attractive for the carriers, which is reflected by a negative impact on transportation tariffs, indicating that the manufacturing activities could lead to more competitive transportation markets. As when controlling for the market structure, transporting food aid within the Somali region of Ethiopia also has an important impact on the tariffs when controlling for the socio-economic factors.



(a) International market, Model 1.6.

(b) Domestic market, Model 2.6.

Figure 7: Dominance analysis overall additional contributions for the models considering the socio-economic factors.

5.4 Discussions and implications

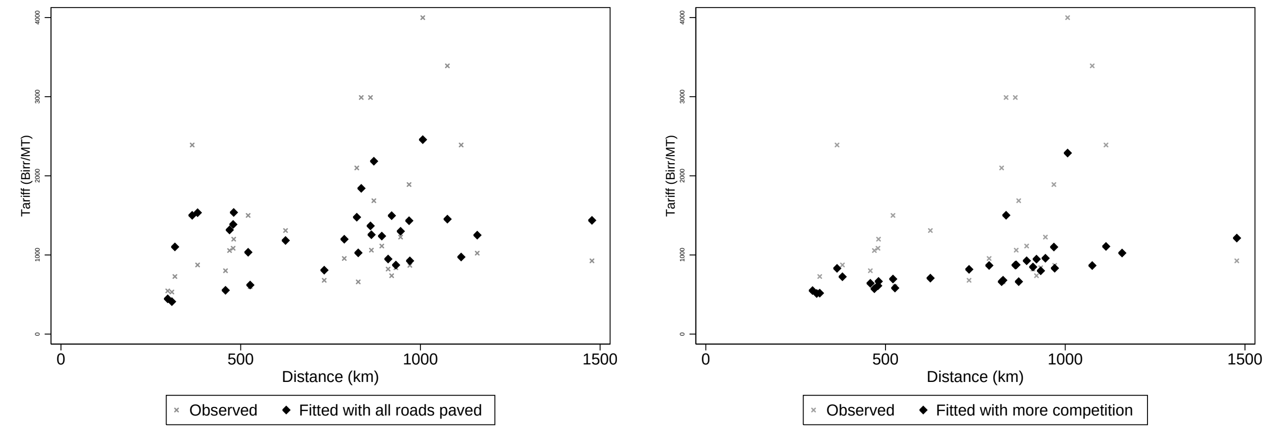
We now show how our models can be used to compute counterfactual costs and determine potential outliers. Assessing counterfactual costs will enable us to evaluate "what if" scenarios such as the consequences on transportation tariffs of improving road conditions or increasing competition in Ethiopia. These counterfactuals are done using the simple reduced-form estimates and do not consider the dependance with some of the other independent variables. They are therefore not predictors for long-term development, but can assist short-term scenario analyses. We also identify potential outliers to support the WFP by pointing to transportation network segments where tariffs might need to be reviewed.

5.4.1 Counterfactuals and development policies

Using the regression models 1.4 and 2.4, we can predict what would be the transportation service tariffs when improving the road conditions or when increasing the competition intensity. We have therefore estimated the total transportation costs incurred by unpaved roads and lack of competition. To account for better road conditions, we have computed the predicted transportation tariffs as if all the international corridors were paved and as if all the domestic lanes were in good condition. To account for more competition intensity, we have computed the predicted transportation tariffs if the competition intensity variable values were replaced by the maximum value between the actual number of bids and the third quartile of the number of bids for each network segment ($\ln(\#bids)$ equal to 3.23 for the international corridors, and $\ln(\#bids)$ equal to 3.04 to for the domestic lanes).

In Figures 8 and 9, the grey crosses correspond to the effective transportation tariffs and the black diamonds are the predicted values obtained when all roads are paved on the left chart, and when increasing competition intensity on the right chart. The results depicted in these figures indicate that increasing the level of competition has a greater impact on reducing transportation tariffs than does paving all the roads of the network. By computing the counterfactual costs, we see that paving the roads would reduce shipping costs by 18%, and improving competition would reduce them by 44% on the international corridors. Similarly for the domestic roads, better road conditions would reduce shipping costs by 12% and more competition by 39%. This nevertheless neglects the possibility for better roads to stimulate competition.

These findings are consistent with the results of Teravaninthorn and Raballand (2010), highlighting the low level of competition as one of the blocks toward achieving lower transportation tariffs in Africa. Large investments in infrastructures are not sufficient to improve transportation markets, since the lack of competition can result in high markups for transportation services. Improving road infrastructures in more competitive environment is more likely to yield lower transportation tariffs, as we found in results for the international corridors compared to the domestic lanes. The development of the physical infrastructures is recognized to be fundamental for economic growth and poverty reduction. A study conducted by Diao et al. (2005) revealed that development in agriculture can highly contribute to decreasing poverty and to increasing growth in Ethiopia, but this would also require reduced market transaction costs and more investment in transportation infrastructure. Our results suggest that government authorities responsible for economic development in Ethiopia should consider that policies that facilitate competition in transportation markets are as important as investments in the transportation infrastructure.



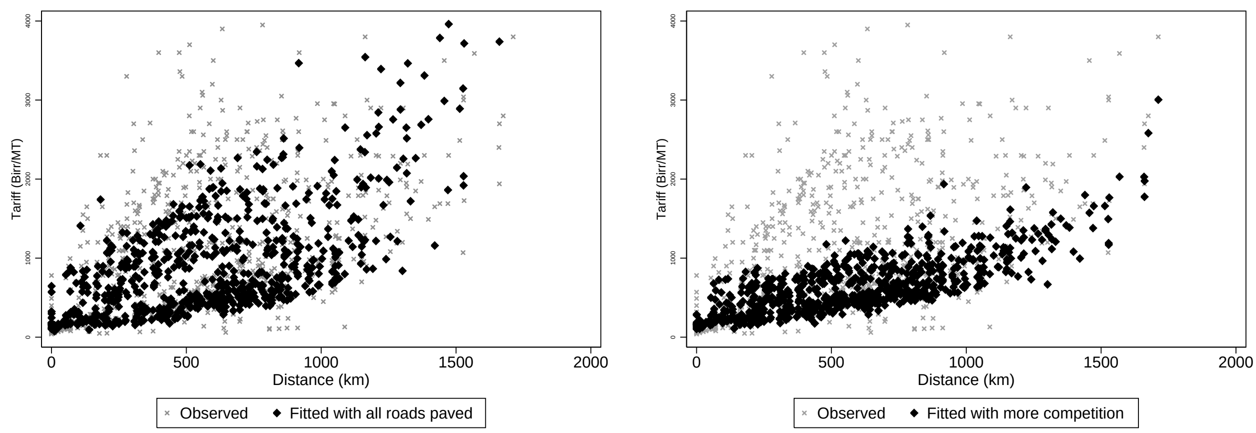
(a) Predicted tariffs if the network segments were all paved.

(b) Predicted tariffs if roads the network segments more competitive.

Figure 8: Illustration of the predicted tariffs in "what if" scenarios for the international corridors.

5.4.2 Managerial tool

Models 1.4 and 2.4 highlight the importance of the transportation tariff structures for the international corridors and domestic lanes in Ethiopia. These models can thus be used



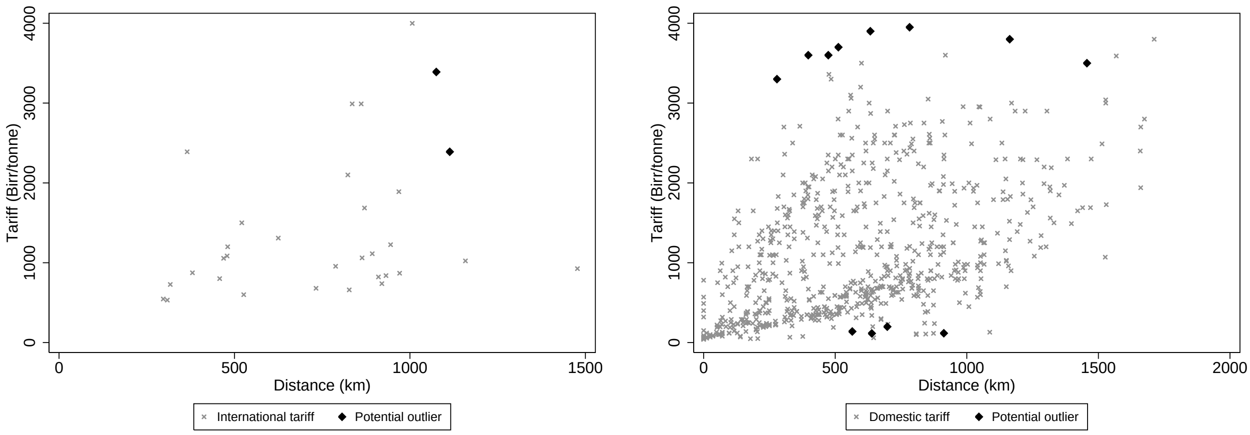
(a) Predicted tariffs if the network segments were all paved.

(b) Predicted tariffs if roads the network segments more competitive.

Figure 9: Illustration of the predicted tariffs in "what if" scenarios for the domestic lanes.

to identify the tariffs that deviate from the pricing tendencies in the WFP transportation network. In order to test for outliers, we have identified the outlying $\ln(tariff)$ observations. The potential outliers are the cases with large deleted standardized residuals in absolute value identified by means of the Bonferroni test procedure with $\alpha = 10\%$ (see Neter et al., 1996). Figure 10 illustrates the lanes for which there appear to be systematic differences in pricing. In this figure the light grey crosses correspond to the effective transportation tariffs and the black diamonds are the transportation network segment suspected to be outliers. These potential outliers are the lanes for which the actual transportation tariffs deviate considerably from the estimates provided by Model 1.4 for the international corridors and by Model 2.4 for the domestic lanes.

The tariffs of the corridors and lanes corresponding to the black diamonds in Figure 10 should be examined carefully. The deviations in tariffs for these lanes may be explained by factors that have not been taken into account in our models and they may even be legitimate. However, if this is not the case, this indicates a need for managerial intervention. The lanes with a significant positive deviation are likely to be especially lucrative for carriers and may be characterized by large markups. The lanes with a significant negative deviation may indicate tariffs that are not effectively covering carrier costs, which would prevent carriers to offer reliable transport capacity at the bid price. The WFP should really consider renegotiating its tariffs on these network segments or ensure that the actual tariffs will not be challenged by the contracted carriers.



(a) International corridors (b) Domestic lanes

Figure 10: Illustration of the WFP potential outliers of transportation tarrifs.

6 Conclusions

This study constitute a first attempt to analytically understand the main drivers in the truckload pricing structure in an African country. It uses a data set that contains bids and effective transportation tariffs in Ethiopia. The data were provided by the WFP, one of the major shippers in the country. The regression models presented reveal that major determinants of tariffs for the transportation services in Ethiopia are road conditions and the market structure. Results indicate that competitive markets are critical for reducing transportation tariffs and that transportation market efficiency should be an integral component of Ethiopia development strategies in the same way as it is currently for road infrastructure investments. In order to determine lanes that may require managerial intervention, useful information is provided by the proposed regression equations to model tariffs. In order to gain a better understanding of the transportation market in Africa, further analyses should be conducted and more transparency in the market is required. However, more data are required to conduct deeper analyses, but access to data in developing countries is often an issue. Still, we view our analysis as an important step on the right direction and we hope it will be followed by other similar studies in other African countries.

7 Appendix 1: Variables and cross-correlation tables

In this appendix, we first present descriptive statistics of the socio-economic variables (Table 5). We then present the variables extracted from the data sources for the 32 international corridors and the 731 domestic lanes (Tables 7 and 8). We also provide the cross-correlation tables for the socio-economics variables and for the continuous variables of the two transportation markets. Table 6 presents the correlation coefficients of the socio-economics variables extracted from the CSAE. Table 9 presents the correlation coefficients of the variables associated with the international corridors and Table 10 presents the correlation coefficients of the variables associated with the domestic lanes for which the distance is known.

Table 5: Data on Ethiopia economic activities and population

Distribution of number of manufactures per major industrial group (Central Statistical Agency of Ethiopia, 2010)	*n*	%
Food products and beverages	562	25.51
Tobacco products	1	0.05
Textiles	47	2.13
Wearing apparel, except fur apparel	41	1.86
Tanning and dressing of leather; footwear, luggage and handbags	89	4.04
Wood and products of wood and cork, except furniture	48	2.18
Paper and products and printing	127	5.76
Chemicals and chemical products	75	3.4
Rubber and plastic products	87	3.95
Other non-metallic and mineral products	608	27.6
Basic iron and steel	18	0.82
Fabricated metal products, except machinery and equipment	120	5.45
Machinery and equipment	5	0.23
Motor vehicles, trailers and semi-trailers	12	0.54
Furniture and manufacturing	363	16.48
Distribution of agricultural production (Central Statistical Agency of Ethiopia, 2009)	*Quintal*	%
Grain Crops	104,713,967	95.07
Vegetables	3,763,778	3.42
Coffee	1,665,791	1.51
Distribution of major livestocks (Central Statistical Agency of Ethiopia, 2008)	*n*	%
Cattle	49,297,898	51.25
Sheep	25,017,217	26.01
Goat	21,884,223	22.75
Population (Federal Democratic Republic of Ethiopia Population Census Commission, 2008)	*n*	
Population	72,840,864	

Table 6: Cross-correlation table for the regional socio-economic factors ($n = 11$)

Variables	*population*	*grain*	*vegetable*	*coffee*	*agriculture*	*cattle*	*sheep*	*goat*	*livestock*	*manufacture*
Demographic										
population	1.000									
Agriculture										
grain	0.949	1.000								
	(0.000)									
vegetable	0.820	0.633	1.000							
	(0.002)	(0.037)								
coffee	0.845	0.788	0.814	1.000						
	(0.001)	(0.004)	(0.002)							
agriculture	0.958	0.999	0.661	0.807	1.000					
	(0.000)	(0.000)	(0.027)	(0.003)						
Livestock										
cattle	0.986	0.978	0.777	0.865	0.985	1.000				
	(0.000)	(0.000)	(0.005)	(0.001)	(0.000)					
sheep	0.952	0.965	0.661	0.678	0.964	0.952	1.000			
	(0.000)	(0.000)	(0.027)	(0.022)	(0.000)	(0.000)				
goat	0.937	0.960	0.624	0.705	0.959	0.948	0.964	1.000		
	(0.000)	(0.000)	(0.040)	(0.015)	(0.000)	(0.000)	(0.000)			
livestock	0.982	0.985	0.728	0.797	0.989	0.992	0.981	0.976	1.000	
	(0.000)	(0.000)	(0.011)	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)		
Manufacture										
manufacture	0.333	0.261	0.263	0.246	0.265	0.275	0.242	0.227	0.261	1.000
	(0.317)	(0.439)	(0.434)	(0.467)	(0.431)	(0.413)	(0.473)	(0.502)	(0.438)	

Table 7: Summary of the variables for the 32 international corridors

Variable	Description	Type	Mean	Std deviation	Median	Min.	Max.
Transportation tariff							
tariff	Effective market tariff	Continuous	1,405.27	902.59	1,058.51	532	3,999
ln(*tariff*)	ln of the effective market tariff	Continuous	7.08	0.56	6.96	6.28	8.29
Linehaul cost drivers							
Distance							
distance	Total distance (km)	Continuous	756.14	289.68	831.21	297.06	1,477.29
Road conditions							
paved	Paved distance (km)	Continuous	507.8	285.31	435.99	19.37	1,136.18
unpaved	Unpaved distance (km)	Continuous	248.33	239.95	227.25	0	1,094
Somali risk perception							
high somali	High WFP risk perception	Categorical	4/32	–	–	–	–
not specified somali	No risk specified by the WFP for corridors ending in Somali	Categorical	12/32	–	–	–	–
not specified other	No risk specified by the WFP for corridors not ending in Somali	Categorical	16/32	–	–	–	–
Estimated tonnage							
high	High WFP estimation for tonnage to transport	Categorical	9/32	–	–	–	–
low	Low WFP estimation for tonnage to transport	Categorical	12/32	–	–	–	–
not specified	No estimated tonnage specified by the WFP in the RFQ	Categorical	11/32	–	–	–	–
Market structure							
Competition intensity							
ln(#*bids*)	ln of the number of bids	Continuous	2.79	0.46	2.91	1.95	3.26
Market dispersion							
bid dispersion	Standardized interquartile range	Continuous	0.22	0.15	0.17	0.09	0.63
Market concentration							
carrier destination	Number of active carrier at desdination	Discrete	57.78	21.17	62	12	82
hhi destination	Bid based Herfindahl-Hirschmann index at destination	Continuous	0.04	0.02	0.04	0.03	0,1
Socio-economics							
Demographic							
population destination	Population in the region of destination (1 unit = 10,000 people)	Discrete	979.59	893.56	443.91	34.28	2,715.85
Economic activities							
manufacture destination	Number of manufactures in the region of destination	Discrete	164.28	200.20	43	12	887
agriculture destination	Agricultural production at destination region (1 unit = 10,000 quintals)	Continuous	1,289.402	1,966.337	75.51	10.71	5,326.89
livestocks destination	Livestocks at destination region (1 unit = 10,000 animals)	Continuous	1,185.00	1,380.28	315.79	0	3,899.13

Table 8: Summary of the variables for the 731 domestic lanes

Variable	Description	Type	Mean	Std deviation	Median	Min.	Max.
Transportation tariff							
tariff	Effective market tariff	Continuous	1,138.84	844.63	900	40	3,950
ln(*tariff*)	ln of the effective market tariff	Continuous	6.69	0.95	6.80	3.69	8.28
Linehaul cost drivers							
Distance							
distance	Total distance (km)	Continuous	589.82	356.33	564.97	0	1,712
Road conditions							
poor	Poor road condition base on % unpaved	Categorical	171/731	–	–	–	–
intermediate	Intermediate road condition base on % unpaved	Categorical	170/731	–	–	–	–
good	Good road condition base on % unpaved	Categorical	184/731	–	–	–	–
unknown	Unknow road condition	Categorical	206/731	–	–	–	–
Somali risk perception							
high	High WFP risk perception in Somali region	Categorical	42/731	–	–	–	–
low	Low WFP risk perception in Somali region	Categorical	25/731	–	–	–	–
none	No risk identified by the WFP in Somali region	Categorical	35/731	–	–	–	–
not specified somali	No risk specified by the WFP in Somali region	Categorical	367/731	–	–	–	–
not specified other	No risk specified by the WFP for other regions than Somali	Indicator	262/731	–	–	–	–
Estimated tonnage							
high	High WFP estimation for tonnage to transport	Categorical	65/731	–	–	–	–
low	Low WFP estimation for tonnage to transport	Categorical	66/731	–	–	–	–
not specified	No estimated tonnage specified by the WFP in the RFQ	Categorical	600/731	–	–	–	–
Market structure							
Competition intensity							
ln(#*bids*)	ln of the number of bids	Continuous	2.45	0.74	2.56	1.1	4.03
Market dispersion							
bid dispersion	Standardized interquartile range	Continuous	0.4	0.22	0.34	0.02	1.34
Market concentration							
carrier origin	Number of active carrier at origin	Discrete	25.85	13.7	26	6	46
carrier destination	Number of active carrier at destination	Discrete	47.59	19.09	46	23	82
hhi origin	Bid based Herfindahl-Hirschmann index at origin	Continuous	0.08	0.06	0.05	0.03	0.22
hhi destination	Bid based Herfindahl-Hirschmann index at destination	Continuous	0.06	0.03	0.05	0.03	0.13
Socio-economics							
Demographic							
population origin	Population in the region of origin (1 unit = 10,000 people)	Continuous	1097.67	1,1019.39	443.92	34.28	2,715.85
population destination	Population in the region of destination (1 unit = 10,000 people)	Continuous	846.92	783.72	443.92	18.33	2,715.85
Economic activities							
Manufacturing activies							
manufacture origin	Number of manufactures in the region of origin	Continuous	181.09	210.66	44	12	887
manufacture destination	Number of manufactures in the region of destination	Continuous	121.87	172.64	12	8	887
Agricultural activies							
agriculture origin	Agricultural production at origin region (1 unit = 10,000 quintals)	Continuous	1,691.791	2,250.78	75.51	8.77	5,326.88
agriculture destination	Agricultural production at destination region (1 unit = 10,000 quintals)	Continuous	1,044.45	1,747.69	75.51	6.06	5,326.88
livestocks origin	Livestocks at origin region (1 unit = 10,000 animals)	Continuous	1,419.50	1,576.29	315.79	0	3,899.13
livestocks destination	Livestocks at destination region (1 unit = 10,000 animals)	Continuous	1,007.43	1,241.36	315.79	0	3,899.13

Table 9: Cross-correlation table for the international corridors ($n = 32$)

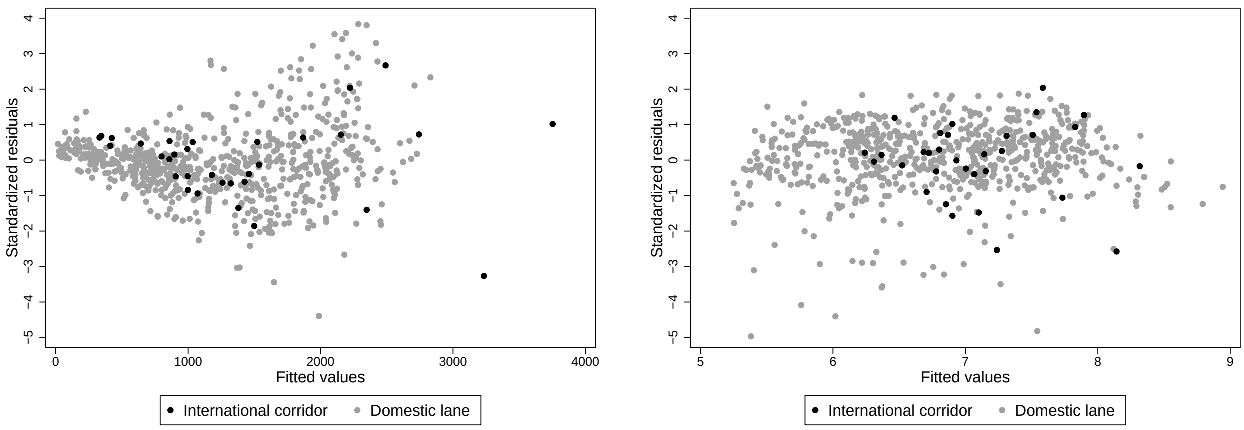
	Tariff	Cost driven			Market structure				Socio-economic			
Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Tariff												
1. ln(*tariff*)	1.000											
Cost driven												
2. *distance*	0.344	1.000										
	(0.054)											
3. *paved*	–0.207	0.652	1.000									
	(0.255)	(0.000)										
4. *unpaved*	0.662	0.432	–0.402	1.000								
	(0.000)	(0.013)	(0.023)									
Market structure												
5. ln(#*bids*)	–0.751	0.063	0.484	–0.500	1.000							
	(0.000)	(0.732)	(0.005)	(0.004)								
6. *bid dispersion*	0.499	0.094	–0.497	0.705	–0.648	1.000						
	(0.004)	(0.608)	(0.004)	(0.000)	(0.000)							
7. *carrier destination*	–0.344	–0.153	–0.006	–0.178	0.224	–0.236	1.000					
	(0.054)	(0.402)	(0.973)	(0.331)	(0.218)	(0.194)						
8. *hhi destination*		0.618	0.012	–0.473	0.577	–0.697	0.680	–0.735	1.000			
	(0.000)	(0.950)	(0.006)	(0.001)	(0.000)	(0.000)	(0.000)					
Socio-economic												
9. *population destination*	–0.327	0.305	0.521	–0.251	0.425	–0.319	0.240	–0.411	1.000			
	(0.067)	(0.089)	(0.002)	(0.167)	(0.015)	(0.075)	(0.185)	(0.019)				
10. *agriculture destination*	–0.340	0.195	0.456	–0.307	0.409	–0.321	0.187	–0.398	0.967	1.000		
	(0.057)	(0.285)	(0.009)	(0.087)	(0.020)	(0.073)	(0.305)	(0.024)	(0.000)			
11. *livestock destination*	–0.336	0.256	0.506	–0.292	0.435	–0.330	0.188	–0.408	0.986	0.992	1.000	
	(0.060)	(0.157)	(0.003)	(0.105)	(0.013)	(0.065)	(0.303)	(0.020)	(0.000)	(0.000)		
12. *manufacture destination*	–0.440	0.399	0.741	–0.400	0.599	–0.448	–0.058	–0.421	0.564	0.553	0.554	1.000
	(0.012)	(0.024)	(0.000)	(0.023)	(0.000)	(0.010)	(0.755)	(0.016)	(0.001)	(0.001)	(0.001)	

Table 10: Cross-correlation table for the domestic lanes ($n = 731$)

	Tariff	Cost driven	Market structure						Socio-economic							
Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Tariff																
1. ln(*tariff*)	1.000															
Cost driven																
2. *distance*	0.520	1.000														
	(0.000)															
Market structure																
3. ln(#*bids*)	–0.737	–0.170	1.000													
	(0.000)	(0.000)														
4. *bid dispersion*	–0.217	–0.193	–0.002	1.000												
	(0.000)	(0.000)	(0.954)													
5. *carriers origin*	–0.431	0.109	0.750	0.054	1.000											
	(0.000)	(0.003)	(0.000)	(0.147)												
6. *hhi origin*	0.452	–0.175	–0.781	–0.039	–0.878	1.000										
	(0.000)	(0.000)	(0.000)	(0.287)	(0.000)											
7. *carrier destination*	–0.444	0.028	0.532	–0.038	0.348	–0.425	1.000									
	(0.000)	(0.453)	(0.000)	(0.307)	(0.000)	(0.000)										
8. *hhi destination*	0.623	0.117	–0.745	0.097	–0.388	0.476	–0.774	1.000								
	(0.000)	(0.002)	(0.000)	(0.008)	(0.000)	(0.000)	(0.000)									
Socio-economic																
9. *population origin*	–0.264	0.113	0.411	–0.044	0.551	–0.447	0.304	–0.298	1.000							
	(0.000)	(0.002)	(0.000)	(0.233)	(0.000)	(0.000)	(0.000)	(0.000)								
10. *agriculture origin*	–0.275	0.126	0.435	–0.029	0.562	–0.492	0.307	–0.306	0.983	1.000						
	(0.000)	(0.001)	(0.000)	(0.437)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)							
11. *livestock origin*	–0.270	0.133	0.423	–0.036	0.546	–0.477	0.313	–0.312	0.992	0.996	1.000					
	(0.000)	(0.000)	(0.000)	(0.335)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
12. *manufacture origin*	–0.334	0.107	0.547	–0.047	0.641	–0.553	0.368	–0.377	0.560	0.564	0.551	1.000				
	(0.000)	(0.004)	(0.000)	(0.202)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
13. *population destination*	–0.439	–0.150	0.503	–0.038	0.259	–0.296	0.433	–0.516	0.231	0.226	0.234	0.264	1.000			
	(0.000)	(0.000)	(0.000)	(0.306)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)				
14. *agriculture destination*	–0.456	–0.136	0.524	–0.032	0.274	–0.318	0.394	–0.527	0.240	0.236	0.245	0.281	0.969	1.000		
	(0.000)	(0.000)	(0.000)	(0.383)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
15. *livestock destination*	–0.134	0.530	–0.039	0.277	–0.320	0.402	–0.536	0.242	0.238	0.246	0.283	0.984	0.994	1.000		
	(0.000)	(0.000)	(0.000)	(0.296)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)		
16. *manufacture destination*	–0.527	–0.148	0.605	–0.054	0.322	–0.377	0.359	–0.603	0.250	0.255	0.260	0.311	0.664	0.653	0.660	1.000
	(0.000)	(0.000)	(0.000)	(0.143)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	

8 Appendix 2: Heteroscedasticity

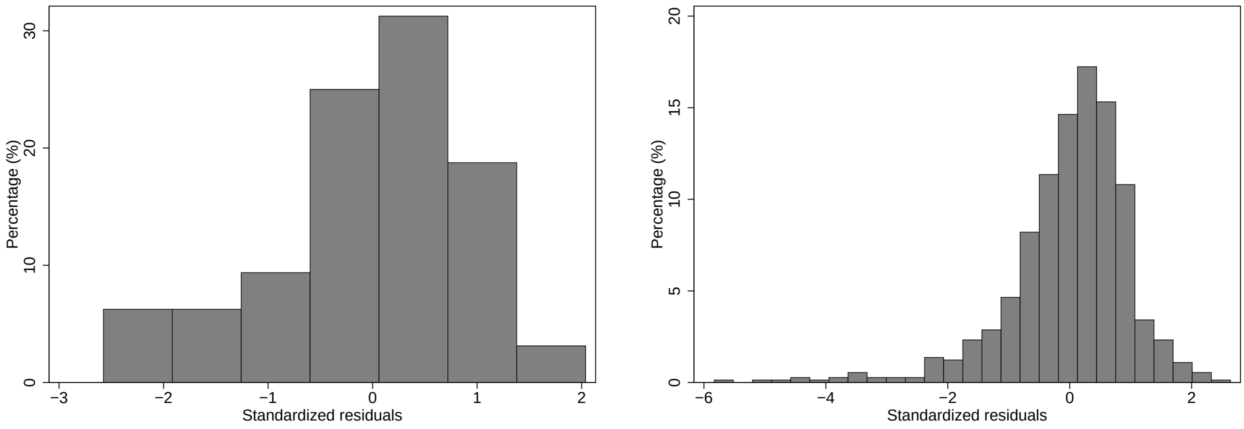
Heteroscedasticity occurs when the error terms from a regression model do not have constant variance, which can be detected by plotting the standardized residuals on the fitted values (Neter et al., 1996). Figure 11 shows the scatter plots of the standardized residuals obtained when regressing *tariff* and ln(*tariff*) on the cost driven and market structure variables. Comparing Figure 11a and Figure 11b, we observe that regressing *tariff* as opposed to ln(*tariff*) generates non-constant error terms (the absolute values of the standardized residuals increase whit the fitted value). Using ln(*tariff*) as a dependent variable into the regression models does not generate significant problem of heteroscedasticity as is the case for *tariff*. The same conclusion can be drawn for the models using the socio-economic variables as shown in Figure 13. To complete the analysis of the OLS assumptions, Figure 12 and Figure 14 show the histograms of the standardized residuals for Models 1.4 and 2.4 as well as for Models 1.6 and 2.6. We observe in these figures that the standardized residuals are close to being normally distributed.



(a) *tariff* as dependent variable.

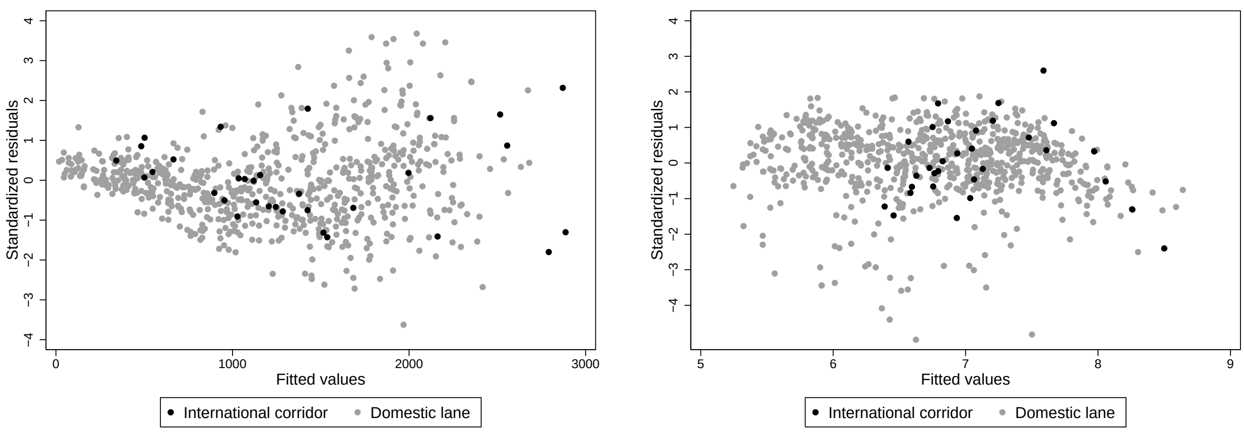
(b) ln(*tariff*) as dependent variable.

Figure 11: Scatter plots of standardized residuals on fitted values for models using the cost driven and market structure variables.



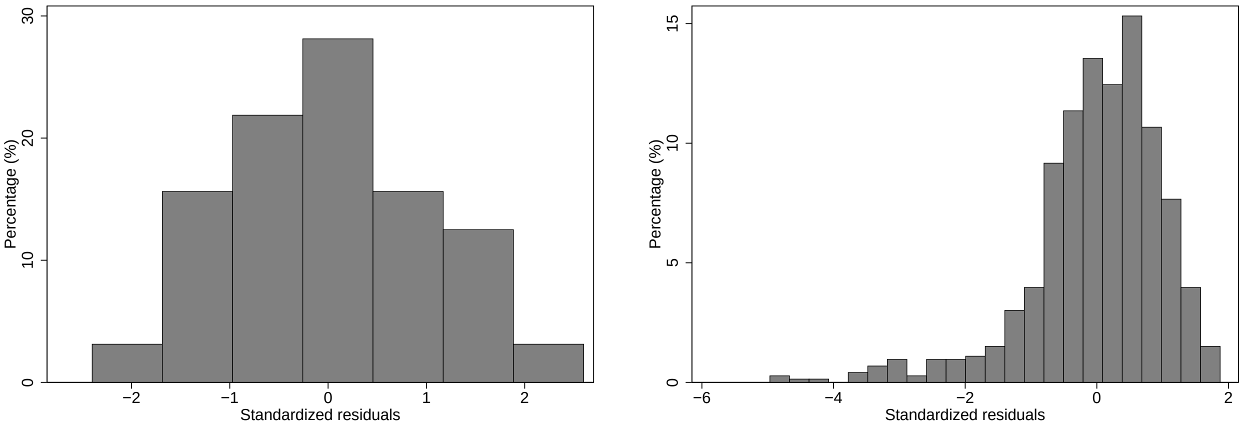
(a) International corridors (Model 1.4).   (b) Domestic lanes (Model 2.4).

Figure 12: Histograms of standardized residuals for models of ln(*tariff*) as the dependent variable using the cost driven and market structure variables.



(a) *tariff* as dependent variable.   (b) ln(*tariff*) as dependent variable.

Figure 13: Scatter plots of standardized residuals on fitted values for models using the cost driven and soci-economic variables.



(a) International corridors (Model 1.6).

(b) Domestic lanes (Model 2.6).

Figure 14: Histograms of standardized residuals for models of ln(*tariff*) as the dependent variable using the cost driven socio-economic variables.

9 Appendix 3: Regressions to explain bid values

Table 11 shows the specifications obtained when regressing the carrier bids on the cost driven factors, the market structure measures and by controlling for carrier specificities through indicator variables for the carriers.

Table 11: Bid regression models

VARIABLES[j]	(1) International ln(*bid*) (Birr/tonne)	(2) domestic ln(*bid*) (Birr/tonne)
Cost driven		
Distances		
paved (km)	0.000404***	
	(5.13e-05)	
unpaved (km)	0.000939***	
	(7.26e-05)	
distance (km)		0.00139***
		(1.62e-05)
Road conditions[k]		
poor		0.295***
		(0.0193)
intermediate		0.0436***
		(0.0131)
good		–0.146***
		(0.0106)
Risk perception[l]		
none		–0.0154
		(0.0241)
low		0.378***
		(0.0319)
high	0.610***	0.501***
	(0.0480)	(0.0262)
notspecified	0.0551	0.144***
	(0.0344)	(0.0131)
Tonnage estimates[m]		
low	–0.113***	–0.0929***
	(0.0302)	(0.0132)
high	–0.241***	–0.210***
	(0.0339)	(0.0155)
Market structure		
Competition intensity		
ln(#*bids*)	–0.744***	–0.388***
	(0.0429)	(0.0158)
Market dispersion		
bid dispersion	–0.682***	–0.443***
	(0.147)	(0.0225)
Market concentration		
carrier origin		0.00113*
		(0.000611)
carrier destination	–0.00341***	–0.00412***
	(0.000616)	(0.000295)
Constant	9.075***	7.537***
	(0.162)	(0.0463)
n	562	10,377
R-squared	0.852	0.772
Adj. R-squared	0.845	0.771
Max. VIF value	2.39	5.20

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

[j] Carrier indicator variables are also included in the models but not shown in Table 11.
[k] The category of reference is “unknown”
[l] The category of reference is “not specified” for regions other than Somali.
[m] The category of reference is “not specified”.

References

R. Azen and D.V. Budescu. The dominance analysis approach for comparing predictors in multiple regression. *Psychological Methods*, 8:129–148, 2003.

A. Bagchi, J.A. Paul, and M. Maloni. Improving bid efficiency for humanitarian food aid procurement. *International Journal of Production Economics*, 134:238–245, 2011.

C.F. Baum. *An Introduction to Modern Econometrics Using Stata*. Stata Press, Texas, 2006.

K. Behrens and P. M. Picard. Transportation, freight rates, and economic geography. *Journal of International Economics*, 85:280–291, 2011.

W. D. Berry and S. Feldman. *Multiple Regression in Practice*. 07-050. Sage Publications, Newbury Park, CA, 1985.

C. Caplice. *An Optimization Based Bidding Process: A New Framework for Shipper-Carrier Relationships*. PhD thesis, Massachusetts Institute of Technology, 1996.

C. Caplice. Electronic markets for truckload transportation. *Production and Operation Management*, 16(4):423–436, 2007.

C. Caplice and Y. Sheffi. Theory and prectice of optimization-based bidding for motor carrier' transportation services. *Journal of Business Logistics*, 24(2):109–128, 2003.

Central Statistical Agency of Ethiopia. Report on livestock and livestock characteristics. 2008.

Central Statistical Agency of Ethiopia. Agricultural sample survey. 2009.

Central Statistical Agency of Ethiopia. Report on large and medium scale manufacturing and electricity industry survey. 2010.

V. Chander and L. Shear. Humanitarian aid in less secure regions: An analysis of World Food Programme operations in the Somali region of Ethiopia. Master's thesis, Massachusetts Institute of Technology, 2009.

C. F. Daganzo. *Logistics Systems Analysis*. Springer-Verlag, Berlin, fourth edition, 2005.

X. Diao, A. Nin Pratt, M. Gautam, J. Keough, J. Chamberlin, L. You, D. Puetz, D.Resnick, and B. Yu. Growth options and poverty reduction in ethiopia, a spatial, economywide model analysis for 2004–15. Technical Report No. 20, International Food Policy Research Institute, Development Strategy and Governance Division, Washington, 2005.

W. Elmaghraby and P. Keskinocak. Combinatorial auctions in procurement. In H. Lee C. Billington, T. Harrison and J. Neale, editors, *The Practice of Supply Chain Management*, Norwell, MA, 2003. Kluwer.

Ö. Ergun, G. Kuyzu, and M.W.P. Savelsbergh. Bid price optimization for simultaneous truckload transportation procurement auctions. Technical report, H. Milton Stewart School of Industrial and Systems Engineering, Georgia Institute of Technology, 2007.

Ethiopia Central Statistical Agency and ICF Macro. *Ethiopia Demographic and Health Survey 2005.* ICF Macro, Calverton, United States, 2005.

Federal Democratic Republic of Ethiopia Population Census Commission. Summary and statistical report of the 2007 population and housing census. 2008.

C. T. Haan. *Statistical Methods in Hydrology, second edition.* Iowa State University Press, 2002.

O.C. Herfindahl. *Concentration in the Steel Industry.* PhD thesis, Columbia University, New York, 1950.

A.O. Hirschman. National power and the structure of foreign trade. Berkeley: University of California Press. 1945.

P.E. Kennedy. Estimation with correctly interpreted dummy variables in semilogarithmic equations. *American Economic Review*, 71:801, 1981.

K. Kirkeby. *Transportation: Commercial.* Standard & Poor's Industry Surveys, 2012.

C. Kunaka. Logistics in lagging regions. Technical report, The World Bank, 2011.

S. V. Lall, H. G. Wang, and T. Munthali. Explaining high transport costs within Malawi - bad roads or lack of trucking competition? *World Bank Policy Research Working Paper No. 5133*, 2009.

N. Limão and J. Venables. Infrastructure, geographical disadvantage, transport costs and trade. *The World Bank Economic Review*, 15:451–479, 2001.

S. C. Liu. Production cost analysis of road freight enterprise. *Journal of Highway and Transportation Research and Development*, 23(4):143–146, 2006.

Logistics Cluster. Mission statement, November 2012. URL http://www.logcluster.org/ops/som11a/ethiopia-general-logistics-and-planning-map.

Z. Ma, R.H. Kwon, and C.-G. Lee. A stochastic programming winner determination model for truckload procurement under shipment uncertainty. *Transportation Research Part E*, 46:49–60, 2010.

S. Nandiraju and A. Regan. Freight transportation electronic marketplaces: A survey of market clearing mechanisms exploration of important research issues. In *Proceedings of the 84th Annual Meeting of the Transportation Research Board*, 2008.

J. Neter, M.H. Kutner, W. Wasserman, and C. Nachtsheim. *Applied Linear Statistical Models*. McGraw Hill, Boston, fourth edition, 1996.

R. M. O'Brien. A caution regarding rules of thumb for variance inflation factors. *Quality and Quantity*, 41(5):673–690, 2007.

E. Özkaya, P. Keskinocak, and R. Weight V. R. Joseph. Estimating and benchmarking less-than-truckload market rates. *Transportation Research Part E*, 46:667–682, 2010.

P. O. Pedersen. Freight transport under globalisation and its impact on Africa. *Journal of Transport Geography*, 9:85–99, 2001.

A. Portugal-Perez and J. S. Wilson. Trade costs in Africa: barriers and opportunities for reform. *World Bank Policy Research Working Paper No. 4619*, 2008.

W. B. Powell, Y. Sheffi, K. S. Nickerson, K. Butterbaugh, and S. Atherton. Maximizing profits for North American van lines' truckload division: A new framework for pricing and operations. *Interfaces*, 18:21–41, 1988.

C. Rizet and J.L. Hine. A comparison of the costs and productivity of road freight transport in Africa and Pakistan. *Transport Reviews*, 13:151–165, 1993.

J.-P. Rodrigue, C. Comtois, and B. Slack. *The Geography of Transport Systems, second edition*. New York: Routledge, 2009.

S. R. Jara-Díaz and L. J. Basso. Transport cost functions, network expansion and economies of scope. *Transportation Research Part E*, 39:271–288, 2003.

T. Sandholm, S. Suri, A. Gilpin, and D. Levine. CABOB: A fast optimal algorithm for winner determination in combinatorial auctions. *Management Science*, 51(3):374–390, 2005.

Y. Sheffi. Combinatorial auctions in the procurement of transportation services. *Interfaces*, 34:245–252, 2004.

A. Skiba. Regional economies of scale in transportation and regional welfare. Technical Report 200705, University of Kansas, Department of Economics, 2007. URL `http://ideas.repec.org/p/kan/wpaper/200705.html`.

L. D. Smith, J. F. Campbell, and R. Mundy. Modeling net rates for expedited freight services. *Transportation Research Part E*, 43:2007, 2007.

S. Teravaninthorn and G. Raballand. *Transport Prices and Costs in Africa: A Review of the Main International Corridors*. The World Bank, Washington, 2010.

J. Trestrail, J.A. Paul, and M. Maloni. Improving bid pricing for humanitarian logistics. *International Journal of Physical Distribution & Logistics Management*, 39:428–441, 2009.

WFP. *Annual Report – Ethiopia*. 2011.

WFP. WFP activities in Ethiopia, February 2013. URL `http://www.wfp.org/countries/ethiopia/operations`.

WFP Ethiopia Country Team. *Joint Evaluation of the Effectiveness and Impact of the Enabling development Policy of the World Foof Programme – Ethiopia Case Study*, volume 1. December 2004.

World Food Programme. Mission statement, November 2012. URL `http://www.wfp.org/about/mission-statement`.