Modal Choice between Rail and Road Transportation

Evidence from Tanzania

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Abstract

Rail transport generally has the advantage for large-volume long-haul freight operations. The literature generally shows that shipping distance, costs, and reliability are among the most important determinants of people’s modal choice among road, rail, air, and coastal shipping transport. However, there is little evidence in Africa, although the region historically possesses significant rail assets. Currently, Africa’s rail transport faces intense competition against truck transportation. With firm-level data, this paper examines shippers’ modal choice in Tanzania. The traditional multinomial logit and McFadden’s choice models were estimated. The paper shows that rail prices and shipping distance and volume are important determinants of firms’ mode choice. The analysis also finds that the firms’ modal choice depends on the type of transactions. Rail transport is more often used for international trading purposes. Exporters and importers are key customers for restoring rail freight operations. Rail operating speed does not seem to have an unambiguous effect on firms’ modal selection.

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MODAL CHOICE BETWEEN RAIL AND ROAD TRANSPORTATION: EVIDENCE FROM TANZANIA

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I. INTRODUCTION

Rail transport generally has the advantage for large-volume long-haul freight operations. Because of the large amount of fixed costs required for rail infrastructure development, rail operations exhibit significant economies of scale. A practical norm is that 1 million net tons a year would be needed to justify economic viability of railways (World Bank 2010). By distance, railways can achieve good financial performance with an average haulage of more than 500-600 km (e.g., World Bank 2013; Llano et al. 2017). From the environmental point of view, railways also have an important advantage to foster sustainable transportation. In theory, railways are more than 50 percent greener than road transportation (Kopp et al., 2013). According to the global statistics, the rail sector accounts for only 3.6 percent of total transport emissions, while it contributes to over 8 percent of the total movements of passengers and goods over the world (IEA and UIC, 2015).

Railway carries 6.3 percent of the global passenger transport demand and 9 percent of the total freight demand (Table 1). For passenger movements, road transport is a dominant mode in many countries, except for some countries, such as China, India, Japan and the Russian Federation, where railway accounts for about 15-30 percent of the total passenger transport (Figure 1). In Africa, railway passenger transport is minimal.

On the other hand, railway has a more vital role to play in freight transportation. With navigation excluded, rail carries the same amount of freight as road does. In non-OECD countries, the demand for rail freight transport has been increasing in recent years, while developed countries have been experiencing more stable rail freight activities (Figure 2). The rail dependency varies across countries: While rail freight accounts for more than 30 percent in India and the United States, the modal share of rail freight in Japan is less than 1 percent. In the Russian Federation, the share exceeds 85 percent.
Table 1. Global transport modal share (%), 2012

| Mode      | Passenger (passenger-km) | Freight (ton-km) | Total (Transport unit) |
|-----------|--------------------------|------------------|-----------------------|
| Road      | 82.7                     | 8.8              | 31.3                  |
| Aviation  | 10.6                     | 0.7              | 3.7                   |
| Navigation| 0.3                      | 81.5             | 56.8                  |
| Rail      | 6.3                      | 9.0              | 8.2                   |

Source: IEA and UIC (2015)

Figure 1. Rail passenger transport (trillion pkm)

Figure 2. Rail freight transport (trillion tkm)

Source: IEA and UIC (2015)

Historically, Africa possesses important rail assets, however, intermodal competition has been becoming increasingly intense in recent years. At the end of 2008, there were 52 railways operating in 33 countries in Africa. The total rail network size is about 70,000 km, out of which some 55,000 km are currently operational, mainly transporting mining and agricultural products. Africa’s rail freight tariffs, which range from US$0.03 to US$0.06 per ton-km, are competitive against truck transportation (Table 2). However, the quality of rail services continues deteriorating, mainly because of lack of infrastructure maintenance. Many rail lines in Africa are more than 100 years old and lack resources for rehabilitation, falling into a vicious circle (e.g., Gwilliam, 2011).

Table 2. Road user costs and average rail tariff (US$/ton-km)

| Country/Region         | Company       | (a) Road | (b) Rail | (a)/(b) |
|------------------------|---------------|----------|----------|---------|
| Senegal-Mali           | Transrail     | 7.9      | 5.3      | 1.49    |
| Côte d'Ivoire-Burkina / Mali | Sitarail     | 7.9      | 5.5      | 1.44    |
| Cameroon–Chad          | Camrail       | 11.2     | 6.3      | 1.78    |
| Mozambique             | CCFB/CFM      | 10.0     | 5.5      | 1.82    |
| Tanzania-Great Lakes   | TRL           | 13.5     | 4.3      | 3.14    |

Source: World Bank (2013)
In the literature, transport mode choice has long been discussed not only from the transport planning point of view, but also from the trade and industrial development perspectives. There are a number of discrete choice models investigating people’s or firms’ modal choice decisions. For instance, Brooks et al. (2012) use a stated preference experiment to examine Australian shippers’ preferences among truck, rail and coastal shipping. It is shown that freight rates are important but transit time is also critical. Especially, rail transit time has a significant negative impact on shippers’ choice. In the revealed preference literature, it is shown that multinational firms are particularly sensitive to transport reliability and prefer air or maritime shipping to truck transportation in Southeast Asia (Hayakawa et al. 2013).

On the passenger side, McFadden (1974a and 1974b), Hensher (1986), and Hensher and Greene (2002) are among the most important studies on urban transport choice. The demand for public transportation, including bus and train, is often examined in relation to individual car use. A recent study shows that for long distance trips in Spain, transport costs are an important determinant of people’s modal choice. The rail cost elasticity is estimated at -0.442 in the multinomial logit setting (Gonzalez and Suarez, 2016). Agarwal and Koo (2016) show that the implementation of congestion toll rate adjustment, which is among the most innovative road pricing systems, increased public bus ridership by 12 to 20 percent in Singapore, though relying on a different estimation approach, i.e., difference-in-differences.

From the trade facilitation point of view, the gravity model is frequently used. For instance, Llano et al. (2017) estimate a gravity equation to examine the effect of intermodal competition on the freight flows on the road network across provinces in Spain. It is shown that road and railway can coexist and be positively associated for the segment of distance between 600 and 1,200 km, supporting the currently observed modal mix in Spain. The firm location literature also provides relevant insight on firms’ modal preferences. Firms are often found to be located along major highways (e.g., Holl, 2004; Chandra and Thompson, 2000). This is because reliable transport infrastructure is critical to improve firm productivity. For example, firm inventory is reduced with proximity to interstate highways in the United States.
Access to good port facilities is also essential for firms (Belderbos and Carree, 2002; Deichmann et al., 2005). There are only a few studies showing the impact of rail proximity. Banerjee et al. (2012) show the positive effect of rail infrastructure on local economies in China.

The current paper analyzes the modal choice made by firms in Tanzania. As discussed above, Africa has important rail infrastructure, of which the quality has been deteriorating in many countries. More and more shippers prefer using truck transportation, as the road network is improved in the region. However, certain companies are still taking advantage of rail transport. In the literature, there is little evidence on freight modal choice in Africa. This paper aims at casting light on the demand for rail freight in the region. With firm-level data collected from about 500 firms in Tanzania, the traditional discrete choice models are estimated.

The remaining sections are organized as follows: Section II provides an overview of recent developments in transport infrastructure in Tanzania. Section III develops our empirical models and describes data. Section IV presents main estimation results and discusses policy implications. Then Section V concludes.

**II. RECENT DEVELOPMENTS IN TRANSPORT INFRASTRUCTURE**

Tanzania is a large country with a land area of 885,800 km², where more than 55 million people live. Intercity connectivity is critical for the economy. While Dar es Salaam is the primary city, with an estimated population of 5.4 million, other secondary cities are also growing, such as Mwanza, Arusha, Dodoma, Morogoro and Mbeya. Each city is estimated to have a population close to 500,000. A number of firms are located in secondary cities and other small towns. According to the Central Register of Establishments, about 45,000 enterprises were formally registered by 2010 (Figure 3).
The firm concentration in Dar es Salaam seems to be accelerating. About 2,300 firms were newly created or formally registered in the three districts in Dar es Salaam in 2010 alone. Dar es Salaam accounts for about 25 percent of the total firms registered (Figure 4). Long distance transportation is of particular importance for firms located in inland areas to connect Dar es Salaam. Port access is also critical for many businesses that engage in international trading. Tanzania traditionally exports mining and agricultural products. The country also imports a lot of goods and equipment from abroad. The Port of Dar es Salaam is one of the largest hub ports in the region, which handled about 10.4 million tons in 2011, 13.1 million tons in 2013 and 15 million tons in 2015.

Tanzania has a relatively well developed road network composed of over 86,000 km of roads. The government spends approximately US$310 million for road development and maintenance every year. Regional and trunk roads managed by a national road agency,
Tanzania National Roads Agency (TANROADS), are generally well-maintained. About 12,000 km of roads are paved, of which half or 55 percent are maintained in good or fair condition. On the other hand, most rural roads remain unpaved, and nearly 90 percent are in poor or very poor condition.

Rail transport has the general advantage of long-haul freight transport. Tanzania has about 3,557 km of rail lines, which are operated by two rail companies: Tanzania Railways Limited (TRL) and Tanzania Zambia Railway Authority (TAZARA). The TRL lines were constructed during the colonial era in the early 20th century. The construction of the Central Railway was started in 1905, to Kigoma, a port town situated on Lake Tanganyika, which was reached in 1914 (e.g., Amin, Willetts and Matheson, 1986). The current TRL was established as a parastatal company jointly owned by Reli Assets Holding Company (RAHCO) on behalf of the Government of Tanzania (49 percent) and an Indian private operator RITES (51 percent) in 2007. However, the anticipated increase in performance under RITES management did not materialize.

Since the completion of negotiations in 2011, the company has fully been owned by the government.

The TRL network is based on a 1,000 mm narrow-gauge standard and extends more than 2,500 km, connecting Dar es Salaam and large inland cities, such as Mwanza, Kigoma and Arusha. These inland areas are more than 1,000 km away from the coast. Historically, rail transport has been playing an important role to provide affordable access to the global market to Tanzania, which is a large country with a land area of about 900,000 km².

TAZARA is another major rail line connecting Dar es Salaam to Mbeya and New Mposhi in Zambia. Unlike the TRL, which is primarily a national network with the ends of lines located at Dar es Salaam and Tanga on the Indican Ocean, Mwanza on Lake Victoria and Kigoma on Lake Tanganyika, TAZARA is a binational rail network, extending 1,860 km, with 975 km in Tanzania and 885 km in Zambia (Table 3). TAZARA is a statutory body established under

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1 Based on the TRL website and TRL (2014). TRL performance review: JTSR 2014.
TAZARA Act No.4 of 1995 (Repealed Act No.23 of 1975) and jointly owned by the two governments, Tanzania and Zambia, on 50:50 basis. Other neighboring countries, such as Malawi and Southern Democratic Republic of Congo, which are practically landlocked in the region, are also benefiting from the TAZARA lines. The network is based on the Cape Gauge with a width of 1,067 mm, a different standard from TRL. It is relatively new compared to the TRL lines. TAZARA was constructed in the 1970s. However, the rail infrastructure has already been in poor condition because of lack of proper maintenance. Recently, the two governments have agreed to take up responsibility of funding infrastructure maintenance, locomotives and wagons.2

Table 3. Tanzania: Rail networks (km)

|          | TRL  | TAZARA |          |
|----------|------|--------|----------|
| Central Line | 1,254 | Tanzania | 975      |
| Tanga Line | 437  | Zambia | 885      |
| Link Line | 188  |        |          |
| Mwanza Line | 378  |        |          |
| Mpanda Line | 210  |        |          |
| Singida Line | 115  |        |          |

Given the deterioration of the service quality as well as the improvement of road infrastructure along the regional corridors, the current freight volume hauled by the TRL represents only 13 percent of the peak demand in the early 2000s (Figure 5). Similarly, the traffic on TAZARA is only about 15 percent of its peak demand during the early 1990s (Figure 6). Despite the deteriorated service quality, some businesses and shippers are still using rail transport, mainly because of low relative costs compared with road transport. Rail tariffs have increased in U.S. dollar terms in recent years but are still lower than truck road user costs in Tanzania, which are US$0.05 to US$0.12 per ton-km, depending on road surface and condition (Figure 7).

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2 Tanzania Zambia Railway Authority. (2014). TAZARA performance review: JTSR 2014.
Although truck transportation accounts for the vast majority of freight shipment, some firms and shippers are still using railways, perhaps depending on location. Particularly, firms located in inland areas of central and western Tanzania may have an incentive to rely on rail transportation because it is cheap despite distance. Based on the network analysis in which unit road user costs and average rail tariffs are assumed, transport costs of moving one ton of goods to Dar es Salaam are estimated at about US$91 per ton from Mwanza and US$95 per ton from Kigoma, respectively (Figure 8). Rail transport presumably has the advantage to connect those areas from the cost perspective.

The advantage of rail freight is considered to be attributed fundamentally to the fact that unit rail tariffs are often set lower when the shipping distance is longer. For instance, the TRL
tariff for general goods is TSh1.5 million per large wagon for the first 100 km, which translates into about 61 U.S. cents per ton-km (Fig 9). But when the shipping distance is greater than 500 km, the tariff is TSh2.6 million per wagon, which is equivalent to about 11 U.S. cents per ton-km. The unit rate is even lower when the distance exceeds 1,000 km, i.e., TSh3.9 million per wagon or 8 U.S. cents per ton-km.

Such a pricing strategy is rational because loading and unloading goods from rail wagons incur significant fixed costs, especially when transported goods are uncontainerized bulk cargo. Waiting times that are required for each train to have sufficient wagons to carry may also add additional economic costs to shippers. Because of these fixed costs, short-haul rail shipping tends to be relatively expensive, and long-haul bulk shippers are more induced to use rail transportation. Although no detailed data are available, most rail cargo are large volumes, such as minerals, cement, agricultural products and fertilizer. According to the port statistics, at the Port of Dar es Salaam, wheat accounted for about 40 percent of total imports, followed by fertilizer, cement and rice (Fig 10). Similarly, wheat and fertilizer are among major commodities exported through the Port of Dar es Salaam.

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3 Average loaded weight per wagon is assumed to be 36.5 tons.

4 This is consistent with our survey data. See the following sections.
Figure 8. Transport costs to the port of Dar es Salaam

Source: Authors’ estimation

Figure 9. TRL average tariff by distance

Source: Ministry of Transport, Tanzania (2011).
III. EMPIRICAL MODEL AND DATA

To examine how firms choose transport modes, the traditional discrete choice model is considered: Firm $i$ chooses mode $m$ to carry out transaction $j$ if its indirect utility of this modal choice is greater than the utility of any other transportation mode:

$$U_{ij}^{(m)} > U_{ij}^{(t)} \quad \text{for } \forall t \neq m \quad (1)$$

In our analysis, there are only two modes: $m = \{\text{rail}, \text{road}\}$. There are four types of transactions: $j = \{\text{export}, \text{import}, \text{domestic sales}, \text{domestic input}\}$. Each firm can use different transport modes, depending on type of transaction. For instance, firms can use truck transport to purchase some inputs for production, while relying on rail transport for exporting products. It may depend on where their trading partners exist and what level of transport service is required. Note that a firm engages in at least one type of transaction but may not carry out all transactions.
As usual (e.g., McFadden 1974b), the utility is assumed to comprise a deterministic term, \( V \), and a random error \( \varepsilon: U_{ij}^{(m)} = V_{ij}^{(m)} + \varepsilon_{ij}^{(m)} \). When the error term is distributed according to the type I extreme value distribution, the probability that a firm chooses mode \( m \) is given by:

\[
\Pr(Y_{ij} = m) = \frac{\exp(V_{ij}^{(m)})}{1 + \sum_t \exp(V_{ij}^{(t)})}
\]

The following linear specification is assumed for the deterministic part:

\[
V_{ij}^{(m)} = \beta_0^{(m)} + X_{ij} \cdot \beta^{(m)}
\]

where \( X_{ij} \) contains firm- and transaction-specific characteristics.

Our data were collected by carrying out an enterprise survey in February to May 2016. The survey aimed at about 500 firms focused on light manufacturers and agribusinesses in major urban areas of 18 regions.\(^5\) Based on the customer databases of the two rail companies as well as with freight forwarders and clearing agents, firms were randomly selected in each major urban area. The subsample size was determined in proportion to the size of each city. In the survey, each firm was asked about not only its basic characteristics, such as year of establishment and ownership, but also its chosen transport mode and transport spending for each type of transaction.

As discussed above, only a small number of firms are currently directly using railway services for shipping their freights, because of the diminished rail operations and the poor quality of the services. In the current analysis, both direct and indirect rail users are considered as beneficiaries. Some are directly using rail services, and others have

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\(^5\) Arusha, Dar es Salaam, Dodoma, Iringa, Bukoba, Kigoma, Moshi, Babati, Musoma, Mbeya, Morogoro, Mwanza, Sumbawanga, Shinyanga, Singida, Songea, Tabora, and Tanga.
transactions with freight forwarders and clearing agents that are using rail transportation. In
our data, only 3 percent of firms are road users (Table 4). Relatively speaking, firms are more
likely to use rail transportation for exporting and importing purposes.

**Table 4. Modal choice by firms**

| Type of transaction | Road user | Rail user |
|---------------------|-----------|-----------|
| Domestic input      | 283       | 3         |
| Domestic sale       | 438       | 14        |
| Export              | 57        | 4         |
| Import              | 95        | 6         |

In the data, there are 165 pairs of firm location and their trading partners (Table 5). This is
based on the firm location by region. Technically, however, there is a more granular variation
because firm locations are geo-referenced and can be different within the same region. It is
clear that Dar es Salaam is the center of all business relationships in Tanzania. No matter
where firms are located, they tend to have some transactions with other companies in Dar es Salaam. The table also suggests that geographic proximity matters to businesses. Beside
within city transactions, there are a certain amount of freight movements between two close
locations, such as Mwanza and Kagera, and Arusha and Moshi/Kilimanjaro. From the global
point of view, there are international trade flows from almost all regions. This must generate
the demand for long-haul freight transportation.

Notably, these international shipments may not necessarily be handled at the Port of Dar es Salaam. There are several important regional border points, such as Rusumo, a border town
between Rwanda and Tanzania, and Tunduma, a border point between Tanzania and Zambia.
A border point can serve not only a direct neighbor but also other countries. For instance,
Rusumo is presumably passed when firms export something to or import from Rwanda,
Uganda and the Democratic Republic Congo (DRC).
### Table 5. Firm location and destination/origin pairs

| Destination or origin of shipment | Firm location: | Arusha | Dar es Salaam | Dodoma | Iringa | Kagera | Kilimanjaro | Manyara | Mara |
|----------------------------------|----------------|-------|---------------|--------|--------|--------|-------------|---------|------|
| Arusha                           |                | 2     | 6             | 1      | 1      | 0      | 0           | 12      | 1    | 0    |
| Bukoba                           |                | 0     | 1             | 0      | 0      | 3      | 0           | 0       | 0    | 0    |
| Dar es Salaam                    |                | 10    | 133           | 9      | 8      | 4      | 5           | 4       | 0    | 8    |
| Dodoma                           |                | 0     | 8             | 15     | 3      | 3      | 0           | 1       | 0    | 0    |
| Iringa                           |                | 2     | 4             | 2      | 19     | 0      | 0           | 3       | 0    | 0    |
| Lindi                            |                | 0     | 0             | 0      | 1      | 0      | 0           | 0       | 0    | 0    |
| Mbeya                            |                | 1     | 7             | 1      | 1      | 3      | 1           | 0       | 0    | 0    |
| Morogoro                         |                | 0     | 9             | 0      | 2      | 2      | 0           | 0       | 0    | 0    |
| Moshi                            |                | 6     | 0             | 0      | 0      | 0      | 0           | 0       | 18   | 1    |
| Mwanza                           |                | 8     | 22            | 1      | 0      | 10     | 1           | 0       | 0    | 5    |
| Shinyanga                        |                | 2     | 1             | 0      | 0      | 1      | 0           | 0       | 0    | 1    |
| Songea                           |                | 0     | 1             | 0      | 1      | 0      | 0           | 0       | 0    | 0    |
| Stone Town                       |                | 0     | 3             | 0      | 0      | 0      | 0           | 0       | 0    | 0    |
| Tabora                           |                | 1     | 2             | 1      | 0      | 1      | 0           | 0       | 0    | 0    |
| Congo, Dem. Rep.                |                | 0     | 11            | 0      | 0      | 0      | 0           | 0       | 0    | 0    |
| Dubai                            |                | 0     | 5             | 0      | 0      | 0      | 0           | 1       | 1    | 0    |
| Germany                          |                | 0     | 8             | 0      | 0      | 0      | 0           | 0       | 0    | 1    |
| India                            |                | 1     | 10            | 1      | 0      | 0      | 0           | 1       | 0    | 1    |
| Kenya                            |                | 4     | 8             | 1      | 2      | 0      | 0           | 1       | 3    | 1    |
| Malawi                           |                | 0     | 3             | 1      | 0      | 0      | 0           | 0       | 0    | 0    |
| Mozambique                       |                | 0     | 2             | 0      | 0      | 0      | 0           | 0       | 0    | 0    |
| Rwanda                           |                | 0     | 4             | 1      | 0      | 0      | 0           | 0       | 0    | 0    |
| UK                               |                | 2     | 6             | 1      | 0      | 0      | 0           | 0       | 0    | 0    |
| USA                              |                | 0     | 4             | 0      | 0      | 0      | 0           | 0       | 0    | 0    |
| Uganda                           |                | 0     | 5             | 0      | 0      | 2      | 0           | 1       | 0    | 0    |
| Zambia                           |                | 0     | 10            | 0      | 0      | 0      | 0           | 1       | 0    | 0    |
| Total                            |                | 39    | 273           | 35     | 40     | 27     | 6           | 43      | 6    | 17   |

| Destination or origin of shipment | Firm location: | Mbeya | Morogoro | Mwanza | Rukwa | Shinyanga | Singida | Songea | Tabora | Tanga | Total |
|----------------------------------|----------------|-------|----------|--------|-------|-----------|--------|--------|--------|-------|-------|
| Arusha                           |                | 0     | 1        | 1      | 0     | 1         | 0      | 1      | 0      | 1     | 0     | 27    |
| Bukoba                           |                | 0     | 0        | 3      | 0     | 0         | 0      | 0      | 0      | 0     | 0     | 7     |
| Dar es Salaam                    |                | 18    | 18       | 13     | 1     | 12        | 1      | 2      | 9      | 4     | 259   |
| Dodoma                           |                | 0     | 2        | 0      | 1     | 2         | 0      | 0      | 0      | 0     | 35    |
| Iringa                           |                | 2     | 4        | 0      | 1     | 1         | 1      | 0      | 1      | 0     | 40    |
| Lindi                            |                | 0     | 1        | 0      | 0     | 0         | 0      | 2      | 0      | 0     | 4     |
| Mbeya                            |                | 45    | 4        | 1      | 3     | 0         | 0      | 0      | 1      | 0     | 67    |
| Morogoro                         |                | 0     | 34       | 1      | 0     | 0         | 0      | 0      | 1      | 2     | 51    |
| Moshi                            |                | 0     | 0        | 0      | 1     | 0         | 0      | 2      | 0      | 0     | 28    |
| Mwanza                           |                | 0     | 0        | 49     | 0     | 3         | 0      | 0      | 3      | 0     | 102   |
| Shinyanga                        |                | 0     | 0        | 7      | 1     | 39        | 1      | 0      | 3      | 0     | 56    |
| Songea                           |                | 0     | 0        | 0      | 0     | 0         | 0      | 20     | 0      | 0     | 22    |
Summary statistics of our covariates are shown in Table 6. Transport prices paid by firms (denoted by \textit{PRICE}) could be defined in terms of firms’ transport spending per ton-km. Unfortunately, the quantity or volume of freight transported is not available in our data. Instead, our transport price variable is defined by the amount of transport spending divided by the value of shipment and distance from the origin or to the destination. While knowing the value of shipment may not matter to transport costs, this is the only available proxy. Firms spent on average TSh174 million or about US$80,000 to ship to transport inputs or outputs, of which the average value (\textit{VALU}) is TSh5.4 billion or US$2.4 million.

The distance between the surveyed firms and their business partners is on average 425 km but has a wide variation from several kilometers to over 2,300 km (denoted by \textit{DIST}). Note that this is only measured within Tanzania, up to the Port of Dar es Salaam or other border points.\textsuperscript{6} Maritime travel distance and road distance in other countries are ignored because the paper aims at focusing the firms’ choice between rail and road transport within Tanzania.

\textsuperscript{6} Three border points are taken into account: Rusumo, Kasumulu and Tunduma.
Average speed is defined by the distance divided by the number of days required for that shipment \((SPEED)\). It is further divided by 24 hours.\(^7\)

In our sample data, firms are highly heterogeneous.\(^8\) Firms vary considerably in terms of age, market orientation and ownership structure. Surveyed firms were established on average 14 years ago \((AGE)\). The survey also asked firms’ targeted markets: Global, national or local. The last two market orientations are represented by two dummy variables: \(NATN\) and \(LOCL\), while the global orientation is used as a baseline. The average share of foreign ownership is 12 percent \((FORN)\): Some firms are domestic, and others are fully owned by foreign investors (i.e., the share is 100 percent). More formally, rail users tend to be more foreign owned: Based on the firm-level data, the average foreign share is 20.2 percent among rail users (c.f., 6.1 percent among road users) (Table 7). This is consistent with the fact that rail users are more focused on the global market: The share of firms responding that their main markets are local (within their localities) is 85 percent among road users, while 32 percent of the rail users indicated their local orientation. Rail users are more focused on global and/or national markets.\(^9\) In our sample, rail users are also found relatively larger and more transport-intensive, meaning the share of transport spending in the total operating cost is high.

\(^{7}\) The speed variable defined in this way is obviously underestimated because the normal operating time of rail or truck transportation is less than 24 hours per day.

\(^{8}\) From an empirical point of view, the current sample frame may not be ideal because it is significantly unbalanced. It is not easy to identify clear rail transport users. Still, there is economic potential to (re)develop rail transportation in large countries, such as Tanzania. Thus, the current study was designed as a potential baseline for further surveys. As the government is investing in rail (and lake) transport infrastructure, the follow-up surveys are expected to show more visible impacts of improved rail transport.

\(^{9}\) While local market orientation is referred to mean that firms’ main product lines are targeted at their local areas, national market orientation indicates that firms are active in several locations in the country. Global market oriented firms involve significant amounts of international transactions.
Table 6. Summary statistics

| Variable                                      | Abb. | Obs. | Mean   | Std.Dev. | Min   | Max   |
|-----------------------------------------------|------|------|--------|----------|-------|-------|
| Dummy variable for rail freight users         | RAIL | 900  | 0.03   | 0.17     | 0.00  | 1.00  |
| Price paid per value-km (TSh) \(^1\)          | PRICE| 900  | 43.36  | 526.28   | 0.00  | 13231.41 |
| Distance (km)                                 | DIST | 900  | 425.70 | 491.87   | 0.00  | 2346.48 |
| Average speed (km/hour)                       | SPEED| 900  | 2.57   | 5.70     | 0.00  | 49.65 |
| Value of shipment (TSh billion)               | VALU | 900  | 5.42   | 54.71    | 0.00  | 900.00 |
| Age of firm                                   | AGE  | 900  | 14.68  | 12.88    | 1.00  | 82.00 |
| Education level attained by firm manager      | EDU  | 900  | 3.48   | 1.33     | 0.00  | 5.00  |
| interviewed (0: No education; 1: Primary; 2: Secondary; 3: Vocational; 4: Bachelor degrees; 5: Above) |     |      |        |          |       |       |
| Foreign ownership share (%)                   | FORN | 900  | 12.00  | 31.42    | 0.00  | 100.00 |
| Dummy for local market oriented firms         | LOCL | 900  | 0.80   | 0.40     | 0.00  | 1.00  |
| Dummy for national market oriented firms      | NATN | 900  | 0.64   | 0.48     | 0.00  | 1.00  |
| Dummy for import transactions                 | IMPT | 900  | 0.07   | 0.25     | 0.00  | 1.00  |
| Dummy for export transactions                 | EXPT | 900  | 0.11   | 0.32     | 0.00  | 1.00  |
| Memorandum items:                             |      |      |        |          |       |       |
| Transport spending (TSh billion)              |      | 900  | 0.17   | 2.40     | 0.00  | 70.00 |
| Transport cost estimate (US$ per ton)         | TC   |      |        |          |       |       |
| Alternative = Road                            |      | 911  | 29.78  | 34.84    | 0.00  | 181.74 |
| Alternative = Rail (and Road)                 |      | 911  | 27.66  | 31.48    | 0.00  | 143.78 |
| Transport time estimate (hours)               | HR   |      |        |          |       |       |
| Alternative = Road                            |      | 911  | 6.53   | 7.77     | 0.00  | 43.86 |
| Alternative = Rail (and Road)                 |      | 911  | 7.40   | 8.85     | 0.00  | 44.93 |

\(^1\) Multiplied by 100 for presentation purposes.

Table 7. Two-sample t test statistic tests between road and rail users

|                  | Road users |                  | Rail beneficiaries |                  | Difference | Coef. | Std. Err. |
|------------------|------------|------------------|--------------------|------------------|------------|-------|-----------|
|                  | Mean       | Std. Err.        | Mean               | Std. Err.        | Coef.      |       | Std. Err. |
| Foreign share (%)| 6.152      | (1.288)          | 20.294             | (9.220)          | -14.142    | (6.023)| **       |
| Market orientation dummy: | | | | | | | |
| Global market    | 0.131      | (0.019)          | 0.294              | (0.114)          | -0.163     | (0.086)| *        |
| National market  | 0.482      | (0.028)          | 0.882              | (0.081)          | -0.401     | (0.123)| ***      |
| Local market     | 0.857      | (0.019)          | 0.529              | (0.125)          | 0.327      | (0.090)| ***      |

IV. ESTIMATION RESULTS

Multinomial logit regression is performed: The results are shown in Table 8. Road transportation is used as a baseline. It is found that prices have a negative impact on rail use. The impact is statistically significant: When rail prices are higher, firms are less likely to
choose rail transportation, holding everything else constant. As expected, rail transport seems to have the advantage for long-haul shipments. The coefficient of $DIST$ is positive and significant. It is consistent with the fact that unit rail tariffs are often set lower when the shipping distance is longer, as described above. Thus, firms are more likely to use rail transport, as shipping distance becomes longer.

The results also indicate that the choice of transport modes depends on business purposes. By type of transaction, firms are most likely to use rail transport when they import something from abroad. The coefficient of $IMPT$ is significantly positive. This is plausible because the Port of Dar es Salaam is connected to TRL. On the other hand, $EXPT$ also has a positive but insignificant coefficient. These positive coefficients imply that other domestic shipments (which are used as a baseline) are more likely to be carried by truck transportation. This is also consistent with the current alignment of transport infrastructure. Railways primarily connect the western and eastern parts of the country. However, domestic business transactions can take place in all directions. Therefore, road transportation has advantage in this regard.

The negative coefficient of $LOCL$ is also consistent with this view: Firms focused on local markets do not use rail transportation. But when firms target the national market, they are more likely to take advantage of freight rail services. The coefficient of $NATN$ is found to be consistently positive. This is considered to have primarily captured the effect of rail use for firms in non-primary cities to do business with firms based in Dar es Salaam.
Table 8. Multinomial logit estimation

|      | Coef.    | Std. Err. | Coef.    | Std. Err. |
|------|----------|-----------|----------|-----------|
| PRICE| -0.2401  | (0.1294)  | -0.2780  | (0.1531)  |
| DIST | 0.0013   | (0.0003)  | 0.0011   | (0.0004)  |
| SPEED| 0.0008   | (0.0281)  | -0.0278  | (0.0392)  |
| VALU | 0.0009   | (0.0017)  | 0.0009   | (0.0017)  |
| AGE  | 0.0256   | (0.0148)  | 0.0246   | (0.0158)  |
| EDU  | -0.2059  | (0.1907)  | -0.2682  | (0.1951)  |
| FORN | -0.0018  | (0.0073)  | -0.0048  | (0.0077)  |
| LOCL | -1.3416  | (0.4322)  | -1.4015  | (0.4466)  |
| NATN | 2.3681   | (1.0838)  | 2.4656   | (1.0563)  |
| EXPT | 1.0120   | (0.7368)  | 1.1020   | (0.5150)  |
| IMPT | 1.1558   | (0.5510)  |          |           |
| Constant| -5.0436 | (1.1762)  | -4.9387  | (1.1806)  |

Observations: 900
Pseudo R squared: 0.2407
Wald chi: 53.31

The dependent variable is one if rail is selected. Robust standard errors are shown in parentheses. *, ** and *** indicate the statistical significance at 10, 5 and 1 percent, respectively.

There are two unexpected results in Table 8. First, the speed variable has a statistically insignificant coefficient. Although our speed variable may have a measurement flaw as discussed above, it is expected that the better quality of rail services (i.e., faster operating speed) would increase the probability of firms choosing rail transport. To examine sensitivity to functional forms, the quadratic form is assumed: The result is found to be unchanged (Table 9). Thus, the impact of operating speed of rail transport is inconclusive. Firms may or may not be motivated to use railways if their operating speed is increased. This does not mean that efficient rail operations would not be important. Given the current situation that many firms shifted from rail to road transport in recent years, it should be interpreted to mean that our data do not support firms’ particular preferences to shipment speed when they use rail transport.

Second, the shipment value variable is not significant in Table 8. Our expectation was that firms would use rail transport for large-volume shipments. Again, our variable is not ideal to measure this effect, because the value of shipment may not necessarily be the same as the tonnage of cargo. However, there must be a broad correlation between them. When the
quadratic form is assumed for VALU, it is found that the probability of using rail transport increases with the value of shipment in a concave fashion. Under this specification, it is suggested that large-volume shippers may prefer to use rail transportation. The other results remain unchanged. Price matters. In addition, traditional firms seem to have a tendency to ship goods by rail. The coefficient of AGE is positive and significant. New firms prefer to avoid rail transportation.

| Table 9. Multinomial logit estimation with quadratic forms assumed |
|---------------------------------------------------------------|
| **Coef.** | **Std. Err.** | **Coef.** | **Std. Err.** |
| PRICE | -0.2888 (0.1531) * | -0.2467 (0.1254) ** |
| DIST | 0.0012 (0.0004) *** | 0.0011 (0.0004) *** |
| SPEED | -0.0670 (0.1077) | -0.0254 (0.0404) |
| SPEED*SPEED | 0.0013 (0.0027) |
| VALU | 0.0008 (0.0017) | 0.0391 (0.0111) *** |
| VALU*VALU | -0.00007 (0.00002) *** |
| AGE | 0.0248 (0.0155) | 0.0312 (0.0142) ** |
| EDU | -0.2682 (0.1956) | -0.3715 (0.1944) * |
| FORN | -0.0050 (0.0079) | -0.0018 (0.0074) |
| LOCL | -1.3924 (0.4456) *** | -1.6044 (0.4629) *** |
| NATN | 2.4476 (1.0643) ** | 2.7482 (0.8679) *** |
| EXPT | 1.0846 (0.8135) | 1.2087 (0.7606) |
| IMPT | 1.2293 (0.5675) ** | 1.2018 (0.6011) ** |
| Constant | -4.8951 (1.2163) *** | -5.0455 (1.0208) *** |

The dependent variable is one if rail is selected. Robust standard errors are shown in parentheses. *, ** and *** indicate the statistical significance at 10, 5 and 1 percent, respectively.

To check robustness of the main results above, the alternative-specific conditional logit (McFadden’s choice) model is also performed. While all firm-specific characteristics are used as case-specific variables, two alternative-specific variables are created by using network analysis (as shown in Figure 8). Given the road network condition data as well as average road user costs and rail tariffs, transport costs (TC) and travel times (HR) are estimated by minimizing the total transport costs from a firm to the shipping destination.
These engineering estimates can be different between the following two scenarios: (i) only road transport is assumed, and (ii) both rail and road can be used. The second scenario is referred to as the modal choice of rail transportation. Technically, even if rail is selected, road transportation is also generally needed, for instance, to bring products to a close rail station. TC and HR include all rail and road segments along the optimal route. Not surprisingly, as shown at the bottom of Table 6, rail transport tends to have lower transport costs and greater travel times than road transportation.

The results turned out to be broadly unchanged. Transport costs have a negative effect on shippers’ mode choice: The coefficient of TC is negative and statistically significant (Table 10). Traditional firms are more likely to use rail services, holding everything else constant. Firms aimed at local markets do not use rail transportation, because their transport demand may be focused on short haul shipping. Rather, rail transport is more often used for international trading purposes. Both EXPT and IMPT have significantly positive coefficients.

| Table 10. Alternative specific conditional logit model estimation |
|---------------------------------------------------------------|
| Coef.  | Std. Err. | Coef.  | Std. Err. | Coef.  | Std. Err. |
|--------|-----------|--------|-----------|--------|-----------|
| Alternative-specific var.                                   |
| TC     | -0.0601   | (0.0202) | ***       | -0.0585 | (0.0193) | ***       |
| HR     | 0.1615    | (0.0999) | 0.1284    | (0.0925) |
| Case-specific var.                                         |
| VALU   | 0.0013    | (0.0017) | 0.0010    | (0.0018) | 0.0013    | (0.0017) |
| AGE    | 0.0301    | (0.0145) | 0.0250    | (0.0131) | *         | 0.0285    | (0.0137) | **       |
| EDU    | -0.2397   | (0.1815) | -0.2404   | (0.1784) | -0.2412   | (0.1814) |
| FORN   | -0.0060   | (0.0068) | -0.0051   | (0.0071) | -0.0052   | (0.0069) |
| LOCL   | -1.5714   | (0.4389) | ***       | -1.6600  | (0.4283) | ***       | -1.5595  | (0.4408) | ***       |
| NATN   | 2.7379    | (1.0919) | **        | 2.6759   | (1.0684) | **        | 2.7597   | (1.1077) | **       |
| EXPT   | 1.2485    | (0.6285) | **        | 1.0546   | (0.6503) | *         | 1.0467   | (0.6310) | *        |
| IMPT   | 1.1022    | (0.5021) | **        | 0.9479   | (0.4779) | **        | 0.9898   | (0.4736) | **       |
| Constant | -5.0917  | (1.1647) | ***       | -4.7861  | (1.1476) | ***       | -5.2182  | (1.2133) | ***       |
| Obs.    | 1822      | 1822    | 1822      |          |
| No. of cases | 911       | 911     | 911       |
| Wald chi | 79.62     | 65.46   | 88.08     |

The dependent variable is one if rail is selected. Robust standard errors are shown in parentheses. *, ** and *** indicate the statistical significance at 10, 5 and 1 percent, respectively.
V. CONCLUSION

Rail transport generally has the advantage for large-volume long-haul freight operations. It can be a cheaper and greener option than truck transportation. There are a number of studies analyzing people’s modal choice among road, rail, air and coastal shipping transport, particularly in the developed country context. It is often found that shipping distance, costs and reliability are among the most important determinants.

In the literature, however, there is little evidence investigating the modal preferences in Africa. The region possesses significant rail assets. However, many rail lines are currently not operational, falling into a vicious circle: Less and less shippers are using rail transport because the service reliability is low. Available resources for maintenance and investment are limited since the number of rail users is declining. Because of limited resources, the service quality continues deteriorating.

This paper examines the shippers’ modal choice in Tanzania with new firm-level data collected. The traditional multinomial logit and McFadden’s choice models were estimated. It is shown that rail prices and shipping distance are important determinants of firms’ transport mode choice. With higher rail prices, firms are less likely to choose rail transportation. In addition, firms are more likely to use rail transport, as shipping distance and volume become greater. This is consistent with a view that rail transport has the advantage for long-haul bulk shipments. Which transport mode is used depends on type of transport demand. Rail transport is often used for international trading purposes. Firms aimed at local markets may not need rail transportation. Operating speed does not seem to have an unambiguous effect influencing firms’ modal choice.

The policy implications are straightforward: In order to restore the demand for rail freight, it is crucial to maintain price competitiveness of rail services against truck transportation. Firms’ rail use is sensitive to prices. This is consistent with our companion paper (Iimi et al. 2017). Operational efficiency and reliability are of course important from a practical view.
But this may be able to be subordinated. Key customers that rail operators should particularly focus on include exporters and importers that engage in international trade. Rail transportation is especially preferred by these companies. It is important to meet the freight demand for their operations.


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