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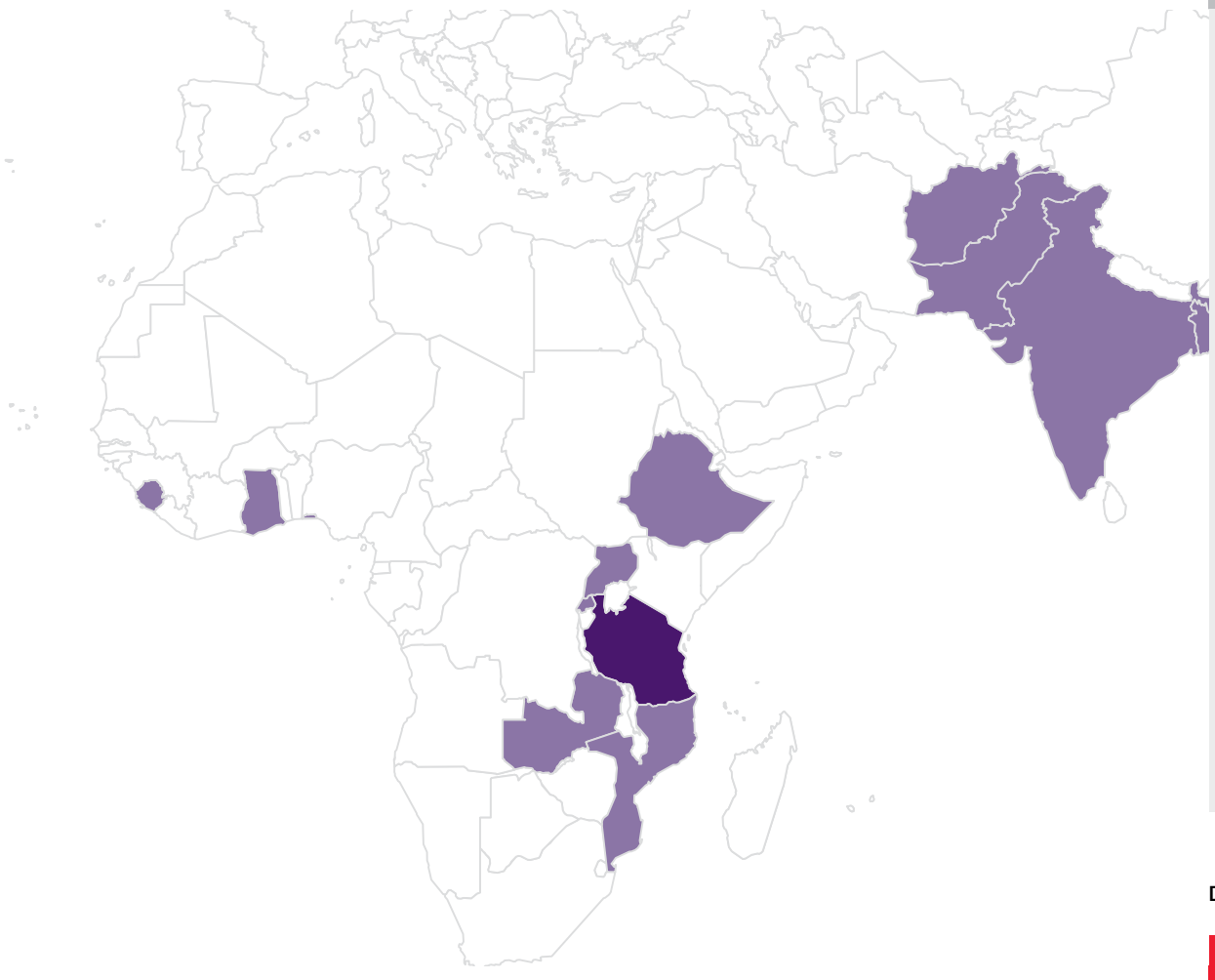

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1 The Context and Rationale

Kilimo Kwanza[1] emphasizes modernization and commercialization of agriculture, which entails improving current technology used, and access and participation of smallholder farmers in markets. However, market participation is not costless. Transaction costs exist in all market exchange, and high transport costs, which are an element of transaction costs[2], are a major deterrent for market participation of farmers in Africa, and they affect the price farmers receive[3] as well as their productivity (Hine and Ellis, 2001). This implies that a reduction in transaction costs can encourage smallholder farmers to participate in marketing of their produce. In addition, and potentially more important in the longer run, the increased prices may trigger the farmer to review his product portfolio in the light of these new opportunities. As such, indirectly, the reductions of inefficiencies along the marketing chain may lead to everlasting productivity gains through a reshuffle of the product portfolio of smallholder farmers that better exploits their comparative advantage.

In the Kilimo Kwanza initiative, improvement in transportation has been recognized as one of the tasks in the implementation framework, where improving the rail and road infrastructure is clearly mentioned. This study is a systematic review of evidence on the scale of transport costs that Tanzanian smallholder farmers face. Such a study is relevant as it will help to formulate policies to improve the incomes of smallholder farmers, as well as the prices that consumers eventually pay.

The agriculture sector is central to the Tanzanian economy. It provides substantial export earnings as well as income and employment to a large number of Tanzanians. Table 1.1 shows that agriculture's share in GDP averaged 28.5% between 2000 and 2006 compared to an average of 19.9% of industry and construction over the same period. In terms of export earnings, between 2001 and 2009, Tanzania's

[1] Officially launched in August 2009, by President Kikwete, Kilimo Kwanza was initiated by the Tanzania National Business Council. It is a private sector driven resolve to accelerate transformation of Tanzania's agriculture. The Kilimo Kwanza strategy outlines ten pillars that are important for its implementation. The ten pillars give details of specific tasks, activities, implementing partners, timeframes and budgets for its successful implementation (see http://www.tnbctz.com; accessed on March 12th 2011).

[2] Throughout the paper, we will frequently use the terms transaction costs, transportation costs and marketing margin, so it is a good idea to define these here. "Transaction costs" is a broad concept that refers to all costs, material or immaterial, that one faces engaging in the process of arbitrage." Transport costs" is much narrower (but often large as a share) and refers to the costs incurred by transporting the goods between locations. For example, it may be that the trader needs a short term loan to bridge the period between when he pays the farmer cash at the farm gate and when he gets the money from the wholesaler. The interest rate on this loan would qualify as a transaction cost, but would not be part of the transportation cost. Transaction costs may also be immaterial, for instance the opportunity time of waiting at a police checkpoint. As such, transaction costs are seen as more of a theoretical concept. One may argue that if trade of a certain good is legally prohibited, transaction costs are infinite. Finally, the term "marketing margin" is generally used as an operational concept. Depending on the context, it refers to the difference between seller price and buyer price (for instance farm gate price and consumer price) or the difference between the price of a homogenous commodity in two different locations.

[3] Research has shown that compared to Asia where transport costs are not as high, Asian farmers received between 70-85% of the final market price, while African farmers received only between 30-50% of the final market price. Most of the difference went to transport costs (Ahmed and Rustagi, 1987, quoted by Hine and Ellis, 2001).

traditional agricultural exports[4] contributed an average of 25% to total commodity export earnings (BOT, 2009). The average is of course lower than that from the previous decade where the contribution from traditional exports averaged 60%. Exports from minerals have in recent years overtaken the contribution of traditional exports.

In terms of labour absorption, the agriculture sector employed 82.1% and 76.5% of total employment in 2001 and 2006 respectively. Although the percentage has fallen somewhat, the sector is still a large employer of labour compared to industry which accounted for 2.6% and 4.2% of employment in the same years.

Table 1.1 Selected Indicators

	2000	2001	2002	2003	2004	2005	2006
Agriculture, Hunting and Forestry	29.5	29.0	28.6	28.7	29.5	27.6	26.5
Fishing	1.8	1.7	1.7	1.6	1.5	1.4	1.4
Industry and construction	17.9	18.0	19.6	21.0	20.8	20.8	21.0
Services	45.3	45.5	44.2	42.7	42.0	42.5	43.8
Employment in agriculture (% of total employment)	-	82.1	-	-	-	-	76.5
Employment in industry (% of total employment)	-	2.6	-	-	-	-	4.3

Source: National Bureau of Statistics (NBS) (2007); World Bank (2010), World Development Indicators CD-ROM.

While the importance of the agriculture sector to the Tanzanian economy in terms of export earnings and employment is undisputable, the level of income of smallholder farmers (the mode of producers engaged in the sector) is low. Table 1.2 shows that although the level of food and basic needs poverty in rural areas has fallen marginally over the years, it is still higher compared to urban areas.

Table 1.2 Poverty in Tanzania

	Year	Dar es Salaam	Other Urban areas	Rural areas	Mainland Tanzania
Food	1991/92	13.6	15.0	23.1	21.6
	2000/01	7.5	13.2	20.4	18.7
	2007	7.4	12.9	18.4	16.6
Basic Needs	1991/92	28.1	28.7	40.8	38.6
	2000/01	17.6	25.8	38.7	35.7
	2007	16.4	24.1	37.6	33.6

Source: NBS, (2009), Household Budget Survey 2007.

[4] Tanzania's traditional agricultural exports are coffee, cotton, sisal, tea, tobacco, cashew nuts and cloves.

Given that the majority of farmers who are the backbone of Tanzania's agriculture sector are smallholders, examining ways in which the agriculture sector can be developed can shed light on how the farmers' livelihoods can be improved. In fact, the launching of Kilimo Kwanza is timely and should help to arouse a renewed interest in research to examine ways in which Tanzania's agricultural sector can be revamped so that smallholder farmers can have higher incomes.

The rest of the paper is structured as follows; section two reviews literature on the importance of transport to agricultural development, and gives an overview of Tanzania's transport infrastructure. Section three analyses how transport costs affect marketing margins and pricing of agricultural crops, and it also presents a review of previous studies that have attempted to quantify transport costs in Tanzania. Section four is our attempt to estimate transaction costs. This is done using three different data sources.[5] First, to get an idea on how trade is organised at the local and the regional level, we did semi-structured interviews with some traders. Next, we use a survey of semi-subsistence farmers in rural Mufindi (Iringa Region) to look at farm-gate prices. Finally, we use price series data from different markets to estimate regional marketing margins. Section five summarizes the main findings.

[5] It is important to clarify the key terms used in this paper. Transaction costs are broadly defined as all costs related to the marketing of commodities. They include transport costs, profit earned, and costs of imperfect information (see Kähkönen and Leathers, 1999). Marketing margins refer to the difference between prices in different points in the marketing chain; for example, the difference between the price a farmers gets for a 100kg bag of maize and the price the retailer pays for the same bag of maize, called the farm-gate-retail margin. Marketing margins are determined by transaction cost, and a key part of transaction costs are transport costs.

2 Importance of Transport to Agriculture and the State of Tanzania's Infrastructure

Studies have shown that economic growth and transportation are closely linked. For example, a study in the United States indicated that areas that were linked by efficient roads and rail links dictated the movement of people and goods, and contributed to economic prosperity and expansion.[6] This is because efficient transport networks enable transportation of goods from where they are produced to markets, and it also helps the movement of people. Indeed, the railroad reduced transport costs, and hence allowed markets to be integrated. The integration of markets in turn led to regional specialisation in production, which increased efficiency and stimulated growth (Eichengreen, 1994).

Agricultural products are perishable, seasonal and bulky. As such, they need an efficient and reliable transport system to preserve their freshness and to take them to markets. Without a reliable transport system, agricultural products can easily rot. Besides transporting produce from farms, an efficient transport network is also instrumental in ensuring that farmers get the required inputs needed for their farm activities. Thus, transportation is crucial for both taking produce to markets and for obtaining required inputs for production.

Tanzania covers a big territory, with uneven distribution of population. In most cases, the urban areas are located far from the major agricultural producing areas. This means that transport costs remain a major component of food prices in the urban centres. The poor transport and logistics compounds the problem. For example Table 2.1 shows crops harvested that got stranded during harvest time from various regions in Tanzania. Although the study was done over two decades ago, it serves to show that an efficient and reliable transportation network is an imperative for ensuring that agricultural produce reach markets and is thus crucial for growth.

Table 2.1 Share of 1987-88 Harvest in Tanzania Stranded

Region	Crop Type (% Stranded)
Northeast Highlands	cotton (24%), coffee (38%), cardamon (13%)
Coastal Belt	food crops (13%), cash crops (35%)
Central and Western	cotton (89%), maize (13%), paddy (22%)
Southern Highlands	all crops purchased by Union (27%), paddy (80%)
Lake Victoria	cotton (50- 60%)

Source: Hine and Ellis (2001).

Table A1 in the appendix gives a few indicators on the state of transport for countries in Sub-Saharan Africa (SSA) for which data was available. It shows that Tanzania is among a few countries in SSA whose total road network per land area and percentage of roads that are paved is under 10% for both

[6] Although Fogel's 1964 work on *Railroads and American Economic Growth* disputed the thesis that railroads were indispensable as other modes of transport could have been developed (see Eichengreen, 1994), it however serves to show that transportation helps to connect production areas separated by vast land, and is instrumental to growth.

indicators. The indicators attest to Tanzania's need to increase its road network given that the country's land area is vast. There is also a significant issue of Tanzania's topography. Figure 1 in the appendix shows that Tanzania has a fairly dense network of dirt roads around the outer rim. However, much of the middle is empty, which results in the averages being pulled down.[7]

The indicators in Table A1 do not say anything about the quality of roads and rail infrastructure. However, it is public knowledge that in most developing countries, roads and rail networks are both inadequate and are of poor quality. This is basically the environment in which goods are transported and traded, which undoubtedly contributes to high transaction costs.

Table 2.2 gives the mean distances to key facilities in urban and rural areas. For example, in 2007 the mean distance to a market place in rural areas was 3.3 kilometres, compared to just 0.7 kilometres in other urban areas and 0.5 kilometres in Dar es Salaam. The longer mean distances that rural people face is evident for other facilities too. This implies that without an efficient transport system, rural people face higher costs of transportation and spend more time to travel between places. On a positive note though, Table 2.2 suggests that access and density in the rural areas is improving, albeit slowly.

Table 2.2 Mean Distance to Selected Social and Economic Facilities by Area (Km)

	Dar es Salaam			Other urban			Rural			Mainland Tanzania		
	91/92	00/01	07	91/92	00/01	07	91/92	00/01	07	91/92	00/01	07
Market place	0.8	0.6	0.5	1.0	0.5	0.7	5.3	3.5	3.3	4.4	2.9	2.5
Public transport	0.7	0.5	0.6	1.0	0.8	0.8	6.1	5.4	5.3	5.0	4.4	4.0
Milling machine	0.4	0.8	0.8	0.5	0.4	0.5	4.4	2.4	2.5	3.6	2.0	1.9
Primary co-op society	**	1.8	1.4	**	2.9	3.4	3.4	5.2	8.3	3.2	5.0	7.3
Bank	N/A	3.0	4.3	N/A	8.5	15.2	N/A	37.6	37.7	N/A	30.5	30.2

Source: NBS, (2009), Household Budget Survey 2007.

Transport is no doubt important in ensuring that agricultural areas that are separated by vast distances are connected and accessible, so that perishable goods reach markets on time. For Tanzania, this is of utmost important given that rural areas are the sources of agricultural products, and are currently not connected by good transport infrastructure. A good transport infrastructure also allows people to access social services that are important for their livelihood. Although distances to key facilities in rural areas are declining, they need to do so at a much faster pace.

[7] The population and agricultural concentration is along the following transport and development corridors; from Dar es Salaam going west to Dodoma, and northwest to Mwanza on Lake Victora, from Dar es Salaam going west and then southwest to Mbeya, from Dar es Salaam going north to Kilimanjaro, and from Mwanza to Kigoma on Lake Tanganyika (AICD, 2010).

3 Spatial Price Analysis and Margins in Agricultural Products in Tanzania – A Review of Previous Studies

The number of studies done on transport costs in Tanzania and their effects on marketing margins are few. In this section, we review these studies, as a first indication of effects of transport costs on marketing margins of agricultural products. The studies reviewed focus on determinants of marketing margins in agricultural markets, how competitive the markets are, and factors accounting for the high transaction costs in markets of agricultural products.

Marketing margins are determined by many factors, including transport costs and how efficient and competitive markets are. In the late 1990s, a study by Kähkönen and Leathers (1999) illustrated the extent to which marketing arrangements are efficient by looking at marketing margins in maize and cotton markets, as well as price differences across regional markets and farms. The study also provided evidence on how competitive maize markets are by the extent to which farmers decide to whom they sell their maize, and how the price of maize is determined. Their main finding was that markets for maize were becoming less efficient since liberalization of the marketing of maize. This conclusion was arrived at by examining how marketing margins had widened over time. They also found that there were large and volatile price differences across regions and farms, with the margin between retail and wholesale prices of maize from Iringa (one of the main suppliers of maize) to Dar es Salaam being consistently positive and increasing. The estimated farm-retail price margin between Iringa and Dar es Salaam was $18.92 per ton per 100km.[8]

Table A2 in the appendix gives wholesale, producer and retail price differences of maize between cities. The variability in prices is large; for example between Iringa and Dodoma, in a period of a year, the difference in wholesale prices was almost double. Producer prices differences are also large; within the southern highland, producer prices were double between Moinga and Mafinga. The difference in retail prices is not as large, although Dar es Salaam has the highest prices, perhaps reflecting high demand.

The study by Kähkönen and Leathers (1999) identified a number of factors accounting for high transaction costs, as being movement restrictions, infrastructural impediments, limited access to credit, lack of storage capacity, and contract enforcement problems. The infrastructural impediments identified are the transport infrastructure being inadequate, roads being impassable in the rainy season, and poor quality of roads. The impediments in infrastructure raise transportation costs and limit competition and the ability of farmers to enter in marketing of maize (p.66-67). When farmers are unable to enter markets, they become limited in selling their produce to buyers or traders who come to them who can afford the high costs of transport, or they simply choose to produce for their subsistence needs.

[8] The actual estimated farm-retail price margin from the Kähkönen and Leathers (1999) study is $0.950 per kilogram. We translate it to a broadly common way of reporting that we adopt in this paper (per ton per 100km). Since the distance between Dar es Salaam and Iringa is 502 kilometres, the farm-retail price margin is $18.92 per ton per 100 km (= (1000*0.950)/5.02).

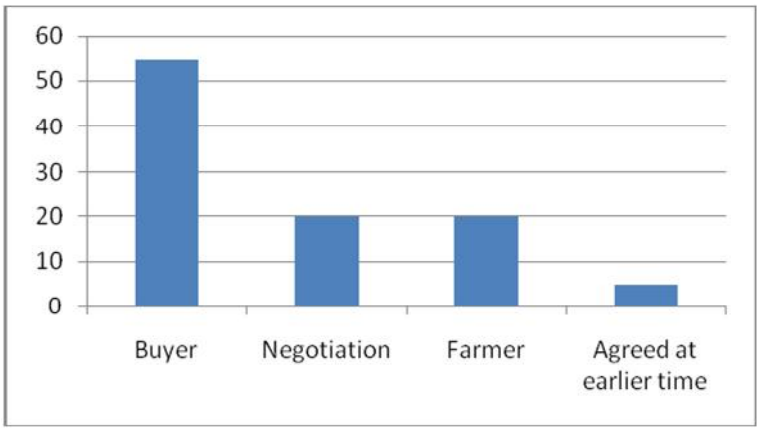
This is further supported by the study findings relating to how competitive maize marketing is. Figure 3.1 shows that while half of the farmers managed to get the best price, the other half were not able to get a competitive price for their maize because they sold to the only buyer they could find or they knew. Not having as many buyers as farmers would want implies that they sell to a few or perhaps just one buyer and hence they do not get the best price. Lack of sufficient buyers for their produce reflects the insufficient transport facilities to enable buyers to make the trip, or for farmers themselves to engage in transporting their own produce to markets where they can get a better price.

Figure 3.1 Percentage of Farmer and their Decision to Sell

Source: Kähkönen and Leathers (1999).

Infrastructural impediments can also manifest themselves in the way prices are determined. If transport costs are not substantial, farmers could afford to take their crops to markets that would guarantee them a good price. However, in the face of bad roads and high transport costs, farmers have no incentive to incur such high costs, and would simply wait for buyers to get to them. When buyers incur these costs, they are likely to offer low prices to farmers. Thus, in the end, high transport costs translate in farmers getting lower prices for their produce. Figure 3.2 shows that only 20% of the sampled farmers were able to negotiate a price for their maize.

Figure 3.2 Price Determination of Maize



Source: Kähkönen and Leathers (1999).

Another study by Eskola (2005) estimated the marketing margins along the national supply chain for various agricultural products. The estimates are given in Table A3 in the appendix. The marketing margins are much higher further along the supply chain, going as high as from 20% to 70% for an orange retailer, compared to grain whosalers, rice brokers and regional traders whose marketing margins do not go beyond 20%.The higher marketing margins along the supply chain is explained by the long supply chains. It is not surprising that brokers are used extensively, mainly to reduce transaction costs. The drawback of using brokers is that the supply chain becomes longer, which has implications on the time and money involved in trading (Eskola, 2005, p.19).

Although the study did not provide estimates of transport costs per product, it estimated the actual costs of transporting a truck from Dar es Salaam to all regions of Tanzania, and these estimates are given in Table A4 in the appendix. There is a high correlation between distance and cost of transportation, of 0.91. Of course distance is not the only component of cost; other factors such as quality of the road, cost of fuel (being higher the more remote the location is), and possibility of shipping something back from Dar es Salaam account for these costs (Eskola, 2005, p.25). The estimated costs (per ton per 100km) range from a low of $3.54 between Iringa and Dar es Salaam, to a high of $12.54 between Dar es Salaam and Mtwara. The high cost of transport between Dar es Salaam and Mtwara is explained by the poor condition of the road.

High transport costs do not just affect internal trade of agricultural crops. For countries like Tanzania it also affects exports of agricultural crops, making high transport costs a significant impediment to the competitiveness of exports. Kweka (2006) estimated both land and sea transport costs for fairly aggregated sectors. Table A5 in the appendix gives the estimated costs of domestic land costs of broad sectors relating to agricultural and non-agricultural products. Overall, Table A5 shows an increase in land freight rates across the sectors over the period. The land freight costs rose from about 4% to almost 7% between 1998 and 2002, attributed to an increase in rail freight rates in 2001.[9] The estimated international freight rates (not reproduced here) showed a slight decline between 1998 and 2002, attributed to a rise in competition following the liberalisation of the freight industry (Kweka, 2006). The downward trend is of course encouraging to the export sector, and it would be interesting to examine whether this trend has continued to go down.

Rapsomanikis and Karfakis (2007) used cointegration analysis on regional prices in Tanzania, with further examination of threshold effects in a number of well-connected and remote markets. Their study found no systematic pattern of the effect of transport costs on prices across Tanzania. A further test using linear cointegration hypothesis supported the hypothesis, suggesting that transport costs do not prevent arbitration and the transmission of price signals between markets. Both results are counterintuitive given the poor transport infrastructure in the country. This made them to further model the effect of transport costs on margins, since distance and high cost of transport is endemic to

[9] The freight rates are charges per unit value obtained from the Tanzania Railway Corporation. To get estimates for the total costs, data on technical coefficients for the transport and communication services as a share of output of each sector was obtained from the 1992 input-output table. A price index for the freight cost was then computed for each good. The rate of change got from the price index was then used to update the freight rate per value to get an estimate of the *ad valorem* freight rate for each year (see Kweka, 2006).

developing countries. They did this by spatial price analysis, which involved isolating variables that determine the farm-gate-market price spread. For example, distance from either the market or that covered by the trade, the per unit cost of transport, number of traders, and specific household or trader characteristics. They employed the approach on maize, beans, coffee and banana prices. They found support for the fact that wholesale farm-gate price margins are affected by transport infrastructure, distance, as well as by the competitive conduct of traders. However, the study did not measure the exact extent of the margin.

Besides affecting competitiveness, high transport costs affect margins in that traders offer low prices to farmers, while consumers face high retail prices. Morrissey and Leyaro (2007) estimated the magnitude of marketing margins of cash crops, food crops, and staple foods. Table A6 in the appendix shows estimates of the marketing margins, and it shows that food crops (rice and maize) in general have higher marketing margins owing to them being traded in the national markets, specifically in Dar es Salaam, where they compete with imports. The marketing margins for cash crops have declined since the early 1990s, but are still high at 10%. Cash crops are exported, with local consumption consisting of a small percentage that is processed. The marketing margin on staple foods (cassava and bananas) is small, owing to them being traded close to where they are produced, and as such transport costs are not a key factor in pricing them.

In a more recent study of asymmetries in price transmission in maize marketing in Tanzania, Mduma and Kipsat (2009) investigated maize prices in six regional markets (Dar es Salaam, Arusha, Mwanza, Songea, Mbeya, and Sumbawanga). When there is asymmetry in the transmission of prices, it means that correlations between prices in spatial locations differ depending on the direction of changes in prices, whether down or up. Asymmetry in price transmission can indicate inefficiencies in marketing, and it can be caused by trade restrictions, transaction costs, market power, different adjustment costs faced by producers depending on whether prices are rising or falling, and the perishable nature of products (see Rapsomanikis et al, 2003; Agra CEAS Consulting, 2007). Understanding asymmetry in price transmission is useful in informing policymakers when to make the right intervention (Mduma and Kipsat, 2009).

The study by Mduma and Kipsat (2009) used monthly data covering the period from January 1997 to April 2005, and Dar es Salaam was taken as the basis of comparison, given that it is the largest maize consumer market. They found that there was significant asymmetry in the transmission of price signals, with the correlations for upward movement of prices being stronger than those for downward movement of prices. In general, geographical distance and communication network explained the co-movement of the pairs of prices. For example, the strongest correlation was found between Dar es Salaam and Arusha, and the weakest correlations between Dar es Salaam and Sumbawanga, and Dar es Salaam and Songea. This is explained by the close proximity of Dar es Salaam and Arusha, and the remote locations of Sumbawanga and Songea. Geographical distance could not however explain the weaker correlation that was found between Dar es Salaam and Mbeya compared to that between Dar es Salaam and Mwanza. The explanation in this case lies in the better communication network between Dar es Salaam and Mwanza.

The following can be drawn from the studies reviewed in this section; transport costs affect the marketing margins of agricultural products. The marketing margins are higher as more brokers are used in the supply chain, the less competitive the markets are, the poorer the condition of the road, and the higher the cost of fuel. Transport costs to different regional centres are determined by the condition of the road and distance. The more remote the area and the poorer the condition of the road, the higher the transport cost per ton per 100km. Marketing margins also vary across types of agricultural products. Foods crops that are traded in national markets such as rice and maize have higher marketing margins than staples that are traded locally, such as bananas and cassava. Transport costs also affect international trade, although competition and liberalisation in the freight industry helped to reduce freight rates. While research found that freight rates fell marginally between 1998 and 2002, it is important that their reduction is further encouraged to enhance trade. The condition of roads and proximity of locations are also important in price transmission, which is crucial for policy intervention.

4 Transaction Costs in Tanzania

In this section, we try to come up with our own estimates of transaction costs in Tanzania. To do so, we have used three different data sources. The first source of information came from traders. We organized semi-structured interviews with a total of 12 traders. This gave us an idea of how the maize trade was organised. The second source of information came from semi-subsistence farmers. We surveyed 1134 households on their maize and beans marketing behaviour over one agricultural year and compared the prices they get with prices in consumer markets from different sources. Third, we used price series data from different regional markets to estimate transaction costs in regional trade.

4.1 Traders perspective

We organized individual semi-structured interviews with 12 traders, all located in the Mufindi District, Iringa Region, Tanzania. Most of the traders were small-scale traders, operating at the village level. We also interviewed 3 wholesale traders that link the small-scale traders to the regional market system (see Section 4.3). The small-scale traders were sampled in the same villages as the ones we used in the survey (see Section 4.2). The wholesale traders were located in the terminal markets for these villages (Makambako and Mafinga). The interviews were conducted in October 2010. At that time, the exchange rate was about Tsh.1498 for a dollar.

The survey area, the district of Mufindi, has 133 registered villages. Mufindi has an estimated population of about 320,000, with a population density of 45 inhabitants per square kilometre. The dominant tribe in the district is the Hehe tribe. The staple food of the Wahehe is maize, which they mill and then use to cook porridge (*ugali*). The two most important minority tribes in the region are immigrants from Njombe (the Wabena) and Makete (the Wakinga). The district can be divided into three agro-ecological zones: the highlands (between 1,700 and 2,200 metres), the middle zone (generally referred to as the Mufindi plateau, between 1,700 and 2,000 metres) and the low plateau (between 1,200 and 1,500 metres). The four villages sampled are situated on the Mufindi plateau. This plateau is characterized by gently rolling hills, with wide ridges and valleys. It has low inherent soil fertility, but reasonable physical characteristics. Average rainfall is between 900 and 1,200 millimetres per year. The average temperature is between 20 and 25 degrees Celsius. The district's capital is Mafinga, which lies along the main road connecting Dar es Salaam to Zambia and Malawi. Makambako lies along the same road, about 70 kilometres west of Mafinga.

In general, most of the traders we interviewed traded in maize. Some also traded in beans in addition to maize. Traders give different reasons why they started a business in maize trade, and not something else. One of the reasons given is that maize is a common product in the region and hence the traders have experience with it. Often, they cultivate it themselves or have been cultivating it in the past. The fact that it can be stored was also a reason, as well as the fact that it is not easily destroyed (compared for instance to tomatoes). Also, it was mentioned that it is easily available in the village, considering that maize is a staple that is consumed by all villagers. This also means that it is easily sold. It was also

mentioned that the buyers of maize (often wholesale traders) are very reliable. Lastly, some traders also engage in maize trade because it requires relatively little capital.

Most of the traders engage in trade in several neighbouring villages, apart from their own village. They mostly buy directly from farmers, but sometimes they buy themselves from even smaller traders. The trader we interviewed in Ikongosi sells to Mr. Sanga, who is a wholesaler located in Mafinga market. He then sells further to small traders who sell to Mafinga residents in Mafinga market. Other similar wholesalers were identified by other traders, namely Mr. Kukudesanga in Makambako. This trader used to be a middleman who bought from villages himself and sold to wholesale traders at Makambako. However, after some time, he built up a reputation and small traders started to collect maize and bring it to him. Local traders not only sell to maize traders, but also to processors. Processors mentioned where IB Sembe, DC Sembe and Saadani Super Sembe. These processors mill the maize and repackage it.

The way in which a transaction materializes differs by trader. For instance, the trader in Ikongosi first communicates with farmers to see if they are ready to sell. He then compares prices quoted by the farmers to the prices in terminal markets. He then looks for a person that he can trust to go and look at the maize. If quantity, quality and price are as agreed, this person gets back to the trader and gets money to collect the maize. All this is done by bicycle. Another trader narrated that he is known by the farmers, and as such, farmers contact him (by phone, and through friends and family). Yet another farmer notes that farmers are in urgent need of money after harvesting and inform him that they have maize for sale. He then goes to check the quality and quantity himself. He then sends someone to collect the maize. He states that the price is always dictated by him. For all the checking, this trader uses a motorbike, which he rents at about 5 dollar per day. In general, traders mention that sometimes the entire transaction is done over phone. If farmers have no phone, the trader will go and check himself. Big traders mainly work through mobile phones.

The quality of maize is judged by the colour, the weight and the hardness of the maize kernels. Before loading, the kernels are spread on a mat in the farmer's house, to check if there is not too much dirt and stones in the maize. Traders do not pay the agreed price if the quality is poor. They will either take it back or renegotiate the price. Grading is also facilitated by the fact that traders often employ people to pick up the maize who know what quality the trader wants. It is also argued that the farmers know themselves what quality they are expected to deliver. Traders who buy repeatedly from the same farmers also know what quality they can expect.

With respect to the quantity, there seems to be little room for disagreement. The standard measure for maize is a *debe* or tin[10]. These days, *debes* are available everywhere, and both the trader and farmer will have one with them when they make a transaction. This to avoid that traders use *debe*s that are larger than the standard (rumour has it that some traders fill their *debe* with hot sand, which makes the *debe,* that is made of plastic, expand) or that farmers use *debe* that are smaller than the standard (by cutting a small piece diagonally from the side of the *debe* and then carefully reattaching it). Traders come with

[10]A *debe* is a 20 litre bucket, which amounts to about 18 to 19kg of maize. Maize is collected and transported in bags. The number of *debe* per bag varies, but a standard bag would have 7 *debe* and weigh +/-130kg.

empty bags and fill the bag. Generally, a bag costs about Tsh.700 (about 50 cents) and it costs about Tsh.100 (0.06 US$) in terms of labour to fill a bag.

Hauling maize within the village is done by bicycles. Once there is enough maize, either pick-ups or trucks are used to take the maize to a regional market. Sometimes a truck picks up maize in several villages, and the cost is shared. We have also heard of a trader that uses an ox-cart within the village. Buses are seldom used, only if there are very few bags to be transported. It was mentioned that because of the poor state of the roads, truck owners ask significant fees, and the fees increase if roads get poorer during the rainy season. None of the traders we interviewed owned trucks; transportation is provided by a third party. Unfortunately, we did not get estimates for these services from the traders directly. However, we did include some questions on access to transport from farmers in the survey. While this is likely to overestimate the cost, it gives us at least some idea of the relative costs. Table 4.1 gives estimates from the different villages to the two market centres for different modes of transport.

Table 4.1 Estimated Costs of Different Means of Transport

	Cost (US$) from village to MAFINGA						
	IBWANZI	IKONGOSI	IPILIMO	KWATWANGA	MTAMBULA	MTILI	NUNDWE
Distance:	75 km	25 k	?	?	?	20 km	42 km
motorbike	13.58	4.40	16.47	16.65	15.15	5.56	9.89
sedan	40.98	11.91	38.90	40.07	37.10	13.30	19.79
pickup	60.79	23.55	54.21	43.89	52.94	23.68	32.96
lorry	103.14	42.89	91.23	58.49	70.69	39.74	61.89
	Cost in (US$) from village to MAKAMBAKO						
	IBWANZI	IKONGOSI	IPILIMO	KWATWANGA	MTAMBULA	MTILI	NUNDWE
Distance	?	?	35 km	86km	47 km	?	?
Motorbike	23.85	11.01	9.45	14.80	11.87	12.18	18.82
Sedan	78.38	25.71	23.91	32.61	27.93	32.96	38.95
pickup	99.12	44.60	39.12	38.25	40.36	53.20	73.55
lorry	152.40	69.98	60.97	56.61	56.34	87.00	113.99

Note: entries are average cost reported by farmers to rent a vehicle to go to the market centre. Data come from the farmer survey (see section 4.2) carried out in august 2008. The exchange rate at that time was 1157.5.

Insurance does not exist, either at the village or regional level. The primary reason mentioned for the absence of insurance was that the capital involved is too low. Furthermore, traders report limited knowledge on (the existence of) insurance instruments. Any loss incurred is borne by the traders themselves. Losses do happen from time to time. One wholesaler from Makambako reported that one night his watchman failed to turn up. That night, everything was stolen out of his storage facility.

The amount of hired labour involved in the maize trade is minimal. Persons that collect the maize at village level get about Tsh.400 (25 cents) per bag collected. If they work hard, they can get 4 bags a day. For bagging, loading and offloading, traders also hire workers.

Capital is provided out or the traders' own pocket. Some people use savings. One trader indicated he used sell tea, and after he saved Tsh.70000 (about 45 US$), he started trading in maize. Another village level trader inherited an ox-cart, which he lends to other villagers. The villagers paid him with maize. As such, he rolled into the business. Most of the village level traders reported that there is no need for loans, because of the relatively small amounts involved.

The two regional traders we interviewed did get loans. One got a loan of Tsh.8,000,000 (US$5340) from Mufindi Community Bank (MuCoBa), a micro finance service provider based in Mafinga town. He reported paying 24% interest on this loan. This wholesaler is also a processor. The wholesaler from Makambako got a loan from Tsh.3,000,000 (about US$2000) from a Rotating Savings and Credit Association (ROSCA)-type trading group. He did not have to pay interest.

The physical capital owned by small scale traders was little. Some reported a bicycle, some empty bags, sewing needles and *debes*. These traders store the maize in their houses. Big traders also sometimes own milling machines and storage structures. Table 4.2 gives the estimates of transaction cost made by the traders.

Table 4.2 Estimated transport costs by traders (per ton in US$)

From	To	Distance	Farm-gate price (FG)	Transport cost (TC)	TC as percentage of FG price (%)
Mtambula	Makambako	47 km	126	15	12.2
Mtambula	Mafinga	?	126	15	12.2
Ipilimo	Makambako	35 km	133	15	11.6
Ibwanzi	Mafinga	75 km	144	15	10.7
Ikongosi	Mafinga	25 km	126	13	10.2
Nundwe	Mafinga	42 km	144	13	8.9

Note: semi-structured interviews with traders, October 2010. The exchange rate was about 1$=Tsh.1498. Care is needed when interpreting distance. Some of these trade routes involve mainly tarred roads (eg. Mtambula – Mafinga), while others are all dirt or gravel roads (eg. Ibwanzi – Mafinga).

In the rest of this subsection, we discuss some factors that were reported to be key aspects of successful trade. We bring these issues together in more or less broader themes and also add some quotes from the traders themselves.

Competition

"When I pay more money than other buyers, I can buy more maize" - Chelestino Mhumba (Ikongosi Village, 13/10/2010)

"When there are no other traders in the area, it is easy to get a good price and more maize" - Masumbuko Lyanzile (Ipilimo Village, 9/10/2010)

"When we have various buyers [at the terminal market] is when the price becomes good" - Esko Idd Mtoya (Ibwanzi Village, 11/10/2010)

Competition between middlemen at the village level seems to be healthy. Maize buying at the village level does not seem to suffer from monopsony tendencies. In most villages, traders report that there are several other agents who are engaged in the "business of buying up maize". The numbers of competitors range from 5 in Mtambula to more than 20 in Ikongosi. While the majority of buyers are from within the village, traders from other villages or even towns are allowed in the villages. Traders from outside the village are required to report to the village government first, where they usually have to reveal the price at which they are willing to buy the commodity. We did not learn of any disputes between buyers from within the village versus buyers from outside the village. There are different reasons why there are many traders in these villages. One of the main reasons mentioned is that entering the market does not require huge amounts of capital

Market conditions

"When farmers need money for school fees, etc., I can buy much and sometimes at cheap prices" - Kanuti Lutego (Ipilimo Village, 9/10/2010)

"If at the market there is a shortage of maize [at the terminal market], I make profit because I decide on the price of maize" - George Chengula (Makambako, 15/10/2010)

"If I get information on good prices and if I have stocked maize, I make good business" - Titho Kabonge (Nundwe Village, 14/10/2010)

Local demand conditions, both in the village and at the terminal market, provide the reference prices for the traders. From the buyer's point of view, traders report to make more profit when there is sufficient supply of maize in the villages. This is often the case immediately after the harvest or in periods when large sums of money are needed (for instance, when school fees have to be paid). From the seller's point of view, traders report that they can dictate (higher) prices if there is a shortage of maize in the terminal market. Note that market conditions are closely related to competition, as excess supply at the local level and excess demand at the terminal market may be the result of insufficient middlemen.

Information

"When farmers have no information on the price of maize in other villages, I can get maize at cheaper prices. That is when I make good business" - Kanuti Lutego (Ipilimo Village, 9/10/2010)

"If farmers do not know the price where I am selling, I can make more profit" - Method Nyondo (Mtambula Village, 9/10/2010)

Price information seems to be very important for traders. It was mentioned as a key determinant of profits by 5 of the 12 traders interviewed. Price information is relevant for both buying and selling maize. Traders report higher margins are possible if the farmers do not know the current reference

prices (eg. price in terminal markets, and prices offered by other traders). In other words, middlemen do seem to exploit information advantages if they have it. In addition, price information is also important when selling the maize. It enables traders to maximize returns on both spatial and inter-temporal (see also market conditions above) arbitrage.

Taxes

"If I don't pay local taxes on the way to the market is when I make profit"- Masumbuko Lyanzile (Ipilimo Village, 9/10/2010)

Traders usually have to pay taxes to the local government, and these have also been reported as critical determinants on the profits they can make. The official tax rates reported by the Tanzanian Revenue Authority are 4% for residents and 15% for non-residents for overland transport (http://www.tanzania.go.tz/tra.html). However, in reality, the rates differ from village to village. In our fieldwork, they range from Tsh.500 (about 33 cents) to Tsh.1500 (about 1 US$) per bag. Traders should get an official receipt upon paying taxes, which they should be able to show at potential checkpoints along the road to the terminal market. Some traders try to avoid these taxes by leaving the village unnoticed, but this may undermine future relationships with the local tax authorities. What also happens often is that traders pay local taxes without requiring a receipt. This is a mutually beneficial arrangement for both the tax receiver and tax payer (as the receiver just puts this in his pocket and the tax payer gets a reduced rate). But then there is still the possibility that the trader gets caught further down the road, possibly incurring an additional fine. In sum, the decision to pay local taxes or not seems to be a complex optimization problem involving the tax rate, the probability of being caught at different checkpoints, future interactions with tax authorities and the expected amount needed to bribe officials at the village and/or different checkpoints.

Trust

"I make good business if I get maize at a cheap price. To achieve this, I must go to the farmers with cash in hand and go house to house. In so doing, farmers are willing to sell maize as they are sure money is paid on the spot" - Kilindapi Mahenge (Mtambula Village, 9/10/2010)

"When I have no money but still the farmer gives maize on loan, that is when I make business"- Esko Idd Mtoya (Ibwanzi Village, 10/10/2010)

Some farmers also mentioned that trust was important for a successful business in maize trade. Lots of traders deal with the same farmers year after year. As was mentioned before, this means that there is a mutual understanding on the quality of maize that should be delivered.

Quality control

"If I make follow up of the farmers on the quality of maize, this is when I get higher profit"- Midano Oneza (Mafinga, 16/10/2010)

While the quality of maize seems to be relatively easy to check, some traders did mention that following up on the farmers could improve the maize.

In sum, the trader survey reveals that transport costs vary between around 0.2US$ and 0.5US$ per km per metric ton. Hired labour and own capital used in local trade is minimal. Competition at the village levels seems good, with lots of agents of agents engaged in maize trade. The market conditions also seem favourable, with frequent transactions going on throughout the year. Traders do sometimes seem to exploit the price information advantage when dealing with farmers. Local taxes are reported to be an important impediment to trade. There are also some minor issues with respect to trust and quality control, but these are often reduced by frequent personal interactions between the different parties.

4.2 Smallholder farmers perspectives

In August 2008, a purposely designed survey to better understand marketing behaviour of smallholder farmers in the Mufindi District, Tanzania, was carried out, as part of a broader research project (Lecoutere et al. (2010); D'Exelle et al. (2010)). While the main focus was on maize, detailed information on production and marketing of beans was also collected. We can use the difference between prices received by the farmer and the price in the terminal markets to infer transaction costs on a local level.

Mufindi District, which is located in Iringa region, was chosen because of the importance of maize in the production system of the farmers. Iringa region, and especially Mufindi, is a main maize production area that supplies the rest of Tanzania, as well as Malawi and Zambia (see also Kähkönen and Leathers (1999)). Within the region, we chose 7 villages. These villages were selected to maximize distance to terminal market (Mafinga, the district capital) and agro-climatic conditions. Within each village, we randomly selected households *pro rata* the size of each village. In total, we interviewed 1134 farmers at their homes. The breakdown of respondents by village is given in Table 4.3.

The first striking feature is that few farmers seem to participate in the market in terms of maize or beans sales. For maize, only 38 percent of the interviewed farmers report having sold once or more during the previous year. While all farmers produce maize, 12 percent of the framers did not grow beans. Of the ones who did, only 36 percent report sales transaction(s) over the last 12 months.

Table 4.3 Villages and Number of Respondents

VILLAGE	NUMBER OF RESPONDENTS
IBWANZI	189
IKONGOSI	143
IPILIMO	157
KWATWANGA	169
MTAMBULA	166
MTILI	161
NUNDWE	149

Disregarding all households that did not participate by selling to the market, we recorded a total of 493 separate maize transactions and 384 beans transactions. So another interesting finding is that most farmers opt to sell everything at once instead of selling smaller quantities at different points in time. There is only one farmer that reports 5 separate maize transactions during the last year. For beans, virtually everybody reports only one occasion where they sell. Given the high variation of prices over the course of an agricultural year (see below), and the associated price risk, it seems strange that farmers do not spread price risk by selling at different points in time. One possible explanation may be that farmers are limited to only a few selling opportunities (eg., traders only visit the village once a year). Another reason may be that, in the absence of consumer credit, farmers are obliged to sell everything at once to meet urgent expenditures.

The above contrasts with high variability in the amounts marketed by the farmers: while mean sales of maize is about 462.5kg, the standard deviation is as high as 450kg. There is even one farmer who reports a single transaction of more than 8 tons! Even when we discard some potential outliers at the upper end of the distribution, we remain with standard deviations that far exceed the mean. For beans, the average transaction is just over 76kg, but also with a significant standard deviation (about 100kg).

Before we turn to the most interesting aspect of smallholder maize marketing, the prices, let us briefly look at the timing of harvests and sales. Figure 4.1 gives 4 basic bar charts, and cover one agricultural year for maize. The first panel (a) reports the timing of the maize harvest. As can be seen, most farmers harvest in August or September. From April to July, we also observe a gradual onset in maize harvesting. While most of this can be accounted for by differences in the agro-climatic conditions (for instance, in Kwatwanga, which lies in a hotter and dryer area, 85 percent of farmers harvest before August), this may also suggest some farmers harvest their maize prematurely.

The second panel (b) reports timing of sales transactions. As can be seen, the bulk of transactions take place immediately after the harvest, mainly between September and December. The high variability in the amounts sold by the farmers is illustrated in panel (c). The last panel (d) presents a bar plot of the total number of *debes* sold. The highest total quantities are recorded in November and December with slightly less than 2000 *debe*, which amounts to 37 tons.

Figure 4.1 Bar Charts for Maize

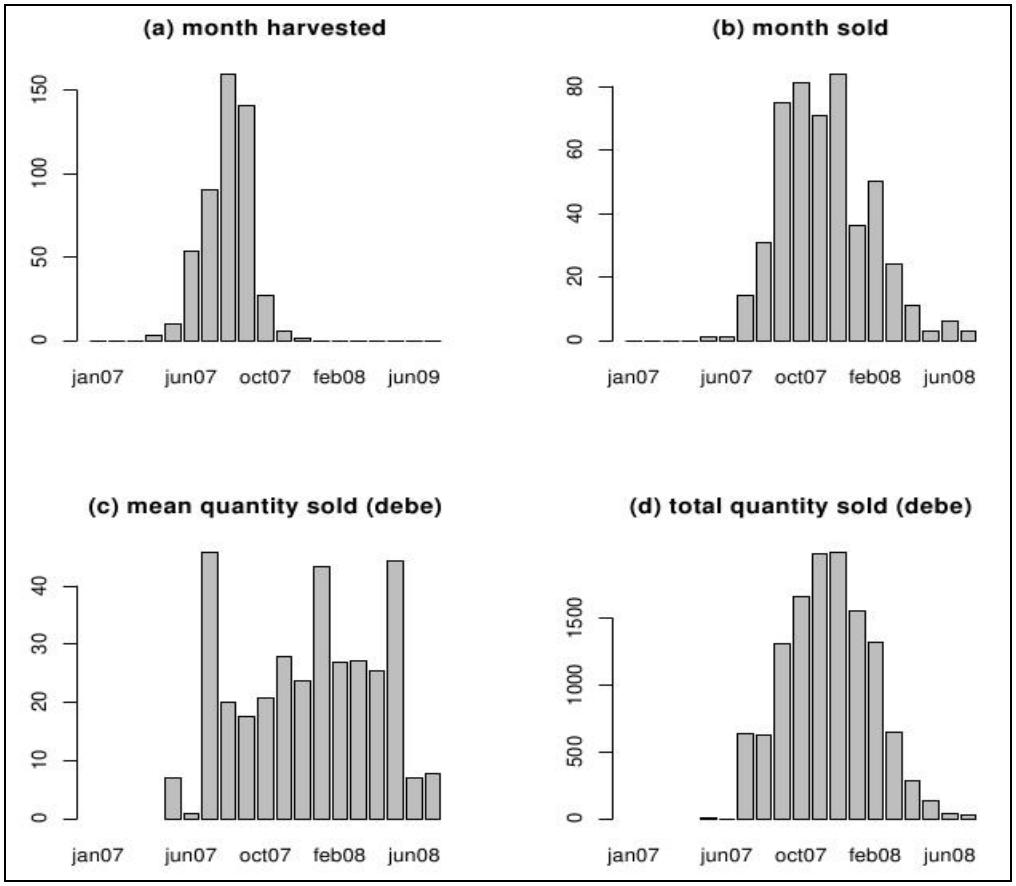
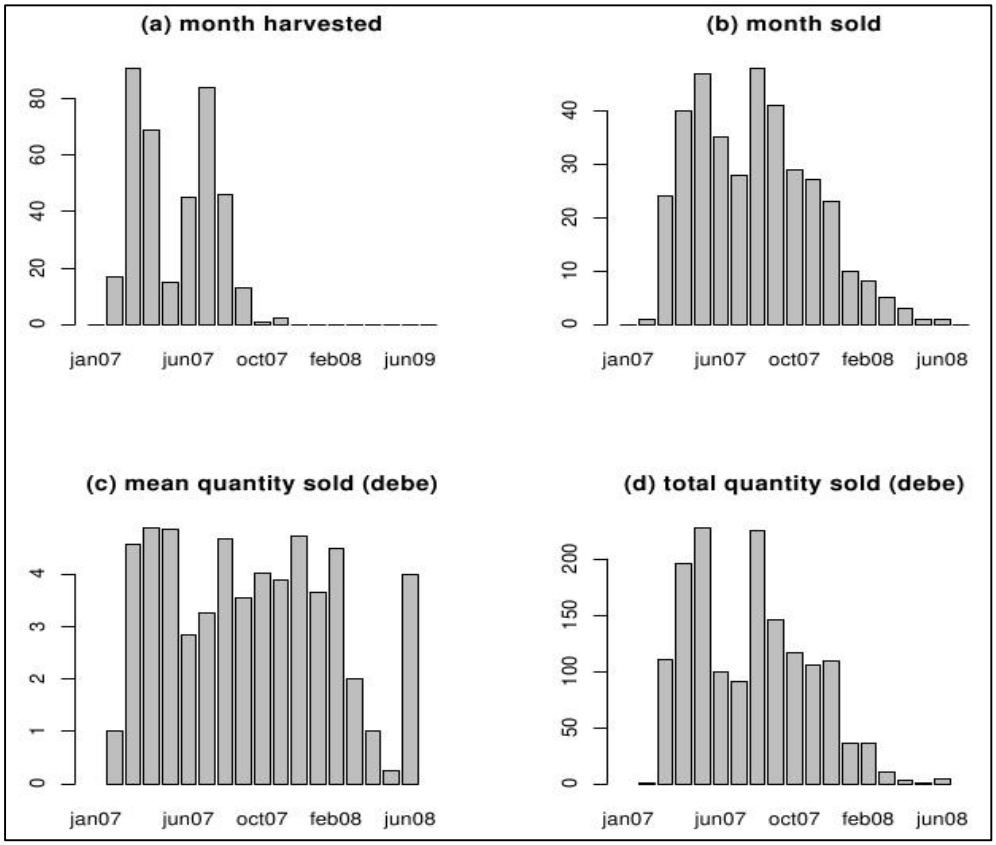


Figure 4.2 repeats the same 4 bar charts from Figure 4.1, but now for beans. An interesting feature here is the bimodal distribution of harvesting time. Main harvesting months for beans are March and July. These differences appear to be related to agro-climatic conditions as well, as three villages clearly have an early harvest (Ipilimo, Kwatwanga and Mtambula). These three villages are all in the western part of Mufindi District. Panel (b) shows the timing of sales of beans transactions. It seems to be more diffuse than sales of maize. Furthermore, the bimodal nature of the timing of harvest is reflected in the timing of sales, which points to the possibility that timing of sales is more determined by timing of harvest then price levels. Panel (c) shows the high variability in average quantities sold over the course of an agricultural year, while total quantity marketed in panel (d) again mimics the bimodal distribution of the timing of the beans harvest.

Figure 4.2 Basic Bar Charts for Beans

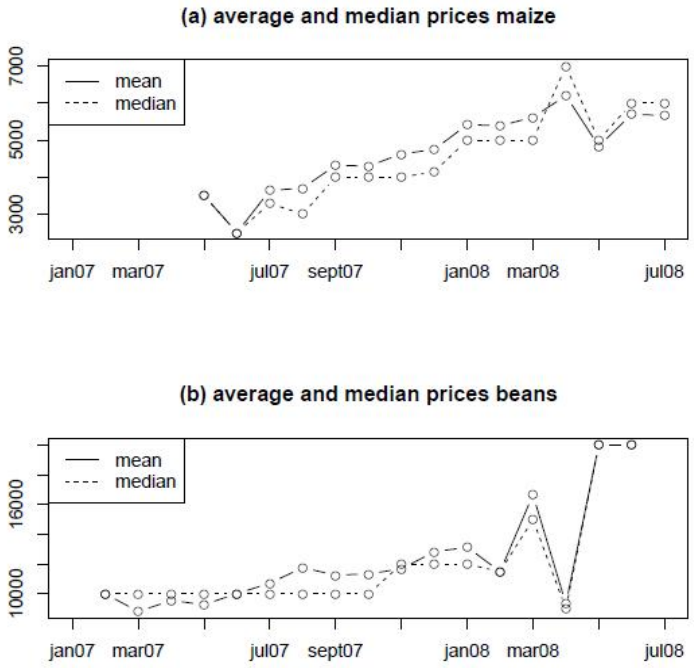


Let us now look at the prices at which farmers sold their products. Overall, a *debe* of maize was sold at Tsh.4687 (about US$220 per ton), while a *debe* of beans was sold at Tsh.10850 (about US$500 per ton). However, such an average over the entire agricultural year hides important month-to-month price variability, especially since our observation period covers the 2007-2008 global food crises.[11] In Figure 4.3, we present time series data of average prices of maize (panel (a)) and beans (panel (b)) sold in each month of the agricultural year.[12] As can be seen, for both commodities, the prices more than doubled over the agricultural year. More specifically, the studentized range for maize is 3.6, while that for beans is 3.2!

[11] Between March 2007 and March 2008, global food prices increased an average of 43 percent, according to the International Monetary Fund. During that time period, wheat, soybean, corn, and rice prices increased by 146 percent, 71 percent, 41 percent, and 29 percent, respectively, according to the U.S. Department of Agriculture (Carcani, 2010).

[12] The representativeness of these prices should be judged by looking at panel (b) in Figure 4.1 and 4.2. For example, for maize, the mean prices in June and July in both 2007 and 2008 are based on only a few observations.

Figure 4.3 Average and Median Time Series Prices for Maize and Beans



The main interest of this paper lies in the marketing margin: the difference in the consumer price in a regional (eg. Makambako, Mafinga or Iringa) or a national market (eg. Dar es Salaam) and the price received by the farmer. This margin will be able to tell us something about the broadly defined transaction cost.[13] As such, we have to compare the price the farmer gets with a price (at the time of sales) in such an end market. We will present three alternatives.

First, we will compare the price consumers get with prices in Dar es Salaam, the main consumer centre in Tanzania. These prices come from the Regional Agricultural Trade Intelligence Network (RATIN) (www.ratin.org).

RATIN was developed to help reduce regional food insecurity by strengthening the ability of markets to provide access to affordable food to poor households and improve food availability through providing adequate incentives to producers. It came out of the realization that, although there are households among the food insecure that are structurally poor and are heavily dependent on food donations, there are also market-dependent households who are able to purchase food if it is available at the right time, price and quantity in the local markets through enhanced effective competition.

[13] When we talk about transaction cost here, we do not only refer to the cost of shipping the commodity from the village to the terminal market. Transaction costs between location A and B not only refers to the cost of physically moving goods between the two locations, but also refers to the cost of the information flow between the two locations, the cost of insuring the shipment between the two locations, the cost of financing this transaction, etc. See also footnote 2.

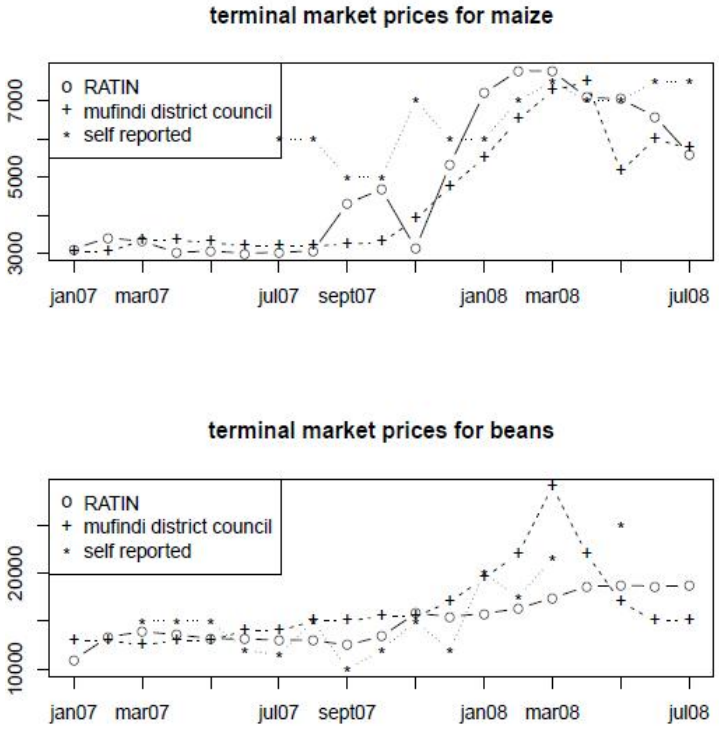
RATIN publishes historical time series data of monthly prices for different commodities in the main regional markets in Tanzania. Unfortunately, only Dar es Salaam has a complete series of prices for the agricultural year used in our study (our preferred alternatives, Iringa or Mbeya, only have a few observations). They publish prices in US$ per metric ton, so we calculated average monthly exchange rates on the basis of the Interbank Foreign Exchange Market (IFEM). Summaries as published on the website of the Bank of Tanzania[14] to convert it to Tsh. per *debe*. Although these prices are quotes far away from our villages, we think they are the most objective quotes at hand.

Second, we gathered prices at Mafinga (the main regional terminal market for the majority of farmers interviewed) from local market authorities at the Mafinga District Council. There, government officials keep records of minimum and maximum retail prices for several goods. In theory, they record prices at the beginning of each month and the middle of each month (the 1st and the 15th, provided these are working days). While the records we obtained from the district council were not complete, it gives us a good indication of price movements in Mafinga, the main terminal market in the district.

Finally, we also asked the farmers if they knew the going price at the market of Mafinga at the time of their transaction. While we have to warn again for the fact that at times of relatively little sales these price quotes may be biased due to an insufficient number of respondents, we also constructed an average price series out of these answers. The three price series over the agricultural year covering our survey are depicted in Figure 4.4. Panel (a) depicts the results for maize, panel (b) for beans.

[14] http://www.bot-tz.org/Archive/ArchiveDirectory.asp#MonetarySurveys.

Figure 4.4 Terminal Market Prices for Maize and Beans

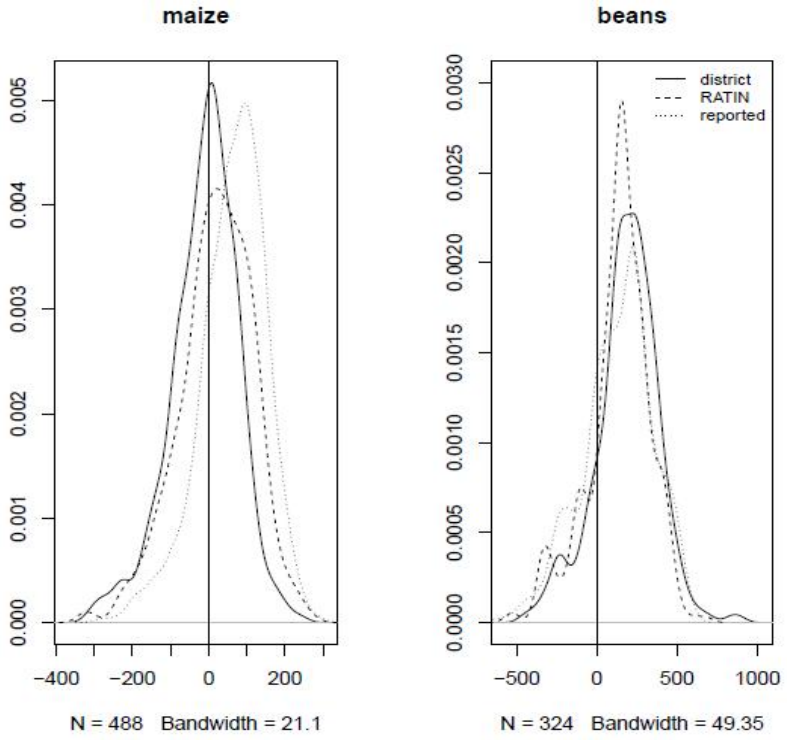


Now that we have defined reference prices, we can calculate price margins for the farmers in our survey. Overall, for maize, and taking the price in Dar es Salaam as our reference, we find an average price margin of Tsh.409 per *debe* (or about US$20 per metric ton). Oddly, if we use the prices reported by the district council, we find a negative average margin of Tsh.244 per *debe* (or about – US$10 per ton). Apparently, farmers sell at a higher price than the going price in the terminal market. While this does not make sense from a simple radial model of market integration perspective, there are at least two possible explanations for this; the first one is aggregation bias. Since we record prices per month, it may be that inter-monthly price variation is sufficiently high to result in negative price margins. For instance, a farmer sells in the beginning/at the end of the month at higher prices than the average price recorded in the terminal market. The second explanation is local market integration. We heard about instances where villages in the lower laying regions sell directly to higher laying regions within the district, bypassing the terminal market.

However, if we compare the sales prices to the self reported prices in the terminal market (Mafinga), we come to a staggering average of Tsh. 1358 per *debe* (or about US$63 per ton). For beans, the averages are all positive (and higher, due to the higher value per kg of beans compared to maize). Using the Dar es Salaam prices as a reference, we find an average margin of Tsh. 2915 per *debe* (translating to about US$130 per ton). If we compare average sales prices to market prices in Mafinga as reported by the district council, we find a margin of about Tsh. 4000 per *debe* (equivalent to about US$180 per ton). If we compare to the prices reported by farmers themselves, we come to Tsh. 2819 per *debe* (or US$125 per ton).

All the above is also summarized in the following kernel density estimates in Figure 4.5. The red curve is the density plot for the distribution of the farm gate – Mafinga prices margin. The black curve represents the farm gate – Dar es Salaam margin and the blue line represents the margin between the farm gate prices and the price in Mafinga as reported by the farmers themselves.

Figure 4.5 Kernel Density Estimates of Price Margins (US$/ton) for Maize and Beans



In sum, our estimates of price margins between farm gate prices and prices in the main regional market (Mafinga) show a high variance. For maize, it ranges from a negative margin to about Tsh.1358 per *debe* (US$63 per ton). For beans, we find average margins range between Tsh.2819 and Tsh.4000 per *debe* (between US$125 and US$180 per ton), depending on what reference prices are used.

4.3 Estimates of transaction costs at the regional level

In this part, we explain how, based on the theory of arbitrage, one can develop a dynamic model of price behaviour that gives an estimate of the transaction cost between two markets for a single, homogeneous commodity[15]. We start by briefly explaining the underlying idea and the empirical strategy. We then apply this model to time series data of maize prices of all possible combinations of 19 markets, obtained from the Ministry of Industry, Trade and Marketing. The aim of this part is to get a first sense of the transaction costs involved in regional trade.

If markets are connected through trade, economic theory predicts that prices of a single homogenous good in those two markets will be related. The idea derives from the law of one price. It may be best explained by starting from an extreme situation where two spatially separated markets are completely autarchic. In this case, the price of a commodity will be determined by local demand and local supply. Thus, there will be an equilibrium quantity and equilibrium price in market A and an equilibrium quantity and price in market B. A shift in local demand or local supply in one market will have no effect on the price of this commodity in the other market.

This changes if we allow for trade between market A and market B. If trade becomes possible, rational economic agents will start exploiting spatial price differences. Suppose local demand and supply conditions in market A are such that the price in this market for the commodity is lower than in market B. This will prompt traders to buy the commodity in market A, ship it to market B and sell it there at the going (i.e. higher) price. The trader makes a per unit profit of the price difference.

What are the consequences of such arbitrage? More and more traders will enter the market (under the assumption of free market entry) as long as profit margins persist. But the increased demand for the commodity in market A will increase the equilibrium price (assuming supply remains unchanged). At the same time, the increased supply of the commodity in market B will, with unchanged demand, lower the price in this market. In other words, the price difference between the commodities in the two markets will diminish over time. Defining m_t as the (absolute) price difference between market A and market B, we get that:

[15] Barrett (1996) makes a difference between three levels of market integration studies: Level I studies rely only on price data of a single homogeneous good, recorded over time in spatially separated markets. Level II studies add information of flows of goods to this, while level III studies supplement both types of information with data on transaction costs. While level II and III studies clearly allow for more precise estimates of the transaction cost, they also are much more data intensive. These days, price series data on different markets are routinely recorded by market authorities in key markets. Trade flows, on the other hand, are much more difficult to monitor than prevailing prices. The same holds for the data on the transaction cost. This is defined as the cost of shipping goods from one location to another location. While one could think this would be neatly approximated by recording the prices of fuel over time, it has to be noted that transaction costs entail much more than physical transport. For example, one would also need the cost of insuring the goods, the price of credit needed for the operation, etc. We believe the volume of price data in terms of observations can make up for the additions in terms of information in level II and III studies, provided we use the right econometric tools to exploit the information hidden in the dynamics of these price series.

$$\Delta m_t = \beta m_{t-1} + \varepsilon_t$$

Where ε_t is a white noise error term and β is to be estimated. Note that this is in fact a simple AR(1) model. If markets are connected through trade and prices move towards each other over time, β will be estimated strictly negative[16].

But prices will not be moving towards each other indefinitely. Indeed, rational arbitrageurs will only trade when they can make profit, that is, as long as the price difference exceeds the cost of moving the goods between the two locations. As such, prices will move towards each other up to the point where the price difference is equal to the transaction cost between the two locations. Once the price difference becomes smaller then the transaction cost, the price of the commodity in each market will be determined by local supply and demand again, and these prices will move independently from each other. This can be modelled by introducing thresholds into the AR model:

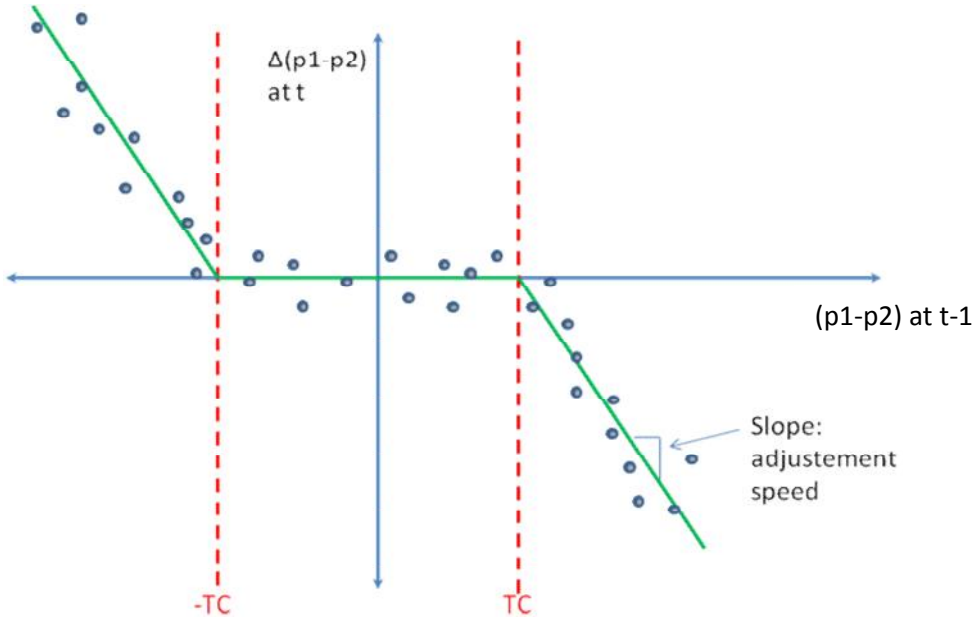
$$\Delta m_t = \begin{cases} \beta m_{t-1} + \varepsilon_t & T < m_{t-1} \\ \varepsilon_t & if -T \le m_{t-1} \le T \\ \beta m_{t-1} + \varepsilon_t & m_{t-1} < -T \end{cases}$$

Where T is the transaction cost. This model belongs to the class of piecewise linear regressions. To keep things simple, we will assume symmetry. In other words, we will assume that the transaction cost of shipping goods from A to B is the same as shipping from B to A. We will also assume that the speed at which prices converge over time is the same regardless of the direction of trade. A final assumption we make is that the average transaction cost remains equal over time[17]. Figure 4.6 represents the function we estimate.

[16] The β is called the adjustment speed. It indicates how fast the price margin reduces to zero over time (expressed as a percentage of the initial deviation). It forms the basis for the calculation of half-lives, which gives the time it takes for a deviation in the margin from zero to return to half the value of the initial deviation.

[17] Strictly speaking, all these assumptions can be relaxed. It is possible to allow for different transaction costs and/or adjustment speed depending on the direction of trade (for instance, if one market is in the highlands, one may want to take into account that it takes more fuel to get up the mountain than to get down). One just needs to specify an additional regime. Van Campenhout (2007) also illustrates how to make the transaction cost a linear function of time. However, relaxing the model has a price, either in a reduction of the observations in each regime or in increased computation time as the algorithm needs to search over more dimensions. Our judgment is that the symmetric transaction cost and adjustment speed outweigh the loss in precision due to the reduction of observations in each regime. We also judged that our deflation methods would be sufficient to render an overall average transaction cost representative.

Figure 4.6 A piecewise linear regression model to estimate transaction costs



When one assumes symmetry, this piecewise linear regression has two regimes: one inside the band formed by the transaction costs, and one outside (above the transaction cost or below the negative of the transaction cost). The theory predicts that when the price difference falls within the band formed by the transaction cost, prices move independently. We can exploit this theoretical prediction to improve identification of the transaction cost and the adjustment speed. We do this by imposing an adjustment of zero inside the band formed by the transaction cost (which is equivalent to modelling the price difference as a random walk in this regime). The thresholds are identified using a grid search procedure. For more information and extensions to this model, as well as a discussion of alternative models, see Van Campenhout (2007).

Inflation may be a concern, as we estimate transaction costs on the basis of time series data that cover roughly five years. However, one has to keep in mind that we model the price difference between two markets, and so one could argue that arbitrage conditions should hold for nominal price if the same deflator is used. Unfortunately, the story does not end here. As transaction costs and adjustment speeds are identified by exploiting the dynamics of this price difference, inflation will affect our estimates[18].

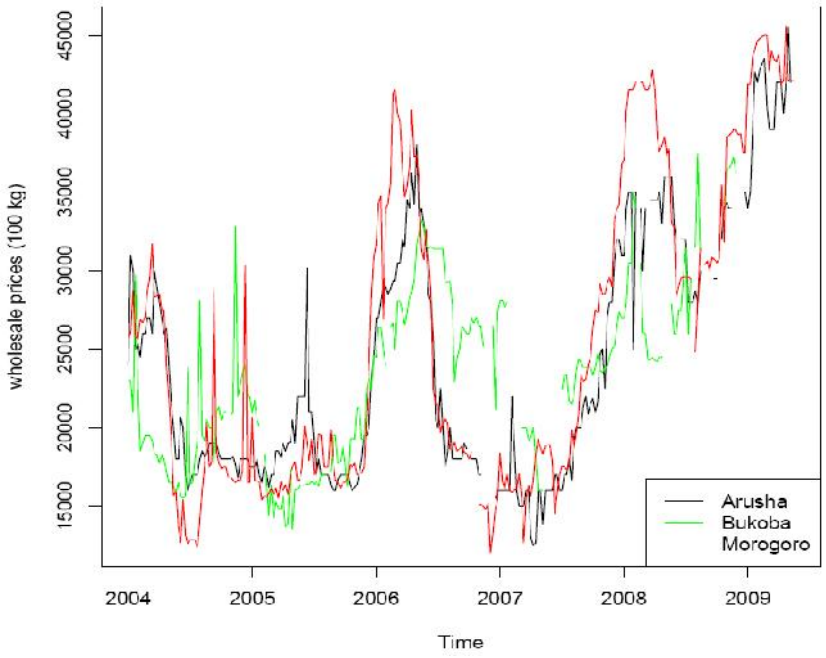
[18] Consider the following simple example. There are two markets [A,B] and two points in time [0,1]. Suppose the price of maize in market A at time 0 is 100, while in market B at time 0 it is 120. Hence the price margin at time 0 is 20. Suppose now that at time 1, the price in market A is still 100, but the price in market B has reduced to 110. So, at time 1, the price margin has reduced to 10. The change in the price margin is thus -10. Suppose now that there is a common inflation of 10 percent. Starting from the same situation, the price at time 1 in market A will now be 110. The price in market B at time 1 will 110(1+0.1)=121. Hence, the price margin will have decreased from 20 at time 0 to 11 at time 1, which gives a change in the price margin of -9. Hence, the existence of common inflation in this case creates a downward bias to the estimate of the adjustment speed due to the fact that the price difference gets inflated as well.

So, recognizing we need to account for inflation somehow, the question comes up of what deflator to use. To get an accurate estimate of transaction costs through time series methods, it is advised to work with time series of a reasonable frequency. For instance, if one expects arbitrage to take place in a matter of weeks, working with monthly price averages may severely bias the results (Taylor, 2001). This is why we work with weekly price series data. However, it is difficult to find an accepted deflator that is available at such a high frequency for prices in Tanzania. One way out would be to interpolate a consumer price index at a lower frequency (eg. monthly) to a lower frequency (weekly). However, this may reintroduce the aggregation bias reported in Taylor (2001). The alternative we use here is to take out common inflation. More specifically, we remove average price changes from individual price changes before doing the analysis.

We will now apply this model to time series data of maize prices of 19 regional markets, obtained from the Ministry of Industry, Trade and Marketing . As an illustration, we plotted the series for three markets in Figure 4.7. We estimate the above model for each possible bivariate market combination[19]. However, for some of the market pairs, an arbitrage connection is unlikely (for instance between say Bukoba and Sumbawanga). The results of the 171 possible bivariate combinations are reported in Table A7 in the appendix. We will take subsets of these results to estimate transaction costs and measures of market integration.

[19] In fact, the analysis assumes cointegration of price series. In other words, it assumes markets are connected through arbitrage. The underlying theory views market integration not as a binary state (integrated or not) but rather as a matter of degree (some markets are better integrated in the market system than others). As can be seen from the three price series in Figure 4.7, prices are moving together in the long run. We agree we should test this formally for all market pairs on beforehand. But we are confident all price series will be cointegrated, even if we impose a (0, 1) cointegration vector (as implicit in our analysis, as we work with price difference). As our interest lies in the degree of market integration (the transaction costs and the adjustment speed) we decided to leave this step out of the analysis.

Figure 4.7 Time series data for prices of maize in three markets



We found that, over all possible combinations, the mean estimated transaction cost is about US$63 per ton maize. The minimum transaction cost was found between Babati and Mbeya. It is only US$17 per ton. Given the locations of these two cities, it is unlikely that there is a direct link between these two markets. However, the second lowest total transaction cost is found between two places that do trade: Arusha and Moshi. The estimated transaction cost here is as low as US$23 per ton. This should not come as a surprise, as these towns are very close to each other and are connected by both a tarred road and a railway (see map in Appendix). The maximum transaction costs are found between Mwanza and Sumbawanga and Mtwara and Sumbawanga. Here we estimate transaction costs of over US$112 per ton of maize. This is also according to our expectations, as Sumbawanga is tucked away in the south west of Tanzania behind Lake Rukwa. It is only accessible through Mbeya and the road is notoriously bad. Mwanza is Tanzania's second largest city and located in the north on the shores of Lake Victoria. Mtwara is located at the coast all the way to the South. There is no tarred road connection.

However, as said above, some of these cities may not trade with each other. We see that those that are likely to trade have generally higher adjustment speed. Hence, somewhat arbitrary, we select all market pairs with an adjustment speed smaller than -0.2 and proceed with these trade routes from here. We now find that the average transaction cost is about US$50 per ton of maize, and the maximum is found to be between Songea and Tabora (US$93 per ton).

We also measured the distance between the different regional markets. This allows us to express transaction costs per ton of maize per unit of distance. If we then average over all market pairs, we find an estimate of about US$100 per ton per 1000km (median US$91, mean US$104). The largest transaction cost per unit of distance was US$365.90 per ton and was recorded between Lindi and Mtwara, while the second largest transaction cost was recorded between Moshi and Arusha. Note that

these markets with highest per distance transaction cost are the ones that are very close to each other. The market pairs with the lowest per distance transaction costs, on the other hand, are all markets that are relatively far from each other. For instance, the trade routes between Singida, Bukoba and Shinyanga on the one end and Dar es Salaam on the other end all have transaction costs of less than US$40 per ton per 1000 km. This suggests significant fixed costs in maize trade[20].

Even though we excluded market pairs that are unlikely to trade, the above estimates include markets that are connected through other towns. As such, it may be that maize moves into a town from two different locations, and prices between these two locations are very similar (say lower than in the central market). While this would result in a low estimated transaction cost between the two supply markets, this would not reflect the real transaction cost between these two supply markets. It would be more careful to look only at market pairs that are directly related to each other by road or railway and to not pass through other markets. If we confine ourselves to markets that are directly connected by a road, we find mean transaction costs increase to about US$150 per ton per 1000km. The smallest cost is now between Dar es Salaam and Moshi, and the largest cost is between Lindi and Mtwara. Since these are, according to our judgement, the most accurate estimates, we reproduce them in Table 4.4 below.

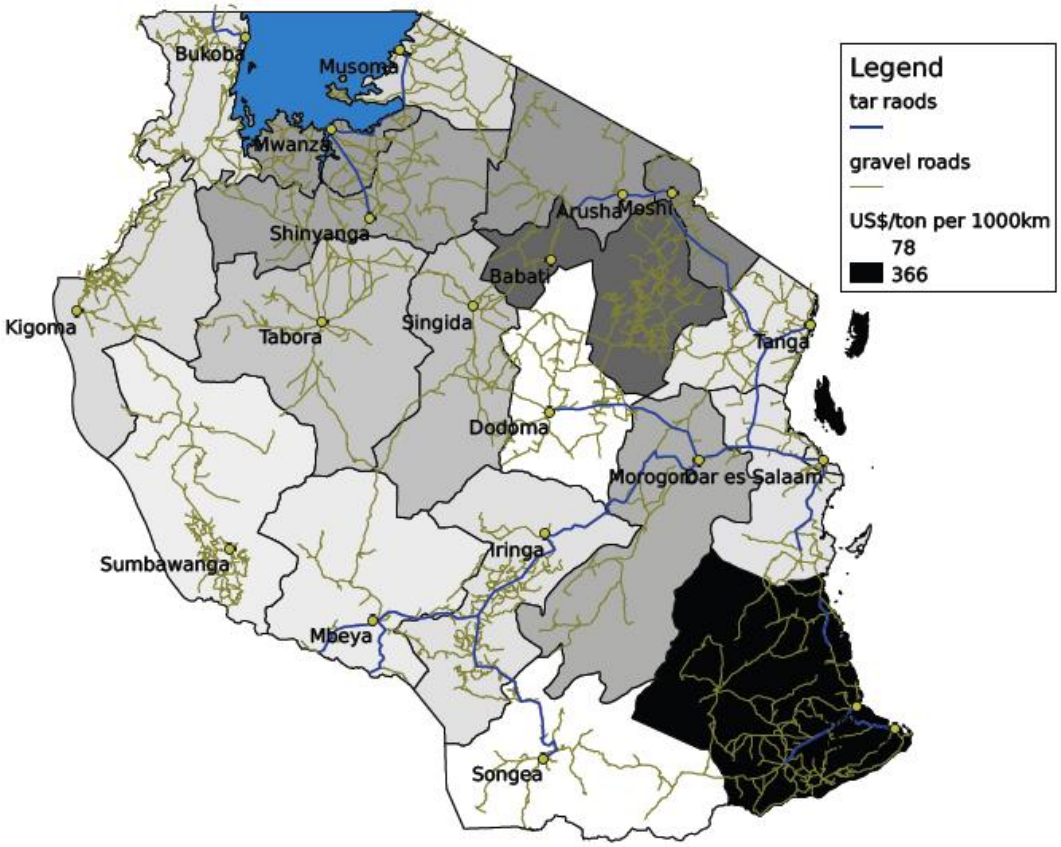
[20] The Pearson correlation coefficient between distance (km) and estimated transaction cost (US$) per 1000 km is -0.70 (p=0.00).

Table 4.4 Estimated transaction cost (US/ton per 1000 km)

		DISTANCE	ADJ	HL	TARRED	US_1000KM
Arusha	Moshi	80	-0.378	1.459	yes	296.4363
Arusha	Musoma	509	-0.228	2.675	no	91.40015
Babati	Singida	166	-0.229	2.661	no	252.2054
Bukoba	Kigoma	557	-0.209	2.949	no	102.0586
Bukoba	Shinyanga	503	-0.206	3.006	no	108.6183
Bukoba	Tabora	594	-0.531	0.915	no	120.6158
Dar es Salaam	Morogoro	194	-0.408	1.324	yes	169.8025
Dar es Salaam	Moshi	566	-0.309	1.874	yes	73.99889
Dar es Salaam	Tanga	356	-0.322	1.782	yes	86.82991
Iringa	Mbeya	337	-0.244	2.482	yes	112.1572
Kigoma	Tabora	415	-0.607	0.742	no	118.931
Lindi	Mtwara	106	-0.388	1.41	yes	365.9481
Mbeya	Songea	422	-0.228	2.673	yes	77.79472
Mbeya	Sumbawanga	374	-0.304	1.916	no	98.12776
Mbeya	Tabora	565	-0.409	1.318	no	130.9199
Moshi	Tanga	356	-0.236	2.575	yes	131.1185
Musoma	Mwanza	223	-0.25	2.412	yes	155.2364
Mwanza	Shinyanga	147	-0.33	1.732	yes	230.3228
Shinyanga	Singida	297	-0.261	2.291	no	131.5386
Shinyanga	Tabora	194	-0.752	0.497	no	176.8386
Singida	Tabora	332	-0.654	0.653	no	141.1694

We can use the transaction cost estimates between the market pairs to see which markets are better integrated with all others and which are worse integrated. This is done by simply taking the (average of the) estimated transaction cost per kilometre with (all) other market(s). The results are presented in 0. We coloured each region depending on the score obtained for the central market in each region. White coloured regions mean that these regional markets have relatively low transaction costs per ton per 1000km, while darker (black) relatively higher costs.

Figure 4.8: Integration of regional markets other markets



5 Conclusion, Recommendations and Ways Forward

The objective of this study was to come up with an estimate of transaction costs for agricultural and non-agricultural products in Tanzania. Although our final estimates are based on the prices of agricultural products due to lack data on non-agricultural products, we feel prices of non-agricultural products are likely to be affected by similar transport costs.

In our review of literature, we have seen that since Tanzania covers a massive land area, this necessitates having in place an infrastructure or road and rail network that ensures that perishable products in the agriculture sector are transported efficiently. However, the reality is that Tanzania's transport network is poor, and studies have documented spoilage of agricultural goods. Another consequence of the poor transport system is that the wholesale-farm gate marketing margins of agricultural goods are affected, as well as competitiveness of agricultural products. Where transaction costs are high, they are translated into higher prices of retail crops and/or lower farm-gate prices for farmers. The marketing margins differ with distance: terminal markets that are close to where the products are grown have lower marketing margins than terminal markets that are far from the source of the agricultural products. In terms of competition, high transport costs prevent farmers from securing better prices for the products as they are limited to selling to traders that come to them. High transport costs do not just affect internal trade; they also affect Tanzania's competitiveness in the export market.

The findings of our study on the effect of transaction costs are based on information coming from three sources. These are from the perspective of traders within Iringa, microeconomic data on farmers in Iringa where data on prices was from three sources, and time series data from regional centres in Tanzania. The findings from these studies are reported in different measures.

Traders report that transaction costs at the local level are about 10 percent of the farm gate price. This is equivalent to about Tsh.360 to Tsh.430 per *debe* (about 13US$ per ton to 15.5US$ per ton). Note that at this level, we do not control for distance. Price margins based on farmers' quoted prices are less precise. They range from a negative market price margin to as much as Tsh.1358 per *debe* (63US$ per ton). At the regional level, we find an average transaction cost of about US$100 per ton per 1000km. If we only consider only markets that are directly connected, this figure goes up to about about US$150 per ton per 1000km. This confirms the estimates at the regional level, since these villages are on average about 100 km away from the terminal market (Mafinga).

Apart from the above estimates, we also observed some other interesting features. First, we were surprised to find low levels of market participation in the villages studied. Second, we found that although farmers do sell substantial amounts of maize and beans, this happens all at once, rather than different sales of smaller amounts. This is strange in view of the substantial interpersonal movements of prices. This may indicate that farmers have little choice in when to sell. For instance, they may need immediate money, or they are visited only once by a trader. A third interesting finding was that, at a regional level, short transport routes were found to be more expensive than longer transport routes (if expressed per measure of distance). This may suggest substantial fixed costs in regional trade.

One interesting extension to this research would be to look at non-agricultural products. In addition, it would be interesting to look at the prices and margins of a product that is not locally produced, but imported at one point (e.g., the harbour of Dar es Salaam). In this case, with no domestic production, the spatial price differences reflect only transaction costs and differences in local market demand; there are no differences in supply that would complicate the analysis. Although the threshold autoregressive models presented in Section 4.3 should take care of these problems, it is always useful to have something to compare with. The above should in principle be possible, as the data are available. The Ministry of Industry, Trade and Marketing collects price series data on several products. But also mobile phone companies disseminate price information these days.

In addition to this, it would be really interesting to take the regional price analysis to a local level. That is, during a specific period of time, record prices within the villages that were used in the trader survey (and the terminal markets of Mafinga and Makambako). This would allow us to see if the extent of market integration (with associated speed of adjustment and transaction costs) that has been found on a regional level carries over to the local level. This should not be so difficult or costly. It would involve some enumerators keeping track of a range of prices. If we take the time interval sufficiently high (e.g., daily) it would not take too long before we can come up with some initial estimates.

One of the interesting findings was, as mentioned above, the fact that farmers seem to sell substantial amounts of maize. However, instead of taking advantage of price differences over the agricultural cycle, farmers usually sell everything at once, often immediately after the harvest. There may be different reasons for this, like a lack of competition in the traders market. It has also been argued that missing credit market may be the root cause of this behaviour (Stephens and Barrett, 2010). It would be interesting to do some more research on this.

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7 Appendices

Table A1: Transport Indicators

	LAND AREA (SQ.KM)	TOTAL ROAD network per LAND area (%)*	ROADS, PAVED (% OF TOTAL ROADS)*
Algeria	2381740	4.5	69.5
Angola	1246700	4.1	10.4
Benin	110620	17.2	9.5
Botswana	566730	4.4	34.1
Burkina Faso	273600	33.8	4.2
Burundi	25680	52.2	8.8
Cameroon	465400	10.9	8.2
Cape Verde	4030	33.5	69.0
Chad	1259200	3.0	0.8
Comoros	1861	47.3	76.5
Congo, Dem. Rep.	2267050	6.8	1.8
Congo, Rep.	341500	4.4	7.3
Cote d'Ivoire	318000	20.5	8.9
Egypt, Arab Rep.	995450	7.9	79.5
Ethiopia	1000000	3.6	12.6
Gabon	257670	3.4	10.1
Gambia, The	10000	33.9	24.7
Ghana	227540	21.6	20.2
Guinea	245720	15.2	13.1
Guinea-Bissau	28120	12.3	27.9
Kenya	569140	11.2	13.1
Lesotho	30350	19.6	18.3
Liberia	96320	11.0	6.2
Libya	1759540	4.7	57.2
Madagascar	581540	8.6	11.6
Malawi	94080	16.4	45.0
Mali	1220190	1.4	15.1
Mauritania	1030700	0.9	22.8
Mauritius	2030	98.5	99.0
Morocco	446300	12.9	58.1
Mozambique	786380	3.9	18.7
Namibia	823290	6.6	12.8
Niger	1266700	1.3	23.0

Nigeria	910770	21.2	15.0
Rwanda	24670	52.7	13.7
Senegal	192530	7.3	29.3
Seychelles	460	99.6	96.0
Sierra Leone	71620	15.8	8.0
Somalia	627340	3.5	11.8
South Africa	1214470	29.9	18.8
Sudan	2376000	0.5	36.3
Swaziland	17200	19.9	30.0
Tanzania	885800	9.4	6.4
Togo	54390	13.8	31.6
Tunisia	155360	12.3	66.5
Uganda	197100	35.9	23.0
Zambia	743390	10.6	22.0
Zimbabwe	386850	25.1	19.0

Note: *Average for 2000-2007.

Source: Authors' calculations and World Bank (2010), World Development Indicators CD-ROM.

Table A2: Between City Price Differences of Maize

Wholesale prices (Tsh. per 100kg bag)				
	IRINGA	DODOMA		
August 1994	6,800	6,250		
August 1995	4,600	8,500		
Producer prices (Tsh. per 90kg bag)				
	SENGEREMA	NJOMBE	MAFINGA	MOINGA
June 1996	3,750	10,000	10,500	5,250
Retail prices, May 1996, (Tsh. per *debe* - 18kg)				
	MOROGORO	DAR ES SALAAM	NJOMBE	IRINGA
May 1996	1,550	2,800	1,300	2,225

Source: Kähkönen and Leathers (1999).

Table A3: Estimates of Marketing Margins along the National Supply Chain

Local Traders/Brokers (rice at Ifakara)	10-20% per kilo
Regional traders in Mtwara	2-4% per kilo
Brokers of transport	10% of transport fee
Large-scale traders	Tshs.20,000 per trip (regions)
Broker (green bananas at Ubungo)	7-11% per bunch
Broker (onions at Kariakoo)	4% per bag
Wholesaler (grain at Kariakoo)	Tshs.10-15,000 daily
Whosaler (rice at Tandale)	8% per kilo
Retailer (potato at Kinondoni)	36% per kilo
Retailer (oranges at Tandale)	20-70% per orange
Retailer (banana at Ilala)	15% per basket
Tanzanian export agent (cashew nuts)	3% per kilo
Indian export agent (cashew nuts)	4-5% per kilo
Subagents for the exporter (cashew nuts)	1% per kilo

Source: Eskola (2005).

Table A4: Estimates of Transport Costs

	KM.	TSH. (PER 10 TONS)	TSH./KM.	TSH. (PER TON PER KM)	$ (PER TON PER KM*)	$ (PER TON PER 100KM)
Dar es Salaam – Mwanza	1164	1,200,000	1030.9	103.1	0.09	9.13
Dar es Salaam – Iringa	501	200,000	399.2	39.9	0.04	3.54
Dar es Salaam – Mbeya	851	450,000	528.8	52.9	0.05	4.68
Dar es Salaam – Dodoma	479	250,000	521.9	52.2	0.05	4.62
Dar es Salaam – Mtwara	565	800,000	1415.9	141.6	0.13	12.54
Dar es Salaam – Singida	709	500,000	705.2	70.5	0.06	6.25
Dar es Salaam – Rukwa/Sumbawanga	1203	1,350,000	1122.2	112.2	0.10	9.94
Dar es Salaam – Lindi	562	600,000	1067.6	106.8	0.09	9.46
Dar es Salaam – Arusha	647	450,000	695.5	69.6	0.06	6.16
Dar es Salaam – Kilimanjaro/Moshi	562	300,000	533.8	53.4	0.05	4.73
Dar es Salaam – Morogoro	196	150,000	765.3	76.5	0.07	6.78
Dar es Salaam – Mara	1369	1,300,000	949.6	95.0	0.08	8.41
Dar es Salaam – Tanga	354	225,000	635.6	63.6	0.06	5.63
Dar es Salaam – Manyara	440	500,000	1136.4	113.6	0.10	10.07

Dar es Salaam – Ruvuma/Songea	992	700,000	705.6	70.6	0.06	6.25
Dar es Salaam – Kigoma	1442	1,200,000	832.2	83.2	0.07	7.37
Dar es Salaam – Tabora	1039	800,000	769.9	77.0	0.07	6.82
Dar es Salaam – Pwani	68	80,000	1176.5	117.7	0.10	10.42
Dar es Salaam – Kagera	1425	1,600,000	1122.8	112.3	0.10	9.95
Dar es Salaam – Shinyanga	1001	800,000	799.2	79.9	0.07	7.08

*Exchange rate use is the annual average in 2005 when the study was done, which was Tsh.1129/$US.
Source: Eskola (2005).

Table A5: Estimates of Domestic Freight Rates

	1998	1999	2000	2001	2002	Average
Livestock	0.071	0.096	0.102	0.097	0.110	0.082
Food Products	0.027	0.028	0.029	0.036	0.036	0.028
Coffee, tea, cotton & sugar	0.058	0.069	0.073	0.077	0.083	0.064
Fish Products	0.000	0.000	0.000	0.000	0.000	0.000
Fish Products	0.000	0.000	0.000	0.000	0.000	0.000
Beverages and Tobacco	0.092	0.099	0.105	0.115	0.121	0.095
Mineral Products	0.041	0.060	0.064	0.069	0.073	0.054
Chemical Products	0.055	0.081	0.087	0.095	0.100	0.073
Forestry Products	0.025	0.027	0.028	0.029	0.031	0.026
Building Materials	0.071	0.082	0.090	0.181	0.150	0.100
Textile and clothing and leather	0.023	0.008	0.008	0.009	0.010	0.011
Metal products and machinery	0.032	0.044	0.047	0.044	0.050	0.039
Transport equipment	0.031	0.043	0.045	0.043	0.049	0.038
Other manufactures	0.059	0.060	0.086	0.103	0.104	0.072
Average	0.042	0.050	0.055	0.065	0.066	0.049

Source: Kweka (2006).

Table A6: Estimates of Marketing Margins (%)

	Early 90s	Late 90s	2000s
Cash Crops	25	10	10
Food Crops			10-20
Other food crops			20-30
Staple foods	<5	<5	<5

Source: Morrissey and Leyaro (2007).

Table A7: Estimated Transaction Costs and Adjustment Speed

		Distance (km)	thres_res	Cost/km	adj_res	hl_res
1	Arusha_Babati	166	4925	29.669	-0.276	2.146
2	Arusha_Bukoba	1025	7187	7.012	-0.194	3.212
3	Arusha_Dar es Salaam	645	3702	5.74	-0.433	1.223
4	Arusha_Iringa	907	6951	7.664	-0.126	5.137
5	Arusha_Kigoma	1074	6927	6.45	-0.182	3.445
6	Arusha_Lindi	1103	8032	7.282	-0.161	3.954
7	Arusha_Mbeya	1233	8556	6.939	-0.077	8.701
8	Arusha_Morogoro	594	2782	4.684	-0.296	1.975
9	Arusha_Moshi	80	2745	34.313	-0.378	1.459
10	Arusha_Mtwara	1207	7580	6.28	-0.192	3.249
11	Arusha_Musoma	509	5385	10.58	-0.228	2.675
12	Arusha_Mwanza	615	5811	9.449	-0.116	5.601

13	Arusha_Shinyanga	624	5959	9.55	-0.189	3.3
14	Arusha_Singida	331	4015	12.13	-0.344	1.644
15	Arusha_Songea	1331	6711	5.042	-0.073	9.105
16	Arusha_Sumbawanga	1607	10863	6.76	-0.055	12.161
17	Arusha_Tabora	659	7070	10.728	-0.418	1.28
18	Arusha_Tanga	436	3975	9.117	-0.484	1.047
19	Babati_Bukoba	860	9573	11.131	-0.104	6.327
20	Babati_ Dar es Salaam	813	6703	8.245	-0.17	3.724
21	Babati_Iringa	1099	5116	4.655	-0.158	4.022
22	Babati_Kigoma	980	12433	12.687	-0.141	4.575
23	Babati_Lindi	1270	7042	5.545	-0.088	7.514
24	Babati_Mbeya	1425	2016	1.415	-0.14	4.609
25	Babati_Morogoro	790	3997	5.059	-0.113	5.781
26	Babati_Moshi	246	5121	20.817	-0.166	3.826
27	Babati_Mtwara	1375	9171	6.67	-0.133	4.873
28	Babati_Musoma	521	5083	9.756	-0.08	8.299
29	Babati_Mwanza	606	9040	14.917	-0.06	11.28
30	Babati_Shinyanga	459	9726	21.19	-0.101	6.484
31	Babati_Singida	166	4846	29.193	-0.229	2.661
32	Babati_Songea	1522	6846	4.498	-0.188	3.323
33	Babati_Sumbawanga	1798	9235	5.136	-0.096	6.866
34	Babati_Tabora	494	8593	17.395	-0.48	1.059
35	Babati_Tanga	602	6680	11.096	-0.149	4.283
36	Bukoba_ Dar es Salaam	1671	7127	4.265	-0.233	2.609
37	Bukoba_Iringa	1957	7261	3.71	-0.13	4.979
38	Bukoba_Kigoma	557	6580	11.813	-0.209	2.949
39	Bukoba_Lindi	2127	10778	5.067	-0.138	4.661
40	Bukoba_Mbeya	2288	9117	3.985	-0.121	5.361
41	Bukoba_Morogoro	1648	9055	5.495	-0.149	4.298
42	Bukoba_Moshi	1104	6083	5.51	-0.161	3.94
43	Bukoba_Mtwara	2232	9015	4.039	-0.131	4.93
44	Bukoba_Musoma	828	5752	6.947	-0.216	2.846
45	Bukoba_Mwanza	650	5993	9.22	-0.228	2.682
46	Bukoba_Shinyanga	503	6324	12.573	-0.206	3.006
47	Bukoba_Singida	697	5843	8.383	-0.182	3.457
48	Bukoba_Songea	2386	11018	4.618	-0.141	4.558
49	Bukoba_Sumbawanga	2656	9562	3.6	-0.118	5.512
50	Bukoba_Tabora	594	8293	13.961	-0.531	0.915
51	Bukoba_Tanga	1460	6585	4.51	-0.122	5.305
52	Dar es Salaam_Iringa	502	6377	12.703	-0.278	2.125
53	Dar es Salaam_Kigoma	1249	4840	3.875	-0.194	3.21
54	Dar es Salaam_Lindi	457	6973	15.258	-0.148	4.316
55	Dar es Salaam_Mbeya	829	7993	9.642	-0.158	4.023
56	Dar es Salaam_Morogoro	194	3813	19.655	-0.408	1.324
57	Dar es Salaam_Moshi	566	4848	8.565	-0.309	1.874
58	Dar es Salaam_Mtwara	562	8656	15.402	-0.259	2.309
59	Dar es Salaam_Musoma	1153	5574	4.834	-0.298	1.962
60	Dar es Salaam_Mwanza	1128	3172	2.812	-0.092	7.152
61	Dar es Salaam_Shinyanga	1271	5847	4.6	-0.241	2.515

62	Dar es Salaam_Singida	978	3904	3.992	-0.253	2.376
63	Dar es Salaam_Songea	927	9212	9.937	-0.145	4.418
64	Dar es Salaam_Sumbawan	1203	10920	9.077	-0.118	5.507
65	Dar es Salaam_Tabora	835	7093	8.495	-0.478	1.065
66	Dar es Salaam_Tanga	356	3578	10.051	-0.322	1.782
67	Iringa_Kigoma	1054	10628	10.083	-0.142	4.536
68	Iringa_Lindi	959	11507	11.999	-0.161	3.962
69	Iringa_Mbeya	337	4375	12.982	-0.244	2.482
70	Iringa_Morogoro	313	7000	22.364	-0.159	4.002
71	Iringa_Moshi	854	9372	10.974	-0.12	5.431
72	Iringa_Mtwara	1065	10734	10.079	-0.13	4.996
73	Iringa_Musoma	1442	8508	5.9	-0.132	4.883
74	Iringa_Mwanza	1549	9967	6.434	-0.089	7.455
75	Iringa_Shinyanga	1558	5938	3.811	-0.075	8.901
76	Iringa_Singida	1265	5927	4.685	-0.213	2.888
77	Iringa_Songea	435	3042	6.993	-0.186	3.365
78	Iringa_Sumbawanga	711	7336	10.318	-0.209	2.955
79	Iringa_Tabora	641	8320	12.98	-0.419	1.277
80	Iringa_Tanga	641	7881	12.295	-0.212	2.908
81	Kigoma_Lindi	1706	5462	3.202	-0.149	4.301
82	Kigoma_Mbeya	975	10269	10.532	-0.142	4.515
83	Kigoma_Morogoro	1060	7072	6.672	-0.178	3.541
84	Kigoma_Moshi	1154	5973	5.176	-0.146	4.378
85	Kigoma_Mtwara	1811	7195	3.973	-0.2	3.102
86	Kigoma_Musoma	933	4800	5.145	-0.207	2.981
87	Kigoma_Mwanza	756	4294	5.68	-0.261	2.292
88	Kigoma_Shinyanga	609	4746	7.793	-0.41	1.315
89	Kigoma_Singida	747	4477	5.993	-0.19	3.287
90	Kigoma_Songea	1395	12641	9.062	-0.14	4.58
91	Kigoma_Sumbawanga	1005	12301	12.24	-0.098	6.736
92	Kigoma_Tabora	415	5713	13.766	-0.607	0.742
93	Kigoma_Tanga	1301	7182	5.52	-0.137	4.709
94	Lindi_Mbeya	1284	10979	8.551	-0.155	4.112
95	Lindi_Morogoro	648	6151	9.492	-0.181	3.469
96	Lindi_Moshi	1020	9604	9.416	-0.11	5.945
97	Lindi_Mtwara	106	4490	42.358	-0.388	1.41
98	Lindi_Musoma	1607	4471	2.782	-0.071	9.465
99	Lindi_Mwanza	1714	6035	3.521	-0.099	6.661
100	Lindi_Shinyanga	1723	4291	2.49	-0.124	5.257
101	Lindi_Singida	1432	7295	5.094	-0.145	4.42
102	Lindi_Songea	1381	12730	9.218	-0.137	4.706
103	Lindi_Sumbawanga	1607	10906	6.787	-0.124	5.217
104	Lindi_Tabora	1290	8258	6.402	-0.443	1.186
105	Lindi_Tanga	810	9099	11.233	-0.138	4.682
106	Mbeya_Morogoro	640	8729	13.639	-0.108	6.048
107	Mbeya_Moshi	1182	8043	6.805	-0.084	7.901
108	Mbeya_Mtwara	1395	11149	7.992	-0.111	5.868
109	Mbeya_Musoma	1083	8846	8.168	-0.106	6.161
110	Mbeya_Mwanza	905	10320	11.403	-0.072	9.276

111	Mbeya_Shinyanga	759	9100	11.989	-0.118	5.503
112	Mbeya_Singida	602	6573	10.919	-0.154	4.153
113	Mbeya_Songea	422	3800	9.005	-0.228	2.673
114	Mbeya_Sumbawanga	374	4248	11.358	-0.304	1.916
115	Mbeya_Tabora	565	8562	15.154	-0.409	1.318
116	Mbeya_Tanga	968	9687	10.007	-0.159	4.001
117	Morogoro_Moshi	543	5398	9.941	-0.264	2.258
118	Morogoro_Mtwara	756	5534	7.32	-0.175	3.6
119	Morogoro_Musoma	1133	4689	4.139	-0.17	3.731
120	Morogoro_Mwanza	1239	4406	3.556	-0.109	6.024
121	Morogoro_Shinyanga	1248	6891	5.522	-0.181	3.476
122	Morogoro_Singida	955	5449	5.706	-0.27	2.2
123	Morogoro_Songea	737	10737	14.569	-0.117	5.579
124	Morogoro_Sumbawanga	1023	7580	7.41	-0.054	12.57
125	Morogoro_Tabora	646	7778	12.04	-0.382	1.44
126	Morogoro_Tanga	333	3626	10.889	-0.409	1.319
127	Moshi_Mtwara	1128	7395	6.556	-0.125	5.205
128	Moshi_Musoma	589	2864	4.862	-0.21	2.936
129	Moshi_Mwanza	695	6198	8.918	-0.125	5.191
130	Moshi_Shinyanga	704	4736	6.727	-0.128	5.08
131	Moshi_Singida	411	4454	10.837	-0.163	3.889
132	Moshi_Songea	1278	8536	6.679	-0.086	7.721
133	Moshi_Sumbawanga	1562	11938	7.643	-0.055	12.257
134	Moshi_Tabora	962	7998	8.314	-0.447	1.17
135	Moshi_Tanga	356	5403	15.177	-0.236	2.575
136	Mtwara_Musoma	1712	4529	2.645	-0.087	7.586
137	Mtwara_Mwanza	1821	5968	3.277	-0.108	6.036
138	Mtwara_Shinyanga	1830	5069	2.77	-0.121	5.391
139	Mtwara_Singida	1537	7997	5.203	-0.126	5.169
140	Mtwara_Songea	1486	12124	8.159	-0.154	4.14
141	Mtwara_Sumbawanga	1765	13182	7.469	-0.133	4.874
142	Mtwara_Tabora	1394	8789	6.305	-0.386	1.42
143	Mtwara_Tanga	915	8605	9.404	-0.211	2.927
144	Musoma_Mwanza	223	4007	17.969	-0.25	2.412
145	Musoma_Shinyanga	327	5403	16.523	-0.197	3.165
146	Musoma_Singida	622	6278	10.093	-0.198	3.148
147	Musoma_Songea	1865	9852	5.283	-0.078	8.547
148	Musoma_Sumbawanga	2144	10725	5.002	-0.061	11.065
149	Musoma_Tabora	518	7827	15.11	-0.455	1.142
150	Musoma_Tanga	943	7123	7.554	-0.176	3.579
151	Mwanza_Shinyanga	147	3919	26.66	-0.33	1.732
152	Mwanza_Singida	444	5092	11.468	-0.121	5.394
153	Mwanza_Songea	1973	12650	6.412	-0.067	10.035
154	Mwanza_Sumbawanga	1772	13074	7.378	-0.055	12.335
155	Mwanza_Tabora	341	6832	20.035	-0.501	0.996
156	Mwanza_Tanga	1051	9556	9.092	-0.092	7.15
157	Shinyanga_Singida	297	4522	15.226	-0.261	2.291
158	Shinyanga_Songea	1982	11360	5.732	-0.101	6.499
159	Shinyanga_Sumbawanga	2258	8207	3.635	-0.068	9.904

160	Shinyanga_Tabora	194	3971	20.469	-0.752	0.497
161	Shinyanga_Tanga	1060	8774	8.277	-0.127	5.11
162	Singida_Songea	1686	7922	4.699	-0.177	3.554
163	Singida_Sumbawanga	927	7247	7.818	-0.111	5.864
164	Singida_Tabora	332	5425	16.34	-0.654	0.653
165	Singida_Tanga	766	5260	6.867	-0.315	1.831
166	Songea_Sumbawanga	818	4874	5.958	-0.327	1.748
167	Songea_Tabora	1073	10816	10.08	-0.27	2.199
168	Songea_Tanga	1065	9170	8.61	-0.143	4.482
169	Sumbawanga_Tabora	595	9809	16.486	-0.387	1.416
170	Sumbawanga_Tanga	1342	9445	7.038	-0.069	9.667
171	Tabora_Tanga	1095	8770	8.009	-0.378	1.46

Appendix 2

Figure 1: Map of Tanzania's Road and Railway Network