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Facilitating trade facilitation with roads:

The case of agricultural products in Sub-Saharan Africa

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Abstract

The purpose of this paper is to examine whether the combined effect of infrastructure and trade facilitation may enhance trade in agricultural products in Sub-Saharan Africa. Due to the widely spread poverty in this region, trade in agricultural products are of specific importance since it may help to secure food supply. Estimates show that enhanced trade facilitation and infrastructure have significant positive effects on imports of agricultural goods in the intra-Sub-Saharan African trade. However, the estimations regarding the marginal effect of infrastructure on trade facilitation are not in line with the theoretical expectations of the variable. The estimates are done using a gravity model specified to estimate the relationship between infrastructure and trade facilitation. The dataset consist of 29 countries over a time period of nine years.

Keywords: Trade facilitation, Infrastructure, Agricultural products, Sub-Saharan Africa, Food security

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1. Introduction

Trade facilitation may not be an entire new way of dealing with trade liberalization, but it is to say the least a relevant subject of discussion in trade forums around the world. In February 2017, the World Trade Organization (WTO) initiated the Trade Facilitation Agreement (TFA), including two thirds of the WTO's members. The positive effect of low frictional costs is well documented throughout the last two decades and as we have seen more non-liberal trade policy trends globally in the last few years, the importance has become even greater (Estevadeordal, 2017).

There is no official definition of what trade facilitation (TF) means in practice, but the most common way to describe the matter is "the simplification and harmonization of international trade procedures" (Persson, 2012, p. 13). Various additional costs are associated with importing and exporting, and plenty of them are due to friction in terms of different technical regulations, inefficient customs procedures and different types of documents. Actions working towards a decrease of these transactional costs are in our sense TF. In practice, nations deal with the problem of high transactional or frictional costs by removing, simplifying and standardizing documents for imports and exports, communicating relevant information to relevant organizations and by training customs workers to be more efficient.

In developing countries, such as those in Sub-Saharan Africa (SSA), trade costs are in general significantly higher than in developed countries (Anderson & Wincoop, 2004). Improved TF therefore has the potential to decrease trade costs in SSA. The countries' in SSA remain as one of the world's poorest regions and the vast majority of its population live in rural areas. Many of the households in the SSA countries are therefore, in one way or the other, dependent on agriculture products. For some, it satisfies the basic human needs and for others it's a source of income. Furthermore, in many of these countries the agricultural sector contributes to a large part, on average 15%, of the overall economy. Agricultural goods are therefore of great importance for SSA countries (Xinshen Diao et al., 2007; OECD-FAO Agricultural Outlook 2016-2025,). Since increased trade is generally assumed to decrease poverty and enhance living standards in developing countries, increased trade in agricultural products by reduced trade costs could have a positive significant effect on the SSA countries' growth (Arvis et al., 2013).

Further, intra-SSA trade may secure the food supply and improve productivity in the agricultural sector in the region. The agricultural products however, contain many perishable products which are specifically time sensitive (Djankov, Freund & Pham, 2006 ; Moïse. et al, 2013), why the intra-SSA trade is important for the countries in question. Trade in these products is therefore not only affected by the level of transaction costs, but also by the quality of the countries' infrastructure.

In general, there tends to be a significant positive effect on international trade when enhancing the quality of infrastructure within a country. According to Limão & Venables (2001) the infrastructure makes up almost half of the excess trade costs of the SSA-countries and it is therefore important for the nations to increase the quality of their infrastructure. How such improvements affect a country depends greatly on how well developed the nation is. If the nation is poorly developed, improvements in "hard" infrastructure, such as physical infrastructure, tend to have a greater positive effect than investments in "soft" infrastructure, such as business environment (Portugal-Perez & Wilson, 2010). The countries' in SSA should therefore benefit more from improvements in hard infrastructure than in soft infrastructure. Improving hard infrastructure is however very costly (Demitriades, 2005). Another approach for the SSA countries to increase their trade would be to focus on improvements in TF. There are several earlier studies that estimates the effect of TF and of infrastructure on trade but to our knowledge, the literature measuring the effect of infrastructure on TF is non existing.

The objective of this thesis is therefore to analyze if enhanced infrastructure quality might have a positive marginal effect on TF, and in turn the intra-trade of agricultural products in SSA. As trade facilitations indicators measures the trade procedure on the border, solely enhancing the TF will mostly favor those firms that can easily reach the border. Therefore, the quality of infrastructure is of great importance due to that the trade procedure is the whole transportation from the producer to the consumer. We will use the gravity model to examine the issue empirically, from 2006 to 2014 for 29 of the nations in SSA. To find the marginal effect of infrastructure on TF mentioned above, we have generated interactive terms from our two original TF-variables and the infrastructure-variable.

The thesis will continue with Trade facilitation & infrastructure (2), an explanation of the gravity equation (3), model specification (4), data (5), method of estimation (6), results (7), summary and conclusions (8) and at last a list of references (9).

2. Trade facilitation & infrastructure

During the last two decades, there have been a great number of studies on TF and infrastructure's impact on international trade flows. The SSA trade has also been thoroughly examined through several studies, especially the trade of agricultural products. Earlier work addressing the impact of TF have clearly emphasized its positive effect on international trade. Using a gravity model and choosing Port Efficiency, Regulatory Environment and Customs Environment as their TF measures, Wilson, Mann and Otsuki (2005) finds a significant positive effect of TF on trade for 75 countries from 2000-2001. Estimating a gravity model similar to the one Wilson, Mann and Otsuki (2005) use, Soloaga, Wilson and Mejía (2006) examines TF's effect on trade in Mexico and finds similar results with Port Efficiency as the most important factor for import improvements. The same effect was shown in de Sá Paolo, Morini and Canuto (2015), where two trade facilitation measures, Single Window and Authorized Economic Operator, had a significant positive effect on trade for the countries in their dataset. The authors also state that "trade facilitation measures as a whole will help countries improve their trade performance" (de Sá Porto, Morini & Canuto, 2015, p. 13). Despite most results indicating a positive relationship between TF and trade, in some studies there are certain issues depending on the chosen dataset.

TF indicators perform well when analyzing its effect in general. Statistically the results tend to be significant when all commodity groups are included and the countries are at least at middle income level (Wilson, Fosso and Njinkeu, 2008; Liapis, 2015). Although, when analyzing the effect of TF on agricultural goods, the result might not be as significant as with all commodities included. In Liapis (2015) none of the TF indicators were significant when solely analyzing TF on certain agricultural goods. The significance dropped substantially after excluding manufacturing goods. Further, the income level in the dataset may affect the result dramatically and the regression tends to be more significant when looking on high income countries compared to middle- and low income countries. Liapis (2015) also found that the TF indicators showed no significance for low income countries. However, the statistical significance of TF indicators increased along with the income level.

Martinez-Zarzoso and Márquez-Ramos (2008), use an augmented gravity model and run several different regressions to estimate the effect of TF indicators on trade in agricultural products. Using 167 importing countries and 13 exporting countries from the WDI's Doing Business Database the authors find, in contrary to Liapis (2015), a significant positive effect for several TF indicators on trade in agricultural products.

If we instead turn to the impact of infrastructure on trade, Limão & Venables (2001) find, using bilateral trade data, that infrastructure have a large significant effect on trade flows. When focusing on SSA, the authors find that a great part of the poor performance of SSA-countries' trade can be explained by their poorly developed infrastructure. In addition, Moïse et al (2013) conducts a quantitative analysis and finds that the exports in agricultural products in developing countries are sensitive to the quality of the infrastructure. By constructing an infrastructure quality index from the World Bank's Logistics Performance Index, Moïse et al. estimates that an increase by 10% in the index could potentially increase the developing countries' exports by up to 30%. According to Wilson and Portugal-Perez (2010), the marginal effect of improvements in hard infrastructure is decreasing with a higher national income level, while the contrary is true for improvements in soft infrastructure.

The earlier research has found both infrastructure and TF to be important for trade flows. As discussed in the introduction, TF concerns trade procedures at the border while infrastructure happens within a country. The interaction between them could therefore be of great importance for trade flows. However, apart from this thesis we have not found any other paper that examines the marginal effect of infrastructure on TF for agricultural products, neither in SSA nor anywhere else. How TF and infrastructure work together may however be important since TF may only be efficient for these countries' if firms could easily reach the border, e.g. easier border controls will not boost trade in agriculture if the goods risk to be destroyed due to poor internal infrastructure.

3. Gravity equation

The overview of previous studies have made it clear that the gravity model is the current workhorse model in international trade analysis. In line with previous research, our paper will also use the gravity model.

In the 1960's, Jan Tinbergen found that bilateral trade flows among countries can be estimated by a model that would become known as the gravity equation. As a parable to the Newtonian theory of gravitation, the gravity model for trade flows assumes that bilateral trade among countries increase with the size of their GDP and decrease as the distance between them grow, and the cost of transportation increases (Bacchetta et al., 2012; Wilson, Fosso and Njinkeu, 2008).

The gravity equation originally took the following form:

$$X_{ij} = GS_i M_j \varphi_{ij} \text{ (1)}$$

where X denotes the value of exports from country i to j and M_j stands for the factors that are specific for the importer's demand. S_i denotes the factors that are specific for the exporter's demand. The variable G refers to an exogenous factor such as the level of liberalization around the world. The last variable, φ_{ij}, captures the exporter's possibility to access the market.

To be able to estimate the equation with ordinary least squares (OLS), a log-linear equation is needed. The equation is obtained by taking the natural logarithm of all variables in the original equation (1) leading to the equation used for estimation:

$$lnX_{ij} = lnG + lnS_i + lnM_j + ln\varphi_{ij} \text{ (2)}$$

Using the logarithmic equation (2) allows for an easier interpretation of the parameters since they then are elasticities, i.e. they show the percentage change in trade flows when the variable change with one percent.

As most new models the gravity equation received criticism in the beginning, mostly for being merely an econometric tool in absence of any theoretical foundation. As a result of this critique, Anderson (1979) made a first effort to provide a theoretical underpinning to the model.

Following the work of Anderson (1979), Bergstrand (1985 and 1989) added to the theoretical base by showing that the gravity model is consistent with monopolistic competition. Another problem with the original model is that it does not take into account the effect of changes in trade cost in one bilateral trade route on another bilateral trade route (Shepherd, 2016). This was however an issue that Anderson and Wincoop (2003) addressed by adding a multilateral resistance variable (MRT). With this approach they find that bilateral trade is not shaped by absolute trade cost but by relative trade costs. However, when dealing with bilateral trade flows, unbiased estimates can be obtained by replacing MRT with dummies. By using country dummies, one captures not only MRT but also all possible bilateral trade costs that does not change over time. Such as distance, landlockedness and common borders (Anderson & Wincoop., 2004) ; Bacchetta et al., 2012).

4. Model specification

In order to analyze the marginal effect of enhanced infrastructure quality on TF, we use panel data from 2006 to 2014 and specify a gravity model using import as dependent variable. The independent variables of our model is the infrastructure variable as well as the TF variables. In addition to these we also include GDP of both the importer and exporter country. However, the centre of interest in our model is the interactive term between our TF variables and infrastructure variable. Based on the original gravity model our modified specification takes the following form:

$$lnImport_{ij} = \ln(mass)_{ijt} + \ln(Infrastructure)_{ijt} + \ln(TF)_{ijt} + \ln Infrastructure_{ijt} * \ln TF_{ijt} + \alpha_{ij} + \lambda_t + \varepsilon_{ijt} \quad (3)$$

$$Import_{ij} = \ln(mass)_{ijt} + \ln(Infrastructure)_{ijt} + \ln(TF)_{ijt} + \ln Infrastructure_{ijt} * \ln TF_{ijt} + \alpha_{ij} + \lambda_t + \varepsilon_{ijt} \quad (4)$$

Where the dependent variable *lnImport* is the imports to importer *i* from country *j* at time *t* and *lnTF* is the trade facilitation variable. The TF indicators measures the quality of TF for either cost to import or time to import. Similarly the *lnInfrastructure* variable captures the effect of road infrastructure. Finally the *lnTF*lnInfrastructure* is the interactive term measuring the effect of infrastructure on TF. Using fixed effect in our specification, we have also included α_{ij} and λ_t which are dummies for country pair and year. As in all regression models, an error term is required, thus ε_{ijt} is included in our model specification. Equation 4 differs from equation 3 in only one way, namely that the dependent variable is *import* instead of *lnimport* in the non-linear model.

As stated above, the GDP-variable is one of the most commonly used variables in the baseline gravity equation. It is somewhat the foundation of the equation. We used the original setup of the variable, the product of GDP for the importer and the exporter which is usually referred to as the mass of the gravity equation. The expectation of *GDP mass* is to be strictly positive. Intuitively, when the wealth of a country increases, the imports will most likely increase as well. When using the theoretical log-linear version of the gravity model, the GDP coefficient is expected to be close to 1, which is interpreted as a one percent increase in GDP will increase imports with one percent as well, i.e. unitary elastic (Bacchetta et al., 2012). In the case of an estimation with a Poisson regression model, the coefficient is not necessarily expected to be close to 1, but it ought to be positive.

Our TF indicators should both have positive signs in the estimation. In order to interpret the TF variables in the regression in a more logical way and to easier understand the result of the interactive term, we have inverted the TF indicators, i.e. divided 1 by the TF indicators. This change in the variables lead to small values if the cost or time for trading is high, and larger values if the time and cost for transporting is low. The TF indicators can now be seen as the quality of TF, the higher value of the observation, the better TF. Therefore, a decrease in costs or time will increase the quality of TF leading to more trade, thus positive signs are expected. Large coefficients are also expected due to the very small observations in the TF indicators.

From the infrastructure variable we expect a positive coefficient. As discussed above, infrastructure often have a positive effect on international trade and we do not expect any difference in this paper when analyzing the intra-SSA trade for agricultural products.

Regarding the most interesting part of our model i.e the interactive terms, we are expecting it to be positive. The variable is to be interpreted as the marginal effect of infrastructure on TF and should be positive, since we expect an increase in infrastructure to increase the quality of TF. Thus, we believe that the quality of roads will improve the TF and in turn increase the trade.

A common way to specify the gravity model is to add dummies for landlockedness, common language, common borders etc. In our case, variables without variation in time or within groups will be omitted due to the group- and year fixed effect and therefore the dummy variables are excluded and will be taken care of by the country dummy mentioned above. Furthermore, we have not used MRT in our regression due to the country dummies discussed above.

5. Data

In order to quantitatively measure the impact of TF on trade, the need for TF indicators in the regression is obvious. The well-known World Bank's World Development Indicator database (WDI) contains several commonly used TF indicators, and we chose two of them: Time to import/export (days) and Cost to import/export (US$ per container).

Time to import/export measures the total number of calendar days for the fastest legal importing/exporting process, considering all procedures from the initiating order to the delivery of the product. Cost of import/export measures fees and similar costs for transporting a "20-foot container in U.S. dollars" during all of the importing/exporting process . Fees for documents, customs clearance, controls and all transport costs are, among others, included in the measure (WDI, 2017).

The chosen TF indicators are often used in similar studies because of the way they are constructed and due to the simplicity of how they can be interpreted (Martinez-Zarzoso & Márquez-Ramos, 2008). Further, the WDI is a reliable source of information and because of that, we do believe these TF indicators are the most suitable measures for our thesis.

Since 2004, the World Economic Forum (WEF) has published the Global Competitiveness Index (GCI) which includes several indicators on nations' development such as measures of infrastructure, institutions and education. From Knoema (2017), a database containing the GCI, we gathered one infrastructure indicator: Quality of roads ,1-7 (best). Quality of roads measure how well developed the roads are according to CEOs and other business leaders in the nation. The measurement is created by surveys to the business executives.

As mentioned above, investing in hard infrastructure will most likely have a positive effect on trade for the countries in our dataset. In Wilson and Portugal-Perez (2010), it is shown that quality of roads, quality of port infrastructure and quality of port infrastructure tend to have a positive significant effect on trade for almost all specifications and samples. Further, according to the Economic Commision for Africa (2009) roads are the most common way of transporting agricultural goods in SSA. Therefore, we believe the indicator on road infrastructure to be the most suitable one for our dataset.

Table 1: Summary of infrastructure and trade facilitation indicators

Variable	Obs	Mean	Std. Dev.	Min	Max
Road infrastructure (1=poor, 7=best)	7,308	2.751191	1.415311	0	5.827178
Time importer (days)	7,308	36.83333	14.07035	14	95
Time exporter (days)	7,308	30.79655	11.63621	12	68
Cost importer (US $)	7,308	2418.415	1244.193	682	7060
Cost exporter (US $)	7,308	1817.486	809.8274	624	5165

In all of the variables, both for TF and infrastructure, the variation is quite large. For example, the maximum cost for importing goods is more than ten times the lowest costs for the same procedure and the maximum time for importing is close to seven times the lowest value. The reason for having 0 as the smallest value of *Road infrastructure* is that the variable contains missing values, thus 0 is the smallest value even though the scale of the variable is from 1 to 7.

The bilateral trade data is on imports to 29 countries in Sub-Saharan Africa from 2006 to 2014 and is gathered from the United Nations Commodity Trade Statistics Database (UN Comtrade). The data we use is limited to four commodity groups: Live animals (01), Meat and edible meat offal (02), Fish, crustaceans, molluscs (03) and Dairy products, eggs, honey (04). Imports or exports are two of the most common dependent variables in the gravity model. Imports data is generally more reliable than exports data since imports generate tariff revenue and is therefore more important for authorities to report (World Bank, 2010). The income data on both the importer and the exporter was downloaded from WDI (2017).

5.1 Potential data issues

When dealing with bilateral trade flows, there is always a risk of having zero trade flows in the data. This risk is also likely to increase when dealing with sectoral trade, as in our case with agricultural goods. Observations of zero trade may arise for several different reasons such as the lack of trade between the countries, rounding errors or simply due to poorly managed reporting (Bacchetta et al., 2012). However, there are solutions to the zero trade problem. One solution is to use a Poisson model which estimates the nonlinear gravity model in its original leveled form and therefore does not take the zeros into consideration. Further, combining the Poisson model with fixed effect, the fixed effect will drop all bilateral trade partners that solely report zero trade, minimizing the risk of dropping zeros containing valuable information.

If the gravity model is estimated with a linear regression model, the logarithmic form of the gravity model is needed. The natural logarithm of zero is however undefined which creates a dilemma. To adjust to the issue of zero trade in a linear model, the zero trade observations may either be dropped entirely or a small constant (e.g. 1 dollar) can be added to each observation to make the new zeros defined in a “ln-form”. With the first solution valuable information from zero trade may be lost and the efficiency of the regression will decrease. However it will not lead to inconsistent estimates. The second solution might however give inconsistent estimates using an OLS estimator.

In an econometric perspective, heteroscedasticity regards the issue when the error terms of the independent variables are not constant (Dougherty, 2016). Due to differences in countries’ size and income level, GDP differ among countries. Heteroscedastic errors are therefore common when dealing with trade flow data (Cerasa, Torti, Perotta, 2016). Heteroscedasticity in the explanatory variables will generate large standard errors for the estimation, which will worsen the efficiency of the estimations. The issue of heteroscedasticity is often taken care of by using robust standard errors or White's standard errors (Dougherty, 2016). Heteroscedasticity might also be solved using a nonlinear regression model, such as a Poisson model (Shepherd, 2016).

Another common problem when estimating gravity models is unobserved heterogeneity, meaning in our model, that trade between countries in the dataset could be explained by components that are specific to these pair of countries and that are not explained by the explanatory variables. With such components being constant over time, each country pair in the panel data would be affected in a different way, which has to be controlled for (Gomez Herrera, 2013).

Furthermore, endogeneity is the issue when one or many independent variables are correlated with the error term (Dougherty, 2016). Endogeneity may emerge due to measurement errors, autocorrelation, simultaneity or omitted variable bias. A common problem with trade data, especially when using panel data, is endogeneity caused by omitted variable bias (Raihan, 2016). Omitted variable bias is the problem of variables becoming omitted even though they may explain the dependent variable very well. When this is the case, the omitted explanatory variables end up in the error term, causing endogeneity.

Unobserved heterogeneity and endogeneity caused by omitted variable bias can be solved using the country-pair fixed effect. The country-pair fixed effect absorbs the omitted variables, mitigating both the issue of unobserved heterogeneity and endogeneity (Bacchetta et al., 2012).

As discussed above, endogeneity can also be caused by simultaneity, autocorrelation and measurement errors, especially when using panel data. A problem in the gravity model could be simultaneity between the dependent variable, imports in our case, and the independent variable, GDP. Intuitively an increase in imports could generate a larger GDP, while an increase in GDP could also generate a higher import. Using an Instrumental Variable (IV) instead of the original variable is a common and efficient, but possibly difficult way of dealing with the problem. The difficulty lies in finding a suitable IV since it needs to be highly correlated with the endogenous variable but at the same time non-correlated with the error term (Benedictis & Taglioni, 2011). The use of lagged explanatory variables is another solution. Taking the endogenous variable and lagging it at least one year could solve the issue of endogeneity. This however requires that the lagged variable is not correlated with the error term but highly correlated with the replaced variable (Shepherd, 2010).

6. Method of estimation

In order to analyze the equation specified above, we used STATA to run two regressions on the model. There is much to gain by trying different regression techniques on bilateral trade data. Therefore we decided to use two regression models, a linear which was estimated with the help of the reghdfe-command, and a nonlinear one, which was estimated with the xtpoisson-command. Using different models may work differently with our dataset and estimating with both of the two models will probably provide us with the best result possible. For example, the nonlinear poisson model drops observations with zero trade between country-pairs while the linear does not, leading to a large difference in numbers of observation depending on the estimation technique used.

In both of our estimations we used country-pair fixed effect and robust standard errors. The reasons for adding these features in our estimations are to avoid the data issues discussed above. We added robust standard errors for solving the problem of heteroscedasticity and the country-pair fixed effect helped us avoid endogeneity and unobserved heterogeneity.

When taking the natural log of the variables, they had to be slightly modified as ln of zero is not defined. Therefore, in order to avoid undefined values in our dataset, a small constant was added (1 unit) to the import and infrastructure variables. Leading to ln of one instead of ln of zero. Furthermore, by choosing estimation techniques other than the OLS, the risk of obtaining inconsistent estimates due to zero trade observations was avoided.

When generating the TF and infrastructure variables, the product of importer and exporter data was used. Estimating the variables independently is not useful to this thesis, thus we combined them to make the interpretation more simple.

The coefficients in the models can be interpreted similarly. The linear model can be interpreted as elasticities, one percent change in the independent variable changes the dependent variable a certain percent. The nonlinear coefficients are to be interpreted as a percentage change in trade when the explanatory variables change one log-unit.

Besides testing our baseline model, we will also test the robustness of the coefficients in the regressions. The reason for testing the robustness of the coefficients is to examine how the core coefficients behave when changing variables within the estimation. This is often done by adding or removing variables or by transforming one of the independent variables, e.g. by lagging the variable. If the coefficients are plausible and similar to the baseline specification, the coefficients are often considered reliable (Lu & White, 2010). We will perform a robustness tests for our coefficients where we use lagged TF variables. When using lagged explanatory variables, they can be seen as an instrumental variable and will therefore, as discussed above, estimate the coefficient with less presence of endogeneity. If the results with lagged TF variables are similar to the baseline estimation, the problem of endogeneity in the baseline estimation is probably small and the results are to be considered reliable.

7. Results

The R-squared, which tells us how well our independent variables manage to explain the dependent variable of our estimations, are around 75%. This is similar to other papers focusing on developing countries and agricultural trade. This result is therefore in line with our expectations. *GDP mass*, the log of the product from importer and exporter GDP, is positive in all four of our regressions and in three out of four the coefficient is significant as well. Being used as an explanatory variable for imports, *GDP mass* was expected to be positive and our result is thereby in line with economic theory. In our linear model the *GDP mass* coefficient is positive and significant at the one percent level in both of the estimations. The coefficients are also close to one, which means they are almost unitary elastic, as they theoretically should be. The coefficients 0.916 and 0.872 means that an increase of 1 percent in *GDP mass* would lead to an increase in imports with 0.916 and 0.872 percent respectively. For the *GDP mass*-coefficients in the nonlinear regression, column one and two, the interpretation is to be made in a different way. The significant coefficient equal to 0.643 is seen as a 1 log-unit increase in *GDP mass* increases import by 0.643 percent.

Table 2: Baseline specification results

	Poisson model		Linear model	
	(1)	(2)	(3)	(4)
VARIABLES	import	import	lnimport	lnimport
GDP mass	0.355	0.643*	0.872***	0.916***
	(0.352)	(0.335)	(0.205)	(0.204)
Road infrastructure	1.701**	3.857***	1.203**	1.897**
	(0.780)	(1.468)	(0.547)	(0.895)
Time to trade	31.847		26.569**	
	(20.081)		(11.861)	
Cost to trade		277.617***		64.855
		(100.586)		(54.294)
Time*Road	-13.107***		-8.597**	
	(4.783)		(3.763)	
Cost*Road		-60.660***		-29.186**
		(22.741)		(13.574)
Observations	3,708	3,708	7,308	7,308
R-squared			0.749	0.749
Number of country pairs	412	412	812	812

Note: Robust standard errors in parentheses. Asteriks denotes significance at the 1%(***), 5%(**) and 10%(*) level.

The TF indicators in our model specification were expected to have positive signs, i.e. a decrease in cost or time should increase imports. Looking at table 2, the variables *Time to trade* and *Cost* *to trade* both have positive coefficients, with two out of four being significant. The positive sign is as expected, when the cost and time for importing decreases, imports should increase. Just as in the explanation above, the significant estimation of the coefficient *Time to trade* in the linear model is interpreted as a 1 percent increase in quality, increases imports by 26.569 percent. For *Cost to trade* in the nonlinear model, a 1 log-unit increase in quality leads to a 277.617 percentage increase in imports. As we also expected, the coefficients of the TF indicators are large.

We predicted the infrastructure variable, *Road infrastructure*, to have a positive impact on imports. The intuitive thought is that higher quality of roads will facilitate trade and thus increase the intra-trade of agricultural product in SSA. According to our results, this is the case for road quality in SSA. The variable *Road infrastructure* was in all four regressions significant and positive, meaning that if the quality of roads increase, the trade between the nations in the dataset increase. The coefficient can be interpreted the same way as the TF coefficient. In the linear model, a 1 percent increase in *Road infrastructure* increases imports by 1.203 in estimation 3 and in estimation 4 the increase in imports is 1.897. In the nonlinear model, estimation 1 and 2, a 1 percent increase in the infrastructure variable increases imports by 1.701 and 3.857 respectively.

However, the variable that was supposed to answer the main question of the thesis, the interaction between TF and infrastructure, have the opposite sign of what we expected. We believed an increase in the quality of roads to increase the quality of the TF variables, however the coefficients for *Time*Road* and *Cost*Road* have negative signs, indicating that both costs- and time to trade increases when roads increase in quality. Also, all of the four estimates are significant.

There may be several reasons for the unexpected results. The infrastructure variable contains many missing values, which could be the reason for the unforeseen results of the interactive terms. A potential solution to this issue would be to exclude the missing values. However, using this approach we ended up with too few observations, causing insignificant results.

Also, there might have been an issue with the lack of observations in the data on imports. However, the poisson model dropped all country-pairs without bilateral trade and should therefore have had a better result than our linear model, but looking at table 2, that is not the case. The reason for lacking observations in imports might be the fact that we have chosen sectoral trade and mostly poorly developed countries. As we stated in section 2 "Trade facilitation & infrastructure", data with either sectoral trade or data on developing countries tend to be difficult to work with.

Another reason for the unexpected result of the interactive terms might be the lack of some independent variables such as political agreements or corruption. It is likely that bilateral trade might increase due to a Preferential Trade Agreement (PTA), even though the physical environment (roads) and the TF are worse within a PTA than between nations without a PTA. The presence of corruption may also bias the estimation. The level of corruption is however very difficult to include in the regression since the data on corruption in many cases is insufficient, thus corruption is in the error term of the estimation, biasing the result.

In total, the two estimation techniques partly managed to explain the data in the way we expected. In the regressions, several of the coefficients have the expected signs and are significant. Thereby supporting our expectations. The interactive terms however, did not behave as expected. Additionally, in regression (1) both *GDP mass* and *Time to trade* are insignificant. This is also the case for *Cost to trade* in regression (4).

7.1. Robustness test - Lagged trade facilitation variable

In this robustness test, the TF variables are transformed into a 1-year lagged variable. The size of the coefficients have not changed dramatically, except for the *Lagged time to trade* variable. In the baseline specification, the variable for time is positive but in this test it had a negative effect on trade. Further, after lagging the TF variables, most coefficients in the robustness test are insignificant. The both coefficients for *GDP mass* in the linear model, the coefficient for *Road infrastructure* in regression (3) and the coefficient for *Cost*Road* in regression (3) are all significant in the robustness test. As the results in the robustness test and in the baseline estimation are fairly similar, the endogeneity problem is most likely not a large issue in our baseline estimation and the coefficients can be assumed to be reliable.

Table 3: Robustness test with lagged TF variables

	Poisson model		Linear model	
	(1)	(2)	(3)	(4)
VARIABLES	import	import	lnimport	lnimport
GDP mass	0.525	0.257	0.922***	0.812***
	(0.353)	(0.359)	(0.208)	(0.207)
Road infrastructure	1.734	0.639	1.787**	0.439
	(1.533)	(0.766)	(0.842)	(0.505)
Lagged cost to trade	59.256		50.108	
	(53.291)		(38.118)	
Lagged time to trade		-4.799		-10.982
		(15.349)		(7.776)
Cost*Road	-28.798		-27.453**	
	(23.061)		(12.751)	
Time*Road		-5.831		-3.288
		(4.719)		(3.479)
Observations	3,708	3,708	7,307	7,307
R-squared			0.749	0.749
Number of country pairs	412	412	812	812

Note: Robust standard errors in parentheses. Asteriks denotes significance at the 1%(***), 5%(**) and 10%(*) level.

8. Summary and conclusion

The aim of this thesis was to estimate the interaction between infrastructure and TF on agricultural products for 29 countries in SSA. Having found no other papers investigating this relationship, our hope was to shed light on this issue and bring further knowledge about the importance of this subject for sectoral trade in developing countries. Displaying positive and significant coefficients for both the infrastructure and TF variables, the results of this paper adds to the existing literature highlighting TF and infrastructure's potential to increase trade. Focusing on agricultural products, this paper indicates that improvements in TF and infrastructure can be important for the food supply in SSA. We were however not able to show that the marginal effect of infrastructure on TF has a positive effect on trade in agricultural products, indicating that there might be other factors for these countries than the interaction between infrastructure and TF that facilitates trade. There is however still theoretical reason to conduct further research on this very subject, particularly on the marginal effect of infrastructure on TF.

For future studies, including more nations and more agricultural commodity groups would most likely have provided more valuable observations which could have benefited the analysis. Further, the presence of corruption in the nations in our dataset may very well have an impact on trade flows and it would therefore be interesting to find data that might strengthen our belief in that matter. Another interesting approach would be to investigate if the interactive term in this paper could have the desired effect when looking at higher income-level countries or in another regions. Further studies in this field are therefore encouraged, not only on SSA, but globally as well.

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