Misaligned distance: Why distance can have a positive effect on trade in agricultural products

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Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29, 2014.

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Abstract

This contribution argues and proves empirically that trade in agricultural products could be the higher the more distant two trading partners are. Distance in agricultural trade does not only reflect transport costs but also differences in climatic and cultivation conditions and, thus, in resource endowment of two trading partners. A gravity model is enhanced by different variables that capture differences in factor endowment. The model is estimated for an annual panel of agricultural trade flows of nearly 10,000 country pairs for the period 1970 to 2010. We show that the interpretation of the distance coefficient as transport costs' effect is misleading as the transport cost related effect of distance is underestimated if the model does not account for differences in growing conditions. Particular, a trade increasing effect for North South distance shows up. Moreover, we find that this pattern is clearer the more disaggregated the product group is.

1 Introduction

In studies on the determinants of trade flows and trade costs it has been frequently proven that transport costs are a major trade-hampering factor (e.g. Anderson and van Wincoop 2004). In the lack of true data on transport costs the distance between trading partners is regularly used to proxy transport costs. It is understood that the higher the distance the higher the transport costs are and, thus, the lower trade between two countries is.

Opposed to this point of view, the article argues and proves empirically that trade in agricultural products could be the higher the more distant two trading partners are. It is argued that distance in agricultural trade does not only reflect transport costs but also differences in climatic and cultivation conditions of two trading partners. Trade in agricultural products occurs due the possibilities to cultivate different crops in different growing areas of the world. Generally speaking, the more distant two countries are the more different are the cultivation conditions and the more different are the products produced and the basket of supplied goods. This point of view is consistent with a comparative advantage model of trade as advantages occur due to favorable/different growing conditions. Additionally different growing conditions can be seen as differences in factor endowment, a common known reason for trade. If this argumentation holds, interpreting the distance coefficient as transport cost effect is misleading. Moreover, the transport cost effect on trade could be underestimated.

The motivation of this study is, thus, to provide evidence on the development of distance effect in agricultural trade and more important to relate the effect of distance to differences in resource endowment. The article considers the described patterns by taking into account different areas of cultivation and different measures to captures differences in growing conditions in a trade model. Without doing so, an interpretation of the distance coefficient as transport costs' effect is misleading as the effect of distance is underestimated.

The reminder of this study is organized as follows. The next section gives a literature based overview on transport costs, the usage of distance as a proxy for transport costs and its relevance as trade-hampering factor. Based on this hypotheses underlying the motivation of this paper are derived. Section 3 presents the estimated gravity equation, describes the measurement of different growing conditions and introduces the data. In Section 4 results are presented and discussed and the last section concludes.

2 Literature review: Transport costs, distance and gravity

Trade costs are a major element of gravity type studies and "[…] the most important contribution of the gravity equation is that it points out the relevance of trade costs." (van Bergeijk and Brakman, p.14). Broadly defined trade costs include all cost of bringing a good from the producer to the consumer. Trade costs capture a nearly infinite range of measures reaching from manmade trade barriers such as tariffs and non-tariff trade barriers to the cost of physical transportation. Anderson and van Wincoop (2004) show that for industrialized countries on average trade costs tax equivalent is roughly 170% of the mill prices. Thereof 21% are transportation costs, 44% are border-related trade barriers, and 55% are retail and wholesale distribution costs (2.7=1.21* 1.44*1.55). Transport costs include a 9% tax equivalent of the time value of goods in transit.[1]

In empirical studies transport costs are regularly captured by the distance between two trading partners, a fact that can be traced back to three major reasons. First, the gravity equation was "derived" by Tinbergen (1962) and Pôyhönen (1963) from Newton's law of universal gravitation known from physics. The law of universal gravitation states that the force of attraction between two bodies is directly proportional to the product of the masses of the bodies and inversely proportional to the square of the distance between them. Thus, there is a type of a historical reasoning. In theoretical foundations of the gravity equation done nearly 20 years later by Anderson (1979) or Anderson and van Wincoop (2003) trade costs enter the derivation as producer prices in the origin country are converted to consumer prices in the

[1] Behar and Venables (2010) provide another comprehensive overview on transport cost in international trade.

destination county via a trade cost factor. In empirical solutions this trade cost factor is described by a vast number of variables (see below). In the lack of true data on transport costs, the distance between trading partners is regularly used to proxy transport costs.[2] This lack of data and the simplicity to implement data on the distance is the second reason to use distance as a proxy. Third reason is that it works well in the empirical solutions as well in the sense of a high explanatory power of the models and the plausibility of the results. This is especially true for high aggregated level of trade flows.

However, in recent decades two in trade cost related away opposed patterns in international trade that have direct impact on the effect of transport costs and distance can be observed. First there is the general globalization and the increasing international trade that maybe can be described best with Friedman's (2005) statement "The world is flat" or the discussion on the "death of distance" as proclaimed by (Cairncross, 1997). Glaeser and Kohlhase (2004) argue for instance that technological change has now eliminated most transport cost charges related to trade.

On the other hand in recent years there is an increasing trend towards the regionalization of world trade as regional trading blocs (see e.g. Frankel, 1997), regional trade agreements and integration of markets such as the EU are fostered leading to increasing trade of mostly contiguity or nearby member countries. While the first point would state that transport costs and distance are becoming less important, the second point implies an increasing effect of distance on trade as trade flows are redirected from non-member to inter-member trade. However, as liberalization and general reduction of tariffs was fostered by many countries in the last decades, the relative importance of transport cost as trade-hampering factor has increased (Clark et al. 2004; Hummels, 2007).

Indeed, Hummels (2007) shows that the price of ocean shipping exhibit little change from 1952-1970 than substantially increased through the mid-1980-s, followed by a decline in the next 20 years. Hummels argues that cost reductions related to technological advantages such as the introduction of standardized containers were offset by increasing prices of inputs foremost oil prices. In a meta-analysis of 1,467 distance effects in more than 100 studies Disdier and Head (2008) found that the elasticity of trade in respect to distance is -0.9 with 90 % of estimates lying between -0.28 and -1.55. Where a slightly decrease could be obtained in the first area of globalization, a stronger rose of the trade hampering effect was obtained in the

[2] The best way to obtain data on transport cost would be industry or shipping firm information. This data are hardly available. An alternative is to calculated cif/fob ratios or to use these ratios as provided by the IMF. However, as Hummels and Lugovskyy (2005) show, cif/fob quotients are only good for very disaggregated trade data.

middle of the last century and the effect has remained persistently high since then (see also van Bergeijk and Brakman, 2010). Comparing both studies the main puzzle can be found in the reduction of transport costs in the last two decades but remaining high importance of distance as trade hampering factor. Additionally Hummels (2007) shows that the level of air transport cost drops relative to the level of ocean transport and that the marginal cost of an additional mile of air transport is dropping rapidly. Thus, long distance trade became more attractive.

Researchers are well aware of the fact that distance, in general, is a far away from being an entire proxy for transport costs for mainly two reasons. First, it has been argued that distance can reflect more than transport costs. Second, studies using actual data on transport costs come to ambiguous/doubtful results concerning the effect of distance on transport costs.

As for the first point Ghemawat's (2001) CAGE-model that separates between cultural, administrative, geographical and economic distance is helpful. The importance of the four dimensions of distance differs between sectors and products. The cultural distance that scopes, e.g. linguistic and confessional differences as well as moral codes is supposed to play an important role in agricultural trade. Additionally, one has to separate between mental distance, that is defined as the sum of factors that hamper the collection of information about foreign markets and physical distance. Grossman (1998) speculates that the reason why distance matters so much is a lack of familiarity or cultural differences. Huang (2007) proves this by disentangling the unfamiliarity and transport cost effect of distance. The author shows that countries high in uncertainty-aversion export disproportionately less to distant countries with which they are less familiar. Additionally, Huang finds that this result is mainly driven by differentiated products and not by homogeneous or reference priced goods.

Studies using actual data on shipping costs show that distance might be an inadequate proxy for transport costs. Hummels (2007) shows that the elasticity of transport cost in respect to distance is not close to 1 but 0.15 for sea freight. Clark et al. (2004) calculate an elasticity in around 0.2 for United States imports and Abe and Wilson (2009) conclude in their review that the elasticity with respect to port-to-port distance is between 0.14 and 0.21. Some authors show that transport costs are not only defined by distance but also from other variables. Limao and Vanables (2001) emphasize the dependence of transport costs on the quality of infrastructure and countries' geography. Using price quotes for a shipment of a standardized container from Baltimore (U.S.) to different destinations in the world as well as cif/fob ratios they conclude that poor infrastructure accounts for 40 to 60% of predicted transport costs. Additionally, they find that overland transport is seven times more costly than sea transport.

Clark et al. (2004) support the relevance of efficiency of infrastructure investigating the determinants of shipping costs to the United States. They find that port efficiency that includes the prevalence of organized crimes, excessive regulations as well as general condition of country's infrastructure increase handling costs which are a part of transport costs. Additionally they find strong evidence for increasing returns to scale and economics of scale in transport economics. Using data on road transport cost for French employment areas and different measures of transport costs Combes and Lafourcade (2005) conclude that proxies to capture transport costs, such as great circle distance, real distance, or real time of transport do a good job in cross section analysis but work rather well in time series analysis. Additionally, the authors find that changes in the transport industry market structure and in technology are the sources of a decrease of transport costs rather than the mode of infrastructure. Additionally, there is this ambiguous pattern (feeling) that the transport sector which is one of the most volatile sectors in world economic is represented by a proxy that shifts in the speed of continental drift. However distance, in general is a far away from being an entire proxy for transport costs.

The major argumentation this study follows is that distance can reflect differences in factor or resource endowment, especially in different climate and growing possibilities. We follow the basic argumentation of Melitz (2007) and argue that distance especially in agricultural trade flows not only reflects transport cost but also differences in factor/resource endowment. In our argumentation distance is related to differences in climatic and cultivation conditions of two trading partners and different possibilities to grow a wide range of agricultural products. Trade in agricultural products occurs due the possibilities to cultivate different crops in different areas of the world. As on example, consumers in industrialized countries have a high willingness to pay for a differentiated basket of food products, including, e.g., tropical fruits. Due to considerable imports of these products, a trade-increasing effect related to distance shows up as growing areas of tropical fruits are far away. Generally speaking, the more distant two countries are the more different are the cultivation conditions and the more different are the products produced. As for example the temperature becomes more different the countries become less similar in resource base, export more dissimilar products and trade more. If factor endowment changes for example with North-South distance and climate differences the basis for Ricardian trade increases (Melitz, 2007). Following this argumentation there is a strong hint that trade occurs on the basis of comparative advantages due to different climate conditions. Moreover, there are not only relative but also absolute advantages in producing agricultural products as it is simple impossible to grow for example bananas or coffee in Central Europe. Another obvious reason for trade in agricultural products whose storability is limited is the seasonality and different harvesting times over the world. As consumer demand for fresh fruits throughout the year, non-storable products are imported. Opposed to this argumentation, Leamer and Stern (1970: 164) argue that “On the other hand, tastes may be molded by the domestic production, and the consequent dissimilarity of tastes may induce countries with dissimilar resources to trade less”. The ‘dissimilarity of tastes’ can nowadays be extended to dissimilarities in societies’ requirements for food safety which find expression in countries’ legislation and import restrictions such as non-tariff trade barriers.

Pulliainen (1963) is an early empirical study including a measure of long-term mean temperature differences to capture differences in resource endowments (see Leamer and Stern (1970). Melitz (2007) also follows the argumentation of trade increasing effect of differences in factor endowment by measurer factor endowment by North-South distance and different measures of climate conditions, such as rainfall and average temperature. The author concludes that the impact of North-South distance is about 13% of the ordinary distance. As Melitz also controls for other measures in differences in factor endowment, such as climate difference in counties’ latitude reflect differences in production opportunities.

We expect the described pattern to be clearer the more disaggregated product groups are considered and be clearest for single products, such as green coffee beans that can be grown only in a geographical small area near to the equator. Additionally, trade in raw products/ commodities and in goods with limited storability and different harvest seasons around the world is more affected. Implications rising from this argumentation are serious. If a trade increasing effect related to distance shows up due to the differences in resource endowment, the estimated transport cost effect of distance is underestimated leading to wrong conclusion concerning the effect of transport costs on agricultural trade.

3 Gravity model and data

3.1 Theoretical consideration

To test the hypothesis raised above we apply a gravity model enhanced by various variables capturing differences in growing condition and differentiated distance variables. The gravity equation was derived from different models of international trade by several authors (Anderson, 1979; Helpman, 1987; Deardorff, 1998; Anderson and van Wincoop, (2003). Bergstrand’s (1985, 1989, 1990) derivations explicitly allow for Heckscher-Ohlin and Ricardian trade and are thus, noteworthy for our purpose. However, Anderson and van

Wincoop's (2003) derivation from a full expenditure became the most frequently referred reference in studies applying the gravity model. They established the specification:

$$T_{od} = Y_o E_d \left(\frac{\tau_{od}}{\Pi_o P_d}\right)^{1-\sigma} \quad (1)$$

where T_{od} is the value of bilateral exports of a good from origin county o to destination country d. Y_o is o's total sales to all destinations (including country o itself) and, thus, equal country o's output. E_d is the destination country's expenditure on tradable goods. In empirical studies, counties' GDPs are usually used as proxies for both Y_o and E_d. τ_{od} are all kind of man-made and natural bilateral trade costs. Distance between o and d and various other measures (see below) that make the gravity equation to wide applicable tool are used to capture trade costs. σ is the elasticity of substitution that is assumed to be larger than one.

A novelty of Anderson and van Wincoop's (2003) derivation is the introduction of the 'relative prices matter terms', Π_o and P_d, that capture the so-called 'multilateral resistance'. The concept of multilateral resistance suggests that two states, which are close to each other but far away from other markets, would ceteris paribus trade more between themselves, compared to two different countries that are equally close but located in the middle of a huge market or near to other potential trading partners. These relative prices depend on all bilateral trade resistances and, additionally, are a function of bilateral trade costs. To solve this problem of circular references the authors assume bilateral trade costs (e.g. $\tau_{od} = \tau_{do}$) and estimate a special non-linear system of equations. By now, some other easier to implement methods to determine the price terms Π_o and P_d have been developed (e.g. Baier and Bergstrand, 2009). However, a widespread and easy to implement method to account for multilateral resistance is to include country fixed effects that capture the relative price terms in a panel analysis (Anderson and van Wincoop, 2003). However, including fixed effects makes it impossible to estimate effects of time invariant covariates, such as distance and distance related factors that are captured by dummy variables, e.g. a common religion, language or historical ties between countries, as these variables are perfectly correlated with the fixed effects. However, usually there are also estimates done without fixed effects and the distance effect is than often referred to as transport costs

3.2 Empirical specification

Rewriting Eq. 1 in a reduced and log-linearized form while substituting Y_o and E_d by countries' GDPs and taking distance (*Dist*) as a proxy for trade costs yields in

(2) $$\ln(T_{od,t}) = \alpha + \beta_1 \ln(GDP_{o,t}) + \beta_2 \ln(GDP_{d,t}) + \beta_3 \ln(Dist_{od}) + \mu_{od} + \varepsilon_t + u_{od,t}\,.$$

μ and ε are a full set of country and time specific fixed effects that capture the multilateral resistance terms as well as all other unobserved country and time specific effects. u is an error term assumed to be *iid*.

There are a nearly infinite number of trade- hampering and trade-driving factors that are summarized in the vector Z. The estimated GM accounts for various trade-driving factors known from literature such as cultural and political commonalities (common languages, religion and colonial ties), geographical characteristics (sea access and common land border), trade partners' general openness to trade, their remoteness, tariffs, free trade agreements, and currency unions. Table 1 presents an overview on covariates we identified and used in our study.[3]

For our purpose the estimated gravity model is enhanced by various variables capturing differences in growing condition. The first one is to take into account differences between the trading partners' average precipitation (ΔPreci) and average temperature (ΔTemp).[4] The differences in precipitation that enter the estimation in logarithmic form are calculated by ($|Preci_o$ - $Preci_d|$+1) to avoid taking logs of non-positive numbers. Same holds true for the differences in temperature. Second, the distance between countries is divided into its horizontal (East-West distance, EW) and vertical vector (North-South, NS). The latter is supposed to reflect differences in growing conditions. The hypothesis is that the higher the NS-distance the more different are the growing conditions and, thus, the more trade between the countries occurs. As growing conditions do not remarkably change with EW distance, the horizontal vector is supposed to reflect transport cost and other trade hampering effects related to distance, e.g. unfamiliarly or a lack of information. NS distance is calculated assuming assuming a distance of 111 km between each degree of latitude. EW distance is calculated with the great circle formula that is commonly used to calculated distance between

[3] We also tried to capture transport costs by the World Bank's measure of the cost to export a standardized container (cost to export). Additionally, we tried to capture the quality of infrastructure in the countries by the Logistic Performance Index. However, results were less promising and, thus, are not presented here.
[4] Note that data on average temperature and precipitation are only available for some years at the World Banks database. We build the arithmetic average in the case that more than one value was available for a specific country. Thus, the variables are time independent. However, we are satisfied with this data as our intention is to observe long term differences in growing conditions as the structure of cultivated crops unlikely to change from year to year due to annual changes in weather conditions.

two places on earth. As the earth is a sphere there are two direct ways to get from one place to another. The shortest way is chosen for EW and NS distance, respectively.[5]

The gravity model is often estimated via ordinary least squares (OLS). Silva and Tenreyro (2006) show that under the persistence of heteroskedasticity, which is often the case in gravity estimations, usage of OLS techniques results in biased estimates. They concluded that the Poisson pseudo-maximum-likelihood (PPML) estimators should be used instead. A further advantage of the PPML is that it gives higher weight to zero values in the dependent variable. Silva and Teneyro (2006) argue that PPML estimates are a consistent way to account for zero trade flows. Indeed, PPML-estimates became common practice in gravity research and, thus, only those results from PPML estimates are presented in this manuscript.

[5] We also checked out differences of two countries' proximity to the equator. Growing conditions are likely to change equally if one moves from the equator in the northern or southern hemisphere. Thus the difference of two countries' proximity to the equator might better capture differences in growing conditions. However, results were mixed and, thus, are not presented in this manuscript.

Table 1: Overview on variables of the estimated gravity model

Name	Description	Ex. sign	Source	Selected literature
GDP	**G**ross **d**omestic **p**roduct in US-$	+	World Bank WDI	
GDPpc	**p**er **c**apita **GDP** in US-$	-	World Bank WDI	
Dist	Direct d**ist**ance between main cities of trading partners measured in km	-	Calculated with great-circle formula.	Disdier and Head (2008)
Δ Temp	Difference in countries' average **temp**erature $(\|Temp_o - Temp_d\|+1)$	+	World Bank WDI	Pulliainen (1963)
Δ Preci	Difference in countries' average **preci**pitation $(\|Preci_o - Preci_d\|+1)$	+	World Bank WDI	
NS-Dist	(Shortest) **n**orth-**s**outh **dist**ance between main cities of trading pair in km	+	Calculated assuming a distance of 111 km between each degree of latitude.	Melitz (2007)
EW-Dist	(Shortest) **e**ast-**w**est **dist**ance between main cities of trading pair in km	-	Computed with adjusted great-circle formula.	
Open	**Open**ness captures a country's general openness to trade and is calculated as a sum of a country's total exports and imports divided by its GDP, i.e. $Open_{d,t} = \frac{EX_{d,t}+IM_{d,t}}{GDP_{d,t}}$. Open captures a country's general orientation to international trade and measures overall protection.	+	Calculated with UNcomtrade and World Bank data	
Rem	**Rem**oteness measures a country's relative distance to potential markets/ trade partners. It is the average distance of a country to all possible trading partners k, using partners' share of the world's GDP as weights, i.e. $Rem_{d,t} = \sum_{k}^{n,k\neq d} Dist_{dk} * \frac{GDP_{k,t}}{GDP_{W,t}}$.	-	Calculated with World Bank data	Frankel, (1997: 143), Wei (1996)
TR	Tariff rate (ad valorem; %) applied on imports. One is added to avoid taking logs in the case of no tariff is applied or missing data.	-	World Integrated Trade Solution (WITS)	
Religion	Dummy; 1 indicating that at least 40 % of the inhabitants in the respective trading pair share a common religion.	+	compiled on information of CIA World Factbook	
Language	Dummy; 1 indicating that both countries use a common official language.	+	CEPII gravity database	Egger and Lassmann (2012), Melitz (2008)
Colony	Dummy; 1 indicating a colonial tie between trading partners; i.e. one countries was a colony of the other country.	+	CEPII gravity database	Head et al. (2010)
Contiguity	Dummy; 1 indicating that countries share a common land boarder.	+	CEPII gravity database	
Landlocked	Dummy; 1 indicating that country is landlocked.	-	CEPII gravity database	
non-Euro EU	Dummy; 1 indicating that both countries are members of the EU, but have not (yet) introduced the Euro as currency.	+	Own compilation	

Euro	Dummy; 1 indicating that both trading partners are members of the Euro zone and use the Euro as currency	+	Own compilation	Baldwin (2006), Baldwin et al. (2008), Berger and Nitsch (2008), Flam and Nordström (2006), Nitsch and Pisu (2008)

Source: own compilation.

3.3 Data

The model introduced above is estimated for an annual panel of developed and emerging countries trade with all their trading partners. The panel includes trade of EU27 member states plus all other OECD-countries and BRICS-countries (n=49) with all trading partners included in UNcomtrade database (n=217). The annual panel covers the period from 1970 to 2010 and, thus, in total 435,953 observations (49*217*41years). As not all countries exist during the whole period of 41 years the number of possible observations reduces to 352,704. Products included in this study capture the food and agricultural sector in total. Actual it is the sum of the four product groups 'Food and live animals (SITC 0)', 'Beverages and tobacco (SITC 1)', 'Oil-seeds and oleaginous fruits (SITC 22)' and 'Animal and vegetable oils, fats and waxes (SITC 4)' as termed in Standard International Trade Classification (SITC). As even less and least developed countries are included in the panel and trade values reported by those countries are generally assumed to be less reliably, we chose mirror techniques to obtain trade flows. Thus, the dependent variable is the average of four reported trade values, i.e. the average of exports from country *o* to *d* as reported by country *o*, the imports of *d* from *o* as reported by *d*, the exports from *d* to *o* as reported by *d* and the imports of *o* from *d* as reported by *o*. A positive trade flow, i.e. trade actually occurs, in 241,117 cases or 68.4% of all observations. All other observations are treaded as zero trade flows. However, additionally observations are lost as not all variables are available for each country in each year. Trade values are extracted from the UNcomtrade database. Data on precipitation and temperature are from World Bank's World Development Indicators (WDI). All other variables originate from commonly known databases such as the WDI, WITS-database, IMF and the CIA World Factbook. Additionally, some variables are taken from CEPII's (Centre d'Etudes Prospectives et d'Informations Internationales) datasets. For more information on this data see Mayer and Zignago (2011).

4 Results

First, it is self-explanatory according to our argumentation that the distance variable is to a certain extent correlated with the difference in average temperature (ρ=0.16) and precipitation (ρ=0.29) (Table 2). The correlation of differences in precipitation and NS distance is even lower, whereas the correlation of differences in temperature and NS is higher. However, in general the size of the coefficients is low.

Table 2: Correlation of selected variables

	Dist	Δ Preci	Δ Temp	NS Dist	EW Dist
Dist	1	0.29	0.16	0.59	0.46
Δ Preci	0.29	1	0.32	0.20	0.18
Δ Temp	0.16	0.32	1	0.35	0.18
NS Dist	0.59	0.20	0.35	1	0.22
EW Dist	0.46	0.18	0.18	0.22	1

Source: own computation.

Table 3 presents the outcomes of the estimated gravity equation in different model specifications. All models are estimated with PPML-techniques. Variables that are denote by the subscribe *o* denote EU, OECD and BRICS countries and *d* denotes the trading partner. As the high adjusted R^2 indicates the model explains variation in bilateral agricultural trade flow quit well. Note that across all specifications coefficient of the standard gravity variables are robust, accept of the remoteness that is to a certain extent correlated with distance (ρ=0.45). Additionally, if the direct distance is excluded the coefficient of the contiguity variable roughly doubles. This is also intuitively and correct as without the distance variable the contiguity variable captures a larger part of the trade increasing effect related to the geographical proximity that otherwise would be part of the distance variable. Nearly all coefficients of the standard variables have the expected sign and magnitude. As one example for the interpretation of dummy variables we observe a trade increasing effect of the Euro in model 1 in the amount of $[(e^{0.29}-1)-(e^{0.18}-1)]*100 = 13.9\%$[6]. This is in line with the findings of Baldwin (2006) and Berger and Nitsch (2008) among others. What we cannot yet explain is the positive effect of a o countries' remoteness.

Now turning to the variables that are of particular interest for our purpose we note that in the model without climatic variables, distance has an effect (elasticity) on trade flows in the range of -0.5. The effect size is in line with the gravity literature. Differences in temperature has across all models a significant negative influence on trade flows (-0.29) whereas difference in

[6] Note that due to the specification of the variable *non-Euro EU*, the variable *Euro* captures both, the trade-increasing effect of the EU and the trade-increasing effect of the common currency. Thus, to calculate the pure Euro-effect, the EU effect needs to be subtracted.

Table 3: Estimation outcomes of different model specifications

	1	2	3	4	5	6
const	-10.6 ***	-10.4 ***	-7.53 ***	-9.68 ***	-9.65 ***	-7.08 ***
	0.57	0.54	0.45	0.48	0.48	0.41
GDP_o	0.63 ***	0.65 ***	0.62 ***	0.66 ***	0.66 ***	0.64 ***
	0.01	0.01	0.01	0.01	0.01	0.01
GDP_d	0.67 ***	0.70 ***	0.66 ***	0.69 ***	0.69 ***	0.66 ***
	0.01	0.01	0.01	0.01	0.01	0.01
$GDPpc_o$	-0.19 ***	-0.20 ***	-0.19 ***	-0.2 ***	-0.2 ***	-0.19 ***
	0.01	0.01	0.01	0.01	0.01	0.01
$GDPpc_d$	-0.1 ***	-0.10 ***	-0.09 ***	-0.12 ***	-0.12 ***	-0.11 ***
	0.01	0.01	0.01	0.01	0.01	0.01
$Open_o$	-0.01	0.00	0.11 ***	-0.03	-0.03	0.08 ***
	0.02	0.02	0.02	0.02	0.02	0.02
$Open_d$	0.10 ***	0.11 ***	0.23 ***	0.05 ***	0.05 ***	0.18 ***
	0.02	0.02	0.02	0.02	0.02	0.02
Rem_o	-0.18 ***	-0.22 ***	-0.45 ***	-0.29 ***	-0.29 ***	-0.52 ***
	0.04	0.04	0.03	0.04	0.04	0.03
Rem_d	0.33 ***	0.25 ***	-0.03	0.21 ***	0.21 ***	-0.06 **
	0.04	0.04	0.03	0.03	0.03	0.03
TR_o +1	-0.08 ***	-0.07 ***	-0.11 ***	-0.08 ***	-0.08 ***	-0.11 ***
	0.01	0.01	0.01	0.01	0.01	0.01
TR_d +1	-0.06 ***	-0.06 ***	-0.1 ***	-0.06 ***	-0.06 ***	-0.1 ***
	0.01	0.01	0.01	0.01	0.01	0.01
Religion	0.56 ***	0.49 ***	0.63 ***	0.45 ***	0.44 ***	0.59 ***
	0.03	0.02	0.02	0.02	0.02	0.02
Language	0.66 ***	0.61 ***	1.24 ***	0.62 ***	0.62 ***	1.22 ***
	0.03	0.03	0.03	0.03	0.03	0.03
Contiguity	0.66 ***	0.61 ***	1.24 ***	0.62 ***	0.62 ***	1.22 ***
	0.03	0.03	0.03	0.03	0.03	0.03
Colony	0.15 ***	0.22 ***	-0.17 ***	0.17 ***	0.17 ***	-0.21 ***
	0.02	0.03	0.03	0.02	0.03	0.03
$Landlocked_o$	-0.84 ***	-0.83 ***	-0.94 ***	-0.84 ***	-0.84 ***	-0.95 ***
	0.02	0.02	0.02	0.03	0.03	0.02
$Landlocked_d$	-0.77 ***	-0.74 ***	-0.85 ***	-0.78 ***	-0.79 ***	-0.9 ***
	0.02	0.02	0.02	0.02	0.02	0.02
non-Euro EU	0.18 ***	0.18 ***	0.53 ***	0.16 ***	0.16 ***	0.51 ***
	0.02	0.02	0.03	0.02	0.02	0.03
Euro	0.29 ***	0.25 ***	0.51 ***	0.26 ***	0.27 ***	0.54 ***
	0.03	0.03	0.03	0.03	0.03	0.04
Dist	-0.54 ***	-0.67 ***		-0.65 ***	-0.65 ***	
	0.01	0.01		0.01	0.01	
Δ Preci				-0.01	-0.01	0.02 ***
				0.01	0.01	0.01
Δ Temp				-0.29 ***	-0.29 ***	-0.29 ***
				0.01	0.01	0.01
NS Dist		0.15 ***	-0.12 ***	0.21 ***	0.21 ***	0.01 **
		0.01	0.01	0.01	0.01	0.01
EW Dist		-0.01	-0.05 ***	0.01		-0.11 ***
		0.01	0.01	0.01		0.01
N	176,372	176,356	176,356	162,986	162,986	162,986
Adj. R^2	0.728	0.739	0.706	0.767	0.767	0.716

All continuous variables enter logarithmic. Robust standard errors are shown below the coefficients. *, **, *** denotes significance at 10, 1 and 0.1 % error term level. Source: own estimations.

precipitation has a small but significant trade-increasing effect only in model 6. Note that the inclusion of all four variables increases the adjusted R2 by four percentage points (compare model 1 and 4). Decomposing the distance into a NS and an EW vector leads to fruitful insights. Having a coefficient in the range -0.05 to -0.11 the EW distance explains a big part of the trade hampering effect of distance. The NS distance has a positive impact in the range of0.01 to 0.21, meaning that the higher the NS distance between countries is the higher is the trade between these countries. Most interesting is that if NS distance and the direct distance are included in together in an estimation (models 2, 4 and 5) the trade hampering effect of the direct distance raises by 0.11 to 0.12 points. In these cases the NS distance shows a significant positive coefficient in the amount of 0.15 to 0.21.We interpret this positive effect as caused by differences in factor endowment.

5 Conclusions

This manuscript argues that distance in agricultural trade reflects more than transport costs. Countries are characterized by different growing conditions and, thus, by different resource endowment. These differences are related to distance. As differences in factor endowment are a reason for trade and as differences are the higher the larger the distance is, a trade increasing effect related to distance shows up. The main hypothesis is that the more distant two countries are the more different is their resource endowment and the more different are the products produced and the higher is trade between those two countries.

We prove this hypothesis by enhancing a gravity model by different measures to capture differences in growing conditions. We find that North-to-South distance has a trade increasing effect and opposed to the general findings of gravity literature we find that a trade increasing effect of distance can show up. Particular, an increase of NS distance by 1% increases trade by 0.15 to 0.21%. The results strongly confirm that distance in agricultural trade reflects more than transport costs and that interpreting the distance coefficient as transport costs effects is misleading. Moreover, interpreting the distance coefficient as transport cost factor leads to underestimated influence of transport cost on agricultural trade flows. When analyzing agricultural trade in a gravity equation it is insightful to include variables that account for different growing conditions and, particularly to separate distance into its horizontal and vertical component.

The described pattern is true for the total sector trade but may even become clearer when product sub-groups such as fruits and vegetables are considered. While total sector trade also contains value-added products that are less vulnerable to growing conditions trade in fresh fruits is highly influenced by growing conditions. First estimates done with single products (not presented here) lead us to the conclusion that the described pattern becomes even clearer e.g. in the case of trade in raw coffee.

It would be very insightful to check the argumentation underlining this study with true data on transportation costs of agricultural trade. Moreover, it would be interesting to investigate the effect of distance and growing conditions in a seasonal approach. As the availability of goods characterized by a short shelf life varies between countries, seasonality is another reason for trade in agricultural products. However, more robustness checks need to be done as results vary by estimation method and by method to deal with zero trade flows.

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