Information and communication infrastructure development and agro-food trade

Vývoj komunikační a informační infrastruktury a zemědělsko-potravinářský obchod

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Abstract: The purpose of this paper is to provide an adapted gravity trade model to measure the influence of communication infrastructure development on agro-food trade. The adapted gravity trade model presents associations of bilateral agro-food trade between OECD countries with traditional gravity equation variables and particularly with variables of the information and communication infrastructure development. Using the adapted gravity trade model we find a positive association between the information and communication infrastructure development and bilateral agro-food trade flows between OECD countries. This association is significantly stronger for agricultural than for food products. The improved information and communication infrastructure development improves information and reduces trade transaction costs.

Key words: communication infrastructure, agro-food trade, adapted gravity model, OECD countries

Abstrakt: Cílem tohoto příspěvku je vytvořit adaptovaný gravitační model, který by měřil vliv vývoje komunikační infrastruktury na zemědělsko-potravinářský obchod. Adaptovaný gravitační model asociuje bilaterální zemědělsko-potravinářský obchod mezi zeměmi OECD s proměnnými tradičních gravitačních rovnic a zejména s proměnnými rozvoje informační a komunikační infrastruktury. S využitím adaptovaného gravitačního modelu jsme nalezli pozitivní asociaci mezi vývojem informační a komunikační infrastruktury a toků zemědělsko-potravinářského obchodu mezi zeměmi OECD. Tato asociace je významně silnější pro zemědělské než pro potravinářské komodity. Zlepšený rozvoj informační a komunikační infrastruktury zlepšuje informace a snižuje transakční náklady obchodu.

Klíčová slova: komunikační infrastruktura, zemědělsko-potravinářský obchod, adaptovaný gravitační model, země OECD

The globalization of food chains and the increasing role of the international food supply chains have changed the geographical patterns in agricultural trade towards an increasing share of the global agricultural trade in similar products between developed countries (FAO 2005). In Europe, the most recent agro-food trade flows are significantly determined by the impacts of the European Union (EU) enlargement on the development of the internal (intra) and external (extra) trade (Svatoš and Smutka 2009). This holds also for most new members of the EU such as for example for the Czech Republic (Bašek and Kraus 2009). Most of the EU countries are also members of the Organisation for Economic Cooperation and Development (OECD), which is the focus of the analysis in this presented paper.

International trade plays a significant role in the economic growth and in the economic development (e.g. Jeníček and Krepl 2009). The significant changes in agro-food trade flows have been caused by the trade policy developments and technological changes since the mid-1990s by the implementation of GATT/WTO agreements, trade liberalization and free trade agreements that have been stipulated among

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the world's most developed countries, and the rapid technological changes in the information and communication technologies and in their infrastructure development worldwide.

The globalization of agro-food chains is closely associated with the development and application of the information and communication infrastructure and technologies, which considerably reduce the communication and operational costs and contribute to the trade in differentiated goods (Tang 2006). The information and communication infrastructure development as a determinant of the global trade competition might have positive externalities improving information and reducing asymmetric information, and thus might play a significant role in mitigating the distances between the origin of goods and the demands for goods at different locations (e.g. Rauch 2001; Anderson and van Vincoop 2004).

The paper is motivated by significant changes in the agro-food trade flows that have been caused by the trade policy developments, the information and communication infrastructure and the technology developments since the mid-1990s. First, the analyzed period captures the implementation of the GATT/WTO agreements as one of the reasons that barriers to international trade have become smaller over time, which might reduce the trade costs and increase the agro-food trade. Second, the trade liberalization and free trade agreements have been particularly stipulated among the world's most developed countries. Most of them are the OECD member countries, which might lead to further world agro-food trade concentration. Third, the infrastructure development and the rapid technological changes are seen in the information and communication infrastructure technologies and in the infrastructure development all over the world reducing the role of communication costs on international trade (e.g. Fink et al. 2002; Freund and Weinhold 2004; Tang 2006; Vaněk et al. 2008).

The paper contributes to the literature by investigation the impact of the information and communication infrastructure development on agro-food trade. We expect that a better information and communication infrastructure development will provide positive information externalities and reduce the information and communication costs that affect positively the pattern of the bilateral agro-food trade in the OECD countries. We estimate how the infrastructure and communication infrastructure development influences the bilateral agro-food trade.

This is followed by the presentation and discussion of the regression results for alternative specifications of gravity models. The final section concludes with the policy implications.

MATERIAL AND METHODS

We present the methodology and data used focusing on the impact of the information and infrastructure development on agro-food trade between the OECD countries in the adapted gravity regression analysis. The impact of the information and communication infrastructure development on the agro-food trade so far has been rarely investigated. The previous studies have focused on the globalization of agro-food and distribution management, food industry market chains, and the agro-food supply chain management (Horská 2004; Horská and Krasnodębski 2009). The determinants for the successful food and beverage exporters' performance can be different. On the trade, there can have the impact the inflow of foreign direct investments and the changes in the supply chain management related factors on the location and investments for the entry of foreign food manufacturers into the emerging markets in the supply chain in the economy.

The literature has classified a few factors that determine trade costs and their different significance over time (e.g. Feenstra 2004; de Groot et al. 2004; Olper and Raimondi 2009). Geographical, historical, language, and cultural factors have been often specified as the explanatory variables of trade costs in the adapted gravity equation models. One strand of the literature underlines the effects of the reduction of trade barriers and free trade agreements on the greater increase of trade in differentiated goods than for the homogeneous ones due to the greater reduction of the trade barriers for the former. Another strand of the literature explains the increase of trade in differentiated goods by the decrease in transportation costs. The most recent studies diversify the adapted gravity model equations underlining a few other factors causing the changes towards the reduction in different components of trade costs due to the advanced information and communication technologies and improvements in the infrastructure leading to decreasing communication and transaction costs (Tang 2006).

The literature argues three main reasons why the information and communication costs do matter for the trade flows. First, the information and communication costs are primarily relevant in facilitating the search for trading partners. In such a case, the information and communication costs could be seen as affecting the fixed or sunk costs of trading (Freund and Weinhold 2002; 2004). Second, the information and communication costs affect the trade primarily by influencing variable trade costs between two nations (Fink et al. 2002). Third, the development of

information and communication infrastructure has the potential to reduce these costs (Tang 2006). The empirical evidences confirm that the development of the Internet encourages exports of goods and services (Freund and Weinhold 2002, 2004) and a positive impact of Internet users on the international food industry trade (Bojnec and Fertő 2010). Moreover, the impact of communication costs on the trade in differentiated products is find to be larger than on the trade in homogeneous products (Fink et al. 2002), and that the development of information technology increased the US imports of differentiated goods after the 1970s (Tang 2006).

We aim to identify the impact of the information and communication infrastructure development on the bilateral agro-food trade patterns between the OECD countries using the adapted gravity trade model. Estimating the adapted gravity trade models and assessing the trade patterns on the basis of the empirical results have been subject to several econometric challenges. The recent literature has addressed the issues concerning the correct specification and interpretation of the adapted gravity trade equation in the empirical estimation. We concentrate on two problems.

First, several research papers have argued that the standard cross-sectional methods yield biased the results because they do not control for the unobserved heterogeneous trading relationships (e.g. Feenstra 2004). Because of this, these papers have introduced fixed effects into the adapted gravity trade equation. Fixed-effect models allow for the unobserved or misspecified factors that simultaneously explain the trade volume between two countries, such as the probability that the countries will be in the same regional integration regime (e.g. Matyas 1997; Egger 2002). Although the arguments underlying the use of fixed effects as a solution to the unobserved heterogeneity are roughly consistent in the literature, there is little agreement about how to actually specify the fixed effects. Cheng and Wall (2005) show the correct fixed effect methods in which the country-pair and period dummies are used to reflect the bilateral relationship between the trading partners. For our purposes, we cannot use both fixed importer and exporter effects in our panel regressions. This is because we wish to conduct the analysis with the time-varying country-specific variables related to the infrastructure and communication development, which preclude the use of the time-varying country dummies. Instead, we include time-specific and partner (exporter) country-specific dummies. This forces us to include the variables that are likely to be the important determinants of the reduced-form exporter effects dummies in the adapted gravity equation. From the gravity trade literature, we expect the trade flows to be a function of importer and exporter income size, as well as of the determinants of the bilateral trade costs like the distance, the common border, and the common language. We also include the variables of specific interests. These are the measures of the information and communication infrastructure development of importers and exporters that we expect to impact on trading costs and thus on trade flows positively.

The second issue is how to deal with the zero-valued bilateral trade flows. The standard gravity model cannot easily deal with zero flows. This has resulted in a widespread practice in the literature to ignore zero flows in the analysis of bilateral trade. However, zero-valued observations contain an important information for understanding the patterns of bilateral trade, and should not be discarded *a priori*. Several approaches have been applied or suggested in the literature to address the problem of zero flows. The most common solution in the literature confines the sample to non-zero observations in order to avoid the estimation problems related to zero flows. Alternatively, (part of the) zero values may be substituted by a small constant as a dummy variable, so that the double-log model can be estimated without throwing these country pairs out of the sample. Several studies have used the standard Tobit model to estimate the adapted gravity trade equation with zero trade flows (e.g. Anderson and Marcouiller 2002; Rose 2004). Finally, there are papers, which use the Heckman (1979) sample selection model to deal with the zero values (Linders and de Groot 2006; Francois and Manchin 2007) arguing that the sample selection model is preferred both theoretically and econometrically. This approach is also applied in this presented paper.

The traditional gravity trade theory points out that bilateral trade $X_{ij,t}$ from country i to country j in time t is positively associated with their national incomes and negatively associated with their geographical distance (e.g. Frankel and Rose 2002). We apply the standard gravity trade model variables including the market size (real gross domestic product (GDP) of host i and destination j countries from the World Bank World Development Indicators (WDI) database, geographical factors like the distance (DIST) between capital cities of the OECD countries and common border (CONTIG) from the CEPII database, cultural linkage (common Language), and dummy for a Regional Free Trade Agreement (RFTA) membership as explanatory variables. Particularly, we are interested in the role of the information and communication infrastructure development (ICID) in agricultural and food trade, respectively. We specify the following empirical adapted gravity model:

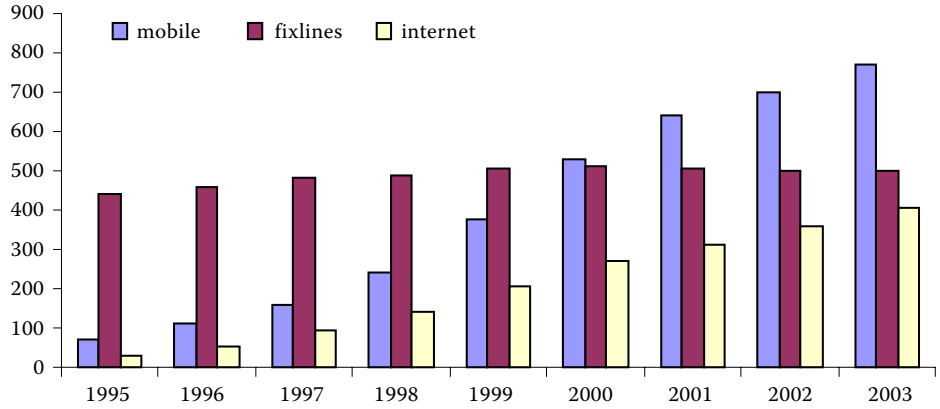

Figure 1. Information and communication infrastructure development in the OECD countries, 1995–2003

Source: Based on the World Bank the World Development Indicators database

$$\ln X_{ij,t} = \alpha_0 + \alpha_t + \alpha_i + \alpha_1 \ln GDP_{i,t} + \alpha_2 \ln GDP_{j,t} + \alpha_3 \ln GDPCAP_{i,t} + \alpha_4 \ln GDPCAP_{j,t} + \alpha_5 \ln DIST_{ij} + \alpha_6 CONTIG_{ij} + \alpha_7 Language_{ij} + \alpha_8 RFTA_{ij} + \alpha_9 ICID_{it} + \alpha_{10} ICID_{jt} + u_1 \quad (1)$$

where ln is a natural logarithm, $X_{ij,t}$ is country i exports to country j at time t, α is the regression parameter, and u_1 is the stochastic element. GDP is a proxy for the market size, and GDPCAP is a general proxy for economic development for both exporter and importer countries. The distance between i and j ($DIST_{ij}$) is the distance between the capital cities of the OECD countries, while the dummy variables reflect whether i and j OECD countries share: a land border ($CONTIG_{ij}$), their primary language (Language), and a membership in a RFTA. The variables of particular interest are the level of the ICID, which is proxied by the three explanatory variables: the number of fix telephone lines per 1000 persons, the number of mobile phones per 1000 persons, and the number of internet hosts per 1000 persons from the WDI database, respectively. For the selection estimation, we assume that $X_{ij,t}$ is observed when we have:

$$\ln X_{ij,t} = \beta_0 + \beta_t + \beta_i + \beta_1 \ln GDP_{i,t} + \beta_2 \ln GDP_{j,t} + \beta_3 \ln GDPCAP_{i,t} + \beta_4 \ln GDPCAP_{j,t} + \beta_5 \ln DIST_{ij} + \beta_6 CONTIG_{ij} + \beta_7 Language_{ij} + \beta_8 RFTA_{ij} + \beta_9 ICID_{it} + \beta_{10} ICID_{it} + u_2 > 0 \quad (2)$$

In equations (1) and (2), u_1 and u_2 have correlation ρ. Equation (1) assesses the determinants of the bilateral trade and shows the main factors influencing the amount of trade that occurred between the two trading OECD partners. Equation (2) sets out the selection criteria and provides information on the factors that determine whether or not we observe trade between OECD country pairs. The trade data are supplied by the OECD Bilateral Trade Database at the two-digit level of the ISIC in US dollars. We use data for the agricultural goods and food products separately. The sample contains 29 OECD countries[1] between 1995 and 2003 resulting in 7308 observations.

EMPIRICAL RESULTS

First, we present the empirical stylized facts on the information and communication infrastructure development in the OECD countries (Figure 1). There is seen a rapid increase in the number of mobile phones per 1000 persons as well as in the number of internet hosts per 1000 persons. The number of fix telephone lines per 1000 persons has, since 2000, stabilized at around 500 fix telephone lines per 1000 persons.

Second, we present the adapted gravity equation results for agricultural and food products separately. Table 1 shows our estimations for agricultural products. The significant inverse Mills' ratios confirm the existence of the selection bias for all specifications, thus we focus on the probit model results. The adapted gravity trade models indicate that the size of GDP has a negative impact for exporting countries and a positive impact for importing countries, irrespective of the types of the infrastructure and communication infrastructure development. The level of economic development measured by GDP per capita has a posi-

[1]List of countries included in the data sample: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Slovakia, Sweden, Switzerland, Turkey, the United Kingdom and the United States of America.

Table 1. The effects of the information and communication infrastructure development on the bilateral agricultural trade between the OECD countries

Dependent variable: agro-food exports from country i to country j at time t ($\ln X_{ij,t}$)						
	(1)		(2)		(3)	
	fix telephone lines		mobile phones		internet	
	OLS	Probit	OLS	probit	OLS	probit
$\ln GDP_i$	−2.159**	−3.359	−2.065**	−2.250	−2.192***	−3.226
$\ln GDP_j$	0.952***	0.740***	0.952***	0.701***	0.945***	0.725***
$\ln GDPCAP_i$	2.571***	3.248	2.310***	2.008	2.452***	3.272
$\ln GDPCAP_j$	0.205***	0.038	0.533***	0.603***	0.611***	0.630***
$\ln DIST_{ij}$	−1.226***	−0.819***	−1.238***	−0.876***	−1.231***	−0.899***
$Contig_{ij}$	0.885***	5.839	0.871***	6.439	0.874***	5.199
$Language_{ij}$	0.282***	2.235***	0.278***	2.353***	0.268***	2.317***
$RFTA_{ij}$	0.710***	0.293	0.691***	0.248	0.696***	0.350*
$ICID_i$	−0.183	0.656*	0.032	0.257***	0.045	0.095
$ICID_j$	0.502***	1.294***	0.060*	0.381***	−0.007	0.263***
Mills lamda		−1.028***		−0.947***		−0.978***
N			7 308			
Censored N			467			

Note: *$p < 0.1$; ** $p < 0.05$; *** $p < 0.001$; i stands for exporters and j for importers the OECD countries

Source: own calculations based on OECD, WDI and CEPII databases

tive association on bilateral agricultural trade, but is significant only for importer countries except for the adapted gravity trade model with the number of the fix telephone lines. As expected, the Distance has a negative and statistically significant association on the bilateral agricultural trade. The Contiguity has

Table 2. The effects of the information and communication infrastructure on the bilateral food trade between the OECD countries

Dependent variable: food exports from country i to country j at time t ($\ln X_{ij,t}$)						
	(1)		(2)		(3)	
	fix telephone lines		mobile phones		internet	
	OLS	probit	OLS	probit	OLS	probit
$\ln GDP_i$	−1.694	−9.733**	−1.390	−4.633	−1.669	−6.868
$\ln GDP_i$	0.853***	0.774***	0.850***	0.715***	0.870***	0.703***
$\ln GDPCAP_i$	1.485	6.261	1.092	0.862	1.478	5.357
$\ln GDPCAP_j$	0.357**	0.816***	0.811***	0.942***	0.451***	1.381***
$\ln DIST_{ij}$	−0.655***	−0.666***	−0.671***	−0.715***	−0.694***	−0.711***
$Contig_{ij}$	1.070***	3.194	1.048***	3.275	1.003***	3.646
$Language_{ij}$	0.656***	3.880	0.648***	3.592	0.657***	4.184
$RFTA_{ij}$	0.817***	5.957	0.793***	5.354	0.833***	5.196
$ICID_i$	0.106	2.722***	0.093	0.451***	0.088	−0.124
$ICID_j$	0.629***	1.125***	0.053	0.495***	0.233***	0.119
Mills lamda		−2.892***		−2.648***		−2.770***
N			7 308			
Censored N			109			

Note: *$p < 0.1$; **$p < 0.05$; ***$p < 0.001$; i stands for exporters and j for importers

Source: own calculations based on OECD, WDI and CEPII databases

no significant impacts on agricultural trade, while the regression coefficients of Language are of a positive sign and statistically significant only for agricultural products. The regression coefficient for membership of a regional free trade agreement has a positive and significant association on agricultural trade. All types of the information and communication infrastructure development have a positive and significant effect. Interestingly, the better information and communication infrastructure endowment is more important in importing than exporting countries.

Table 2 reports our adjusted gravity trade equation results for food products. Again, the significant inverse Mills' ratios confirm the existence of the selection bias for all specifications, thus we focus on the probit model results. The estimations imply that the size of GDP has a negative association for exporting countries only for the number of the fix telephone lines model, while it influences positively and significantly the importing countries irrespective of the types of the information and communication infrastructure development. The level of economic development has a positive association on the bilateral food trade but it is significant only for the food importing OECD countries. The regression coefficients of the Distance variable are of a negative sign and are significant, implying that the Distance reduces the bilateral food trade. The Contiguity, Language, and RFTA variables have no significant impacts on food trade between the analysed OECD countries. The number of the fix telephone lines and the number of the mobile phones have a positive and significant effect, while the number of the internet hosts has no influence on food trade. Interestingly, the better information and communication infrastructure endowment is more important in importing than exporting countries.

CONCLUSION AND POLICY IMPLICATIONS

The OECD countries have experienced, among the first countries in the world, a rapid increase in the level of the information and communication infrastructure development, particularly in the number of mobile phones per 1000 persons and the number of internet hosts per 1000 persons, while the number of fix telephone lines per 1000 persons has stabilized. These variables are used as the proxies for the level of the information and communication infrastructure development to investigate their impacts on the patterns of bilateral trade in agricultural and food products, respectively, between the developed OECD countries with the adapted gravity trade equation.

The empirical results confirm that the information and communication infrastructure development has a significant impact on the bilateral trade in agricultural, and to a lesser extent in food products between the developed OECD countries. This finding suggests that food products, which are more sophisticated products, gain unexpectedly less than the primary agricultural produce from the information and communication infrastructure development. This can be explained by the nature of agro-food produce and the transportation costs, which are usually higher per unit of weight for low value-added primary than for higher value-added processed and consumer-ready food products. However, a better endowment of information and communication infrastructure and its services increases trade for both agricultural and food produces as it lowers transaction costs, which are found more significant for importing than exporting OECD countries. These findings imply that the information and communication infrastructure development is an important source that improves more transparent information availability and thus reduces asymmetric information for agricultural produce and for importing countries, which seem to initially experience greater information transaction costs than food produce and exporting countries.

As expected, the adapted gravity models also confirm the importance of the economy size, level of economic development in importer countries, and trade distance. The other traditional gravity equation variables, like contiguity, language, and regional free trade agreements, have as also expected a positive and significant impact in the majority of the adapted gravity trade equations specifications.

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