Dairy sector trade dynamics. A network perspective

(draft version)

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Abstract

While the positive effect of economic integration on trade is commonly accepted, we still lack a proper understanding of the complex patterns behind this phenomenon. In particular, it is important to better understand how the structure of trade linkages evolves. This is because there are reasons to assume that countries within an economic integration agreement do not trade with each other on random basis. On the contrary, one may argue that they select trade linkages and this choice may be driven by various factors. In this paper we test two specific predictions that originate from the recent literature and which could be informative in this respect. First, we show that the size of the initial trade network is positively correlated with building new trade linkages. In other words, a greater initial number of trading partners facilitates establishing new connections. Second, we also provide some evidence in support of the hypothesis that the evolution of trade network for a given country depends on the trade network of its trading partners. In this case however, our results are slightly less robust.

Keywords Intra-EU trade, dairy sector, network analysis, duration of trade

JEL code C12 C35, F15

Introduction

It is difficult to overestimate the importance of dairy sector in the European Union (EU). Dairy products are the second most important source of animal protein and the yearly average consumption per capita in the EU is equivalent to approximately 300 kg milk (Westhoek et al., 2011). Further, milk is the EU's number one single product sector in terms of value, accounting for 15 per cent of agricultural output in 2013 according to Eurostat data. In addition, not only are dairy products of many EU Member States competitive on global markets (Bojnec and Fertő, 2014), but the intra-EU milk trade is also very significant (EDA, 2014). In fact, over the period 2001-2012, some 90 per cent of all cow milk produced in Europe was commercialised and consumed within the EU. Further, in recent decades we have observed a continuous increase in trade flows in dairy products between the EU member states. Interestingly, this concerns not only processed products but also raw milk which is typically considered as a bulky and highly perishable product.

One may argue that such evolution of trading patterns is an inherent part of economic integration. Indeed, as it is widely recognised, one of the effects of economic integration is an increase in trade flows between countries joining the agreement (Baier and Bergstrand, 2007). The European Union which, according to some estimates, increased members' trade by 127-146% after 10-15 years can serve as a good illustration (Baier et al., 2008).

That said, this overall increase in trade flows masks important and often subtle processes that happen behind the main scene and concern changes in the structure of trade network. As the recent contributions to the literature have convincingly argued (see e.g. Rauch and Trindade, 2002; Chaney, 2014; Bernard et al., 2015; Antras et al., 2016), it seems fair to assume that countries within an economic integration agreement do not trade with each other on random basis. To the contrary, one may argue that they strategically select trade linkages and this choice may be driven by various factors. Trade frictions, and informational barriers in particular, seem to play a huge role here (see e.g. Rauch, 2001). Indeed, establishing trade linkages often requires having a contact in the destination market. Consequently, social and business networks may importantly facilitate international exchange and affect trade structure. This notwithstanding, how exactly these factors work and how do they translate into new trade linkages is still relatively underexplored in the literature.

In this paper we aim at further improving our knowledge in this respect. To do so, we reconstruct the creation of trade linkages in dairy products within the European Union. Our empirical analysis is guided by the recent contributions to the literature on networks of international trade (Chaney, 2016). The two specific predictions originating from these studies which we try to test are the following: 1) the number of currently existing trading partners positively affects the creation of a new trade relationship; and 2) a new export destination will depend on trade linkages of our current trading partners such that starting a relationship with country *a* will be more probable if country *a* are involved in a trading relationship with our current trading partners. Our focus is on the period 2001-2015. This not only gives opportunity to analyse the evolution of a trade network over fifteen years, but also allows us to capture two EU-enlargements in 2004 and 2007. Thanks to this we are able to carefully study what trade connections have been created following these boosts in economic integration.

Data and methodology

While we do not have the firm-level data, in our analysis we try to use as disaggregated data as possible. The source for our trade data is World Integrated Trade Solution (WITS). We use 20 dairy product categories which correspond to HS 5-digit level disaggregation (for exact definitions see table A1 in the Annex).

Our approach is guided by recent advancements in network theory which has been frequently applied to highlight new features characterising international trade (see e.g. Chaney, 2016). Drawing on several contributions to the literature which show that network interactions may importantly shape trade connections (Albornoz et al., 2012; Chaney, 2014; Defever et al., 2015), we test whether the pattern of establishing new trade linkages in dairy sector in the EU depends on the trade network existing at the time of a new node's entry. Two specific hypothesis are tested:

H_1: the size of the initial trade network is positively correlated with building new trade linkages;

H_2: the evolution of trade network for a given country depends on the trade network of its trading partners.

As regards the latter hypothesis, we test whether existing trade relations affect the new links which will be created in the future. In particular, based on a network theory, it can be argued that country *A* which trades with country *B* should subsequently engage in trade relationship with trade partners of country *B*. The rationale behind this argument is that the existing relations as well as linkages that our trade partners have should help to overcome the informational barriers when approaching new markets.

In the course of our empirical investigation we employ duration analysis to assess the impacts of network on trade. Recent papers point out three relevant problems inherent in the Cox model that reduce the efficiency of estimators. Thus following Hess and Persson (2012), we estimate different discrete-time models including Probit and Logit specifications.

We employ the most local network index, degree (D_i) which gives the number of nodes connected directly to node *i*, where *i* can refer either to *r* (reporting country - i.e. exporter) or to *p* (partner country - i.e. importer). Since our (binary) network is directed, the network out-degree[1] ($D_{out,i}$) measure corresponds to the number of links that originate from node *i* (Wasserman and Faust, 1994). For trade networks, out-degree represents the number of trade partners to which a given country exports its products (De Benedictis and Tajoli, 2011). With the large panel dataset, we use a number of MLE estimators, such as panel regression, panel probit, panel logit and random effects cloglog models with clustered variance-covariance matrix to ensure heteroscedasticity robust standard errors[2] to assess the validity of hypotheses H_1 and H_2.

A key issue for our paper, is how do we define new trade relationships? Whilst a new trade relationship may exist only for a short period (minimum 1 year), we are interested in the determinants of longer, 'lasting' trade relationships. Thus we must use subjective criteria to define our dependent variable. Our benchmark definition for *new trade relationship* is a partnership longer than 5 consecutive years. For robustness, we also calculated and used three alternative definitions: longer than 0 (for H_2 only), 3 and 10 years respectively.

Our empirical estimation strategy is as follows: we first calculate the trade spells[3] (i.e. the span of time, measured in years, during which trade between two partners exist); In a subsequent step we use dummy variables to identify the abovementioned (longer than) 0, 3, 5 or 10 years spells. Note, that given that our study covers 15 years, using the definition above two partner countries trading the same dairy product may enter the binary regression more than once (except for the 10 years definition).

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[1] We aim to incorporate further network centrality measures in our future analysis, such as degree centrality, eigenvector centrality, clustering etc.
[2] Xtprobit, xtlogit, xtcloglog commands in Stata
[3] Stset command in Stata

For hypothesis H_1, our dependent variable is a binary, taking the value 1, if a new trade relationship is established and 0 otherwise. For H_2, the dependent variable is the reporter's outdegree centrality (D_{outr}).

Further, the key explanatory variable in for H_1 is the variable lnD_{outr} which is the log of Reporter's (exporter's) outdegree centrality, measured at the time the trade spell begins, whilst for models testing H_2 is the partner country's outdegree centrality (D_{outp}) as a measure of the size of partner's trade network size.

The rest of explanatories for both hypotheses are the standard gravity model variables: *lngdpr*: log of reporter (exporter) GDP; *lngdpp*: log of partner (importer) GDP; *lndist*: log of distance (in km) between trading partners capital cities; *Euro*: dummy, taking the value 1 if both trading partners are Eurozone members and 0 otherwise; *Contig*: dummy, taking the value 1 if trading partners share a common border.

An important trade policy question is whether there is a difference between the trade behaviour of Old Member States (OMS) and New Member States (NMS). Therefore, beside the full sample, we present subset results for these two groups of countries as well.

Results

Results with respect to hypothesis H_1, are detailed in Tables 1 – 3. The tables differ with respect to the definition of new trade relationship (longer than 3, 5 or 10 years). Each table is composed of three main sections, presenting results for the full sample (27 MS), OMS and NMS respectively. Within each sample panel probit, logit and cloglog estimation results are displayed. Most significant results were obtained for the full sample models, followed by OMS and, understandably because of the smaller sample, for NMS.

Table 1. Results for H_1, with a minimum duration new trade relationship > 5 years

	Full sample			OMS sample			NMS sample		
	xtprobit	xtlogit	xtcloglog	Xtprobit	xtlogit	xtcloglog	xtprobit	xtlogit	xtcloglog
lnD_{outr}	1.227***	2.278***	1.947***	1.404***	2.597***	2.049***	0.931***	1.790***	1.528***
lngdpr	0.036	0.055	0.044	0.034	0.052	0.026	0.048	0.087	0.080
lngdpp	0.257***	0.472***	0.409***	0.395***	0.736***	0.569***	-0.105*	-0.198	-0.165
lndist	-0.397***	-0.662***	-0.535***	-0.358***	-0.614***	-0.478***	-0.663***	-1.261***	-1.052***
contig	1.327***	2.327***	1.731***	1.467***	2.578***	1.734***	1.101***	2.024***	1.713***
euro	0.330***	0.552***	0.467***	0.146	0.243	0.195*	0.110	0.196	0.157
constant	-8.050***	-14.920***	-13.448***	-11.812***	-22.099***	-17.293***	2.966	5.770	4.046
Wald chi2	1434.006	1535.942	1820.643	1025.303	1045.614	1267.976	225.575	268.043	300.196
N	50497	50497	50497	13431	13431	13431	8460	8460	8460
rho	0.261	0.167	0.187	0.189	0.107	0.090	0.178	0.169	0.240

Source: Own calculations

Table 2. Results for H_1, with a minimum duration new trade relationship > 3 years

	Full sample			OMS sample			NMS sample		
	xtprobit	xtlogit	xtcloglog	xtprobit	xtlogit	xtcloglog	xtprobit	xtlogit	xtcloglog
lnD_{outr}	1.066***	2.041***	1.773***	1.312***	2.447***	1.958***	0.811***	1.790***	1.354***
lngdpr	0.004	0.004	0.003	0.001	-0.009	-0.016	-0.006	0.087	-0.007
lngdpp	0.220***	0.418***	0.368***	0.371***	0.693***	0.544***	-0.049	-0.198	-0.067
lndist	-0.311***	-0.542***	-0.447***	-0.303***	-0.525***	-0.417***	-0.540***	-1.261***	-0.853***
contig	1.141***	2.058***	1.548***	1.385***	2.484***	1.679***	0.900***	2.024***	1.404***
euro	0.216***	0.384***	0.337***	0.097	0.174	0.146	-0.111	0.196	-0.214
cons	-1.742***	-0.910***	-1.364***	-10.382***	-19.501***	-15.634***	2.579	5.770	3.218
chi2	1650.511	1749.681	2096.844	1324.922	1289.493	1562.398	306.671	268.043	349.587
N	58635	58635	58635	15568	15568	15568	9949	8460	9949
rho	0.149	0.109	0.135	0.136	0.094	0.087	0.105	0.169	0.152

Source: Own calculations

Table 3. Results for H_1, with a minimum duration new trade relationship > 10 years

	Full sample			OMS sample			NMS sample		
	xtprobit	xtlogit	xtcloglog	xtprobit	xtlogit	xtcloglog	xtprobit	xtlogit	xtcloglog
lnD_{outr}	1.586***	2.512***	2.108***	1.733***	2.917***	2.245***	0.919***	1.765***	1.556***
lngdpr	0.085***	0.110**	0.085**	0.077	0.113	0.056	0.134*	0.260*	0.231*
lngdpp	0.338***	0.544***	0.467***	0.494***	0.852***	0.640***	-0.132*	-0.241	-0.204
lndist	-0.582***	-0.827***	-0.652***	-0.474***	-0.765***	-0.570***	-1.022***	-1.992***	-1.736***
contig	1.640***	2.440***	1.752***	1.810***	2.882***	1.927***	0.908***	1.701***	1.536***
euro	0.616***	0.831***	0.676***	0.256**	0.399**	0.312**	(omitted)	(omitted)	(omitted)
cons	-11.231***	-17.911***	-15.826***	-15.663***	-26.705***	-19.952***	3.632	6.900	5.161
chi2	1031.639	1098.037	1329.288	654.446	668.099	803.725	210.059	320.411	361.180
N	30720	30720	30720	8464	8464	8464	4868	4868	4868
rho	0.452	0.167	0.179	0.307	0.090	0.089	0.140	0.174	0.332

Source: Own calculations

All explanatory variables come with the expected sign (positive for GDPs, Euro dummy, common border and negative for log distance) and most importantly, the key variable, lnD_{outr} is highly significant in all estimations. More, it has the largest coefficient (impact) in all estimations. These results, support H_1, a robust result enforced by the output displayed in tables 2 and 3. It is very important to note that as far as our key independent variable is concerned we have found no difference between the behaviour of all EU member states, NMS and OMS, further contributing to robustness of results. The GDP of the reporter (exporter) country becomes significant only if longer than 10 years trade relations are considered, thus, we may cautiously argue that connectivity (lnD_{outr}) plays a more important role in intra-European dairy trade than size does. As regards the size of importer's market (approximated by *lngdpp*), it seems to be more important for establishing new trade linkages for OMS rather than for NMS.

With respect to hypothesis H_2, i.e. whether the size of exporter's network depends on the size of partners' network (dependent variable D_{outr}), results are displayed in tables 4-6 for all Member states, OMS and NMS samples. Each table comes with four columns depicting various specifications for new trade relationship (*newr*): longer than 0, 3, 5 and 10 years respectively.

Table 4. Results for H_2, dependent variable D_{outr} – all Member States

Full sample				
	newr>0	newr>3	newr>5	newr>10
D_{outp}	0.172***	0.173***	0.149***	0.119***
lngdpr	2.543***	2.452***	2.455***	2.474***
lngdpp	-0.497***	-0.589***	-0.543***	-0.495***
lndist	-0.091	-0.117	-0.098	-0.088
contig	-0.075	-0.594	-0.551	-0.485
euro	-0.935***	-0.507***	-0.505***	-0.484***
cons	-43.990***	-39.308***	-40.547***	-42.222***
r2	0.4698	0.3531	0.3488	0.3404
N	142725	68328	66388	64347
rho	0.703	0.676	0.688	0.701

Note: newr>0, newr>3, newr>5, newr>10 denote the minimum duration of new trade relations, i.e. 0, 3, 5 or more than 10 years.
Source: Own calculations

Results are consistent across various definitions of *newr*, but less consistent when full and sub-samples (OMS, NMS) are considered. Whilst the exporter's own GDP is consistently positive as expected, the partner's GDP is either non-significant (NMS) or negative (full sample and OMS). Similarly, log distance has the expected sign for OMS, but is insignificant for the full sample and positive for NMS, a puzzling result. Some degree of multicollinearity amongst explanatories might explain these findings. Most importantly however, our variable of interest, the size of the partner's trade network is significant and positive irrespective of specification or sample, supporting H_2.

Table 5. Results for H_2, dependent variable D_{outr} - Old Member States

OMS sample				
	newr>0	newr>3	newr>5	newr>10
D_{outp}	0.103***	0.194***	0.163***	0.140***
lngdpr	2.744***	2.909***	2.868***	2.877***
lngdpp	-0.536***	-0.801***	-0.746***	-0.683***
lndist	-1.203***	-1.206***	-1.210***	-1.236***
contig	-0.319	-0.469	-0.411	-0.390
euro	0.930*	1.056**	1.075**	1.135**
cons	-40.534***	-38.867***	-38.954***	-40.551***
r2	0.4333	0.3250	0.3208	0.3118
N	53430	17177	16584	15932
rho	0.776	0.754	0.775	0.790

Note: newr>0, newr>3, newr>5, newr>10 denote the minimum duration of new trade relations, i.e. 0, 3, 5 or more than 10 years.
Source: Own calculations

Table 6. Results for H_2, dependent variable D_{outr} - New Member States

NMS sample				
	newr>0	newr>3	newr>5	newr>10
D_{outp}	0.162***	0.092*	0.071	0.022
lngdpr	1.735***	0.944***	0.950***	0.903***
lngdpp	-0.548	-0.413	-0.389	-0.369
lndist	1.021*	0.974**	0.974**	0.914**
contig	-0.046	-0.872	-0.870	-0.898
euro	-2.166***	-1.008**	-1.034**	-0.962**
cons	-31.471**	-14.993	-15.737*	-14.730
r2	0.3382	0.2348	0.2303	0.2116
N	21420	12426	12115	11796
rho	0.549	0.519	0.526	0.541

Note: newr>0, newr>3, newr>5, newr>10 denote the minimum duration of new trade relations, i.e. 0, 3, 5 or more than 10 years.
Source: Own calculations

Conclusions

While there exists an extensive literature devoted to investigate trade in agro-food products, our knowledge about the evolution of trade structure and the nature of the trade network are still relatively poor. Most of the existing studies focus on explaining the volume of trade. Instead, the formation of trade linkages between countries is much less understood. In this paper we tried to fill this gap at least in part. To best of our knowledge, this paper is the first to look at the agro-food trade while incorporating into the analysis recent advancements from the literature on networks of international trade. Our focus is on intra EU trade in dairy products over the period 2001-2015.

As our analysis is quite basic, the results we present should be treated with caution. That said it should be noted that they uniformly point to the fact that network features of intra EU trade in dairy products should be given more attention and may significantly improve our understanding what trade linkages we observe and why. Our analysis provides support for two predictions originating from the existing models of international trade. First, creating a new trade relationship is the more probable the more current trading partners a given country has. Further, we also show that well connected (from a network perspective) countries tend to have longer trade spells than less centrally located ones. We also provide some support for the hypothesis that building new relationships and/or maintaining already existing ones (i.e. the duration of trade) is positively correlated with the location of the milk exporter within the network. More specifically, we observe that a given country has the more central position in the trade network, the more central position have its current trading partners.

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Annex

Table A1. Dairy products used in the analysis

Code	HS1996 Product Description
40110	Of a fat content, by weight, not exceeding 1 %
40120	Of a fat content, by weight, exceeding 1 % but not exceeding 6 %
40130	Of a fat content, by weight, exceeding 6 %
40210	In powder, granules or other solid forms, of a fat content, by weight, not exceeding 1.5 %
40221	In powder, granules or other solid forms, of a fat content, by weight, exceeding 1.5 % : Not containing added sugar or other sweetening matter
40229	In powder, granules or other solid forms, of a fat content, by weight, exceeding 1.5 % : Other
40291	Other :-- Not containing added sugar or other sweetening matter
40299	Other
40310	Yogurt
40390	Other
40410	Whey and modified whey, whether or not concentrated or containing added sugar or other sweetening matter
40490	Other
40510	Butter
40520	Dairy spreads
40590	Other
40610	Fresh (unripened or uncured) cheese, including whey cheese, and curd
40620	Grated or powdered cheese, of all kinds
40630	Processed cheese, not grated or powdered
40640	Blue-veined cheese
40690	Other cheese

Source: wits.worldbank.org