Catalysts and Inhibitors of the Trade Collapse*

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Abstract

I study the responsiveness of Slovenian trade during the collapse of 2008-2009 in an attempt to shed light on channels that enhanced or dampened the sensitivity of international trade to the demand shock and the tightening of credit supply. The responsiveness of intermediate goods' trade is found to be associated with the cost-share of inputs in final output; in other words, imports of inputs accounting for a larger cost-share faced a more than proportionate drop in the downturn coupled with a more than proportionate rebound in the recovery. I hypothesise that this is the outcome of larger post-shock inventory adjustments which higher cost-share intermediates are subject to and support this rationale with a simple (S, s) model of inventory management. The study of the collapse along the intra-firm versus arm's length trade dimension does instead not reveal a differential response between the two organisational modes.

Keywords: Financial crisis; Firm behaviour; Product cost-share; Trade collapse.

JEL codes: D22, D23, F14

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1 Introduction

The 2008-2009 great recession was characterized by a dramatic collapse in international trade. This reduction in world trade attracted considerable attention both because of the unprecedented size of the fall – a 30% reduction from September 2008 to January 2009 with respect to the 3% drop in GDP (Bricongne *et al.* 2012) – and because of its suddenness and homogeneity across OECD countries (Baldwin and Evenett 2009). Levchenko *et al.* (2010) confirm the exceptionality of this episode detecting a 40% shortfall in imports by examining the deviations of the trade time-series from the norm[1]. This unexpected collapse raises important questions and the literature that has emerged points to the decrease in real expenditure, the existence of vertical linkages in production and the tightening of credit supply as the main causes of the event (Bems *et al.* 2012).

This paper contributes to the understanding of the dynamics of the trade collapse by exploring a new channel: the cost-share of imported products. In order to uncover new sources of heterogeneity in the response of firms to the crisis, I examine Slovenian trade and investigate the reaction of different products, depending on their cost-share in firms' output[2]. My primary aim is therefore not to shed light on the root causes of the trade crisis or to quantify their relative importance, but rather to identify a factor that might have amplified the reaction of imports to the demand shock caused by the financial crisis. I find that products' cost-share increased the responsiveness of trade of intermediate goods, in both the subperiods of the crisis; in other words, imports of inputs accounting for a larger cost share fell more than proportionately in the downturn and rebounded more than proportionately in the recovery. This result is robust to controlling for the impact of firm affiliation. Other than confirming the role of inputs' cost-share as a catalyst of the trade collapse, the study of the role of intra-firm and arm's length trade provides an additional contribution of this paper: intra-firm trade was not not observed to perform differently compared to arm's length trade in the crisis. This latter finding differs from the results of Bernard *et al.* (2009), observing intra-firm trade of US firms to be more relient than arm's length trade during the 1997 East-Asian crisis, and Altomonte *et al.* (2012), that estimate an enhanced reaction of trade of french firms in the 2008-09 collapse when shipments took place within firms' boundaries.

I address these questions studying the trade collapse in a small open economy, Slovenia, using high frequency custom data matched with firm balance-sheet and ownership information. This

[1] The demand for import as predicted by domestic absorption, domestic price and import prices.

[2] The cost-share variable is computed as the average value of an imported product in firms' sales, as explained in Section 5.

highly disaggregated dataset allows a detailed examination of the trade crisis[3]. The aforementioned work of Altomonte *et al.* (2012) investigating the relevance of firm affiliation for France, does not explore my main question regarding the impact of products' cost-share. This hypothesis sheds light on a channel that can induce a higher elasticity of trade flows to a demand collapse, the explanation for which may lie in the dynamics of inventory adjustments. To the best of my knowledge no work explores the cost-share hypothesis.

The literature has investigated both demand and supply side factors in order to explain the collapse. On the demand side, the change in real expenditure is identified as the main factor responsible for the strong reduction in trade (Bems *et al.* 2010, 2011, 2012; Eaton *et al.* 2011, Bussière *et al.* (2013)): the asymmetric reduction in expenditure across sectors, largest on the more traded goods, transmitted the demand shock heavily to the border. In the attempt to understand what caused trade to deviate from levels predicted by benchmark theoretical models, authors have studied determinants of the trade wedge[4] (Levchenko *et al.* 2010, Alessandria *et al.* 2011, Bems *et al.* 2012). A standard aggregate CES import demand equation predicts a unit elasticity of trade with respect to a change in aggregate expenditure, and candidates for the larger measured responsiveness of transactions in 2008-09 are durability of goods (Engel and Wang, 2009; Petropoulou and Soo 2011), input linkages across sectors and the adjustment of inventories, especially within Global Value Chains (Alessandria *et al.,* 2010a, 2011; Altomonte *et al.,* 2012). Global Value Chains (henceforth GVCs) are viewed as an important locus of the trade crisis, because of the large fraction of trade originating within them due the worldwide fragmentation of production (Bems *et al.* 2011). Here I analyse mechanisms that enhance or dampen the reaction of trade to a demand shock, within GVCs[5].

On the supply side, the literature mostly points towards the role of the financial shock in impairing firms' production and exporting activities through the constrained access to working capital (Amiti and Weinstein 2011, Bricongne *et al.* 2012, Chor and Manova 2012, Paravisini *et al.* 2012, Behrens *et al.* 2013) and the reduction in trade finance (Korinek *et al.* 2010, Malouche 2011, Coulibaly *et al.* 2011, Antràs and Foley 2014). The first set of studies sought to identify the effect of reduced bank credit on firms' activity by examining pre-crisis financial vulnerability measures (e.g. external financial dependence, payment incidents) to avoid the endogenous link between credit

[3] Only a few studies exploited similarly rich data sources – Bricongne *et al.* (2012) and Altomonte *et al.* (2012) for France; Behrens *et al.* (2013) for Belgium – with no study taking into account Slovenian trade, whose experience might have been different compared to the other two countries.

[4] The deviation of the trade time series form the levels predicted by the evolution of domestic demand and prices.

[5] Identified by the role of intermediate goods, for which the main results are found.

and production decisions: they all find some evidence of harm to firms' activity by the financial shock, with this channel accounting for about 15-20% of the trade collapse. The second group of studies focused instead on the importance of bank- versus firm-intermediated trade finance: the general conclusion is in favour of a moderate impact of the reduction in trade finance, especially when intermediated by banks via, for example, letters of credit. However, the case study of Antràs and Foley (2014) finds evidence of exporters relying more on cash-in-advance agreements during the crisis than in normal times, while Coulibaly *et al.* (2011) show that the behavior of firms that were able to switch to between-firm arrangements away from financial credit experienced lower declines in sales. These studies point in direction of the importance of firm intermediated finance and its relevance for understanding the heterogeneity in responses to the financial crisis.

This paper adds to this literature by unpacking the dynamics of the trade collapse along a new line of explanation. I explore the product dimension of the crisis, by observing the responsiveness of shipments of different products depending on their cost-share in firms' output. The relevance of the cost-share arises in particular for inputs used by firms in production: in a trade crisis firms may adjust purchases of high cost-share inputs differently from low cost-share inputs if, for instance, in the attempt to retain liquidity firms reduced their working capital targets and destocked inventories, with higher cost-share products being more sensitive to the adjustment. This is the mechanism that I propose as an explanatory factor of the estimated higher responsivenes of higher cost-share inputs' trade.

I condition my results on the degree of integration of the value chain and firm's reliance on buyer-seller trade finance. The integration via the acquisition of ownership rights creates business groups within which so-called intra-firm trade can be observed, whose dynamics are likely to differ from arm's length trade, consisting of shipments between unaffiliated firms. Multinationals could adjust more promptly to a shock for reasons such as better and faster communication and the overall lower degree of uncertainty, or else groups could show higher resiliance (especially at the extensive margin) given the different cost structures and depth of integration pursued to overcome the hold-up problem (Antràs, 2003; Antràs and Helpman, 2004). The contemporaneous presence of offsetting channels can explain why no significantly different performance between intra-firm and arm's legth trade is detected in estimation. Concerning the relevance of buyer-seller trade finance, the literature has not reached a consensus about the positive or negative impact that a larger use of firm-intermediated finance implied[6] in the crisis (relative to bank-intermediated finance): these

[6] In an event where financing through the banking sector becomes more costly or gets disrupted because of a credit

additional controls, showing a better performance for importers obtaining more credit from their foreign counterparts, provide a separate contribution on their own to this topic.

Finally, the data permit to perform a detailed decomposition of trade margins, separating among the firm-, destination- and product-extensive margin and the intensive margin of Slovenian trade. These four margins are then further decomposed along the intra-firm versus arm's length dimensions, to evaluate the relative contribution of the two organisational modes of cross-border production. To my knowledge, only Bernard *et al.* (2009) separate intra-firm from arm's length trade margins, examining the East-Asian crisis of 1997, whereas no study so far decomposes trade margins considering the role of intra-firm trade in the recent crisis.

The remaining parts of this paper are organised in this way: Section 2 is dedicated to the exposition of a possible mechanism underlying the unequal trade adjustment of different products. Section 3 presents the data, while Section 4 describes the trade collapse for Slovenian firms. In Section 5 I discuss the methodology before proceeding to the exposition of the results in Section 6. Section 7 shows reduced form estimates in support of the main channel hypothesised in Section 2, whereas Section 8 describes the results of the margin decomposition. Section 9 concludes.

2 The hypotheses

The magnified movements in international trade following the fall in sales have been explained, among other things, by the severe adjustment of inventory holdings (Alessandria *et al.* 2010a, 2011): following a negative shock to demand which is expected to persist, firms find themselves with an excessive level of inventory and therefore cut back on orders. Moreover, since firms involved in international trade hold larger stocks of inventories than domestic firms do (Alessandria 2010b), the response of trade is larger than that of production. Intuitively, since imports equal sales of imported goods plus inventory investment and both sales and inventory investment decline in a recession, imports are more volatile than sales. This amplification mechanism has the potential to explain the short-run elasticity of imports to demand shocks and the movements in the trade wedge: Alessandria *et al.* (2011) quantify it by arguing that inventory adjustments accounted for about 30% of the wedge measured for the United States and about 20% of the decline of US imports. Production

crunch, credit granted between firms might be a way of bridging this disruption (Fisman and Love, 2003): hence firms relying more heavily on buyer-seller trade finance might have performed better during the crisis (Chor and Manova, 2012). If, in contrast, the overall increase in counter-party risk prompted firms to move away from buyer-seller credit to more formal forms of bank intermediated trade finance (Korinek *et al.,* 2010; Mora and Powers, 2009), firms relying more heavily on buyer-seller credit might have ended up suffering more.

chains can be an ideal locus for examining further aspects of this phenomenon. Concentration of trade relationships and rapid communication among firms along a chain of production may explain the speed of inventory adjustments and why the downsizing of trade was so synchronized and homogenous worldwide.

2.1 The cost-share hypothesis

The value of certain imported inputs accounts for a larger share of total sales and this can be a source of heterogeneity in the response of trade to the demand shock, potentially due to inventory adjustments. The cost-share of imported intermediates might lead firms to differentiate inventory management strategies across products: higher purchasing and carrying costs can lead to lower inventories of higher cost-share inputs, which present a higher responsiveness to a symmetric demand reduction. This is summarised by Hypothesis 1:

> **Hypothesis 1***: the responsiveness of trade to a shock to sales is larger for intermediates accounting for a larger cost-share in firm's total output.*

This hypothesis can be accounted for by a model of inventory management[7]. I exploit the so called "lot size-reorder point" model, or (S, s) model, orginally derived by Arrow *et al.* (1951). The objective is to derive the optimal quantity S of inventory to order and the optimal reorder point r at which to place the order, given a rate of demand δ and a procurement lead time τ. The reorder point defines the safety stock s, i.e. the amount of inventory on hand when the procurement arrives. With a rate of demand δ, quantity S is depleted in time $T = S/\delta$, which denotes the length of a cycle. Optimal values for S and r minimise the cost of managing the inventory system. Under the assumptions of a fixed ordering cost A, a constant marginal purchasing cost c, a linearly rising marginal cost of sourcing and handling inventories[8] ωS^2 and an instantaneous carrying charge I proportional to the value of the stock cS and the time over which the items remain in inventory,

[7] The model is fully elucidated in Appendix; here I provide a summary of the main mechanism.

[8] I refer to marginal cost $\frac{d}{dS}\left(\omega S^2\right) = 2\omega S$ as "sourcing and handling cost"; this could conceivably capture a variety of factors that make the cost of holding inventories rise with the quantity stored. An example could be rising transportation costs, if the distance from suppliers increases when sourcing additional items from alternative locations that are further away. Alternatively, there may be rising labour costs, related to the operations of receiving, inspecting and handling a larger quantity of items. Also storage costs could be convex in the quantity stored (Chazai *et al.* 2008). Finally and more generally, this rising cost could capture a higher degree of complexity in coordinating the management of an increasing quantity of items stored.

the optimal order quantity S^* is derived. Average inventory, denoted by $\bar{S}^*$can be shown to be:

$$\bar{S}^* = \frac{S^*}{2} = \sqrt{\frac{A\delta}{2\left(cI + 2\delta\omega\right)}} \tag{1}$$

The reorder point r is derived following Hadley and Whitin (1963). If m denotes the largest integer less than or equal to τ/T, then an order is placed when the on-hand inventory reaches:

$$r^* = \delta(\tau - mT) = \delta\tau - mS^*, \tag{2}$$

while the on-hand inventory is exactly zero at the time the order arrives[9].

It follows directly from equation (1) that average inventory $\bar{S}^*$ varies inversely with the square root of the marginal cost c, so that the average inventory for high cost intermediates is lower than for low cost intermediates. Consider two inputs h and l, where h denotes a high unit-cost intermediate and l denotes a low unit-cost intermediate, such that $c_h > c_l$. It can be shown[10] that although $\bar{S}^*_h < \bar{S}^*_l$, the higher cost input corresponds to a higher value of the stock $\bar{S}^*_h c_h$, such that $\bar{S}^*_h c_h > \bar{S}^*_l c_l$, which in turn implies a higher cost-share $\bar{S}^*_h c_h / \left(\bar{S}^*_h c_h + \bar{S}^*_l c_l\right)$. Intuitively, this is because the elasticity of average inventory quantity to cost is less than 1.

Hypothesis 1 states that a fall in demand induces a larger response of imports of higher cost-share products compared to lower cost-share ones. Since an inventory adjustment corresponds to a change in the flow of imports[11], Hypothesis 1 is confirmed in the model since $\frac{\partial\left(\bar{S}^* c\right)/\partial\delta}{\bar{S}^* c}$ is increasing in c. In particular:

$$\frac{\partial\left(\bar{S}^* c\right)/\partial\delta}{\bar{S}^* c} = \frac{1}{2\delta(1 + \frac{2\delta\omega}{cI})} \quad \text{and} \quad \frac{\partial}{\partial c}\left(\frac{1}{2\delta(1 + \frac{2\delta\omega}{cI})}\right) = \frac{\omega I}{\left(cI + 2\delta\omega\right)^2} > 0. \tag{3}$$

The responsiveness of inventory stocks to a demand change increases in the unit-cost of the items, and therefore also in their cost-share. This more than proportionate adjustment of higher cost-share products accelerates the reaction of imports during a crisis, conferring to the cost-share a role of *catalyst* of the collapse. This mechanism can find an explanation in the attempt of

[9] This rule ensures the firm has a zero safety stock s, and only if the cycle length T is not an exact multiple of the lead time τ, does the firm place the order just a bit before reaching the zero inventory floor.

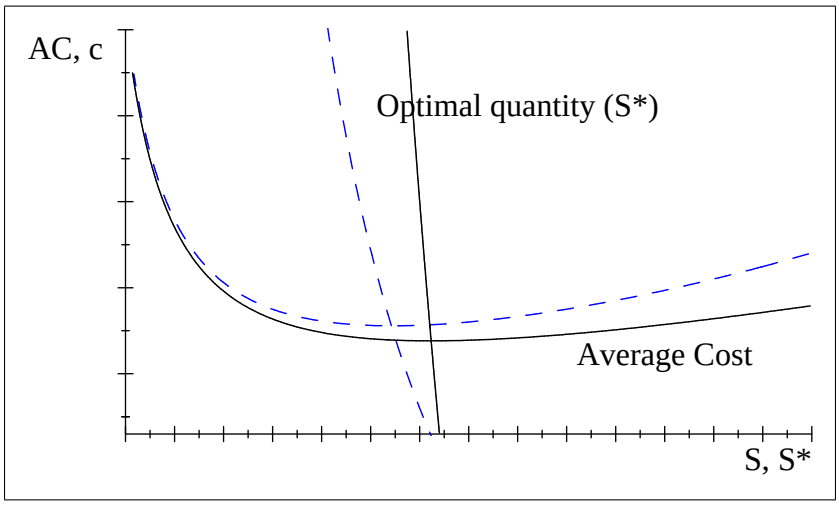
[10] See Appendix for full derivation.

[11] It is straightforward to show that the flow of imports is mononically linked to the average stock of inventories. Consider the accounting equation $M_t = S_t + (I_t - I_{t-1})$, where M_t denotes imports in year t, S_t denotes sales of imported goods, I_t denotes the stock of inventories of imported goods so that $I_{kit} - I_{kit-1}$ is inventory investment. An increase in the average stock of inventories I_{kit}, and therefore of inventory investment, leads to an increase in the flow of imports.

firms to absorb shocks to internal liquidity through changes in inventory investment. Carpenter *et al.* (1994) find systematic evidence of this behaviour for three US recessions throughout the 1980s, whereas for the 2008-09 event Udenio *et al.* (2015) confirm that firms' willingness to retain liquidity prompted a reduction in working capital targets, mostly accounted for by inventory liquidation. The downsizing of inventory levels could have therefore been more sensitive to the demand collapse when involving higher-cost share inputs.

Figure 1 illustrates the average cost (AC) of running a single item inventory system as a function of the quantity ordered S (convex curves), together with the locus of points mapping the optimal quantity stored S^* as a function of the unit cost c (more vertical curves).

Figure 1: Average cost of managing the inventory system, and optimal quantity stored.



A reduction in demand causes the average cost curve to shift inwards (dashed line), such that the minimum is now found at a lower level of S: this determines a reduction in the quantity of inventories ordered. The optimal quantity curve shows instead two facts: first, that regarless of the demand rate, higher cost items are ordered in lower amounts; secondly and more crucially, that a change in the demand rate causes a change in the slope of the optimal quantity curve, indicating that higher cost items see their optimal quantity reduced in a way which is more than proportionate relative to lower cost items.

2.1.1 The intra-firm versus arm's length effect

The responsiveness of different products could differ depending on firm affiliation: due to inventory adjustments, various mechanisms can explain a differential response of intra-firm versus arm's

length trade. In the language of the (S, s) model exposed in section 2.1., multinationals might order a lower quantity S of inventories even in good times if they can be assumed to be subject to a higher carrying charge I. The carrying charge mostly captures the cost of capital; in other words, the opportunity cost of investing in inventories rather than in interest bearing assets. It is conceivable that this opportunity cost is larger for firms belonging to groups, because of their greater ability to differentiate their investments of different kinds and their deeper involvement in financial markets. To see this consider that:

$$\frac{\partial\left(\bar{S}^{*}c\right)/\partial\delta}{\bar{S}^{*}c}=\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\quad and\quad\frac{\partial}{\partial I}\left(\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\right)=\frac{cw}{\left(cI+2dw\right)^{2}}>0. \tag{4}$$

Equation (4) shows that, regardless of the unit-cost of the items, the responsiveness of the stock of inventories to a demand shock is increasing in the carrying charge I.

Alternatively, and more simply, intra-firm trade might show a more pronounced reaction to a drop in demand because of the faster and more effective management of the information stream between trade partners belonging to the same business group (Altomonte *et al.*, 2012). Both these mechanisms would lead to an accelerated reaction of international trade during the financial crisis of 2008-09, conferring also to intra-firm trade a role of *catalyst* of the trade collapse.

> **Hypothesis 1.1:** *intra-firm trade of intermediates accelerates the reaction of trade to a shock to sales, compared to arm's length trade.*

A word of caution is due here: alternative mechanisms able to explain a differential reaction between intra-firm and arm's length trade to a demand collapse are conceivable, even though they would be harder to rationalize within the stylized example offered by the (S, s) model exposed here[12]. It is to be considered in fact that the purpose of all of section 2 is to provide a plausible rationale for the results arising in estimation, but being aware that with the data at hand these explanations remain at the stage of hypotheses, with the possibility of the existence of alternative channels at work during the crisis of 2008-09.

Intensive and extensive margin adjustments, across intra-firm and arm's length trade. Further, in support of a differential impact of shocks between intra-firm and arm's length trade,

[12] If intra-firm trade was more resilent during the trade collapse, as found by Bernard *et al.* (2009) for the East Asian crises of 1997, it would impart an effect of opposite sign, compared to the cost-share hypothesis, to shipments of intermediates in a recessionary environment. Alternatively, the two factors would show a cumulative effect if both the cost-share and firm affiliation acted as *catalysts* during the 2008-09 event. The interaction of the two channels is, therefore, also explored empirically.

there are the different cost structures relating to the two organisational modes as well as the so-called hold-up problem[13] (Antràs, 2003; Antràs and Helpman, 2004; Nunn and Trefler, 2013). With respect to trade margins, deeper integration leading to the establishment of multinationals, due to the presence of sunk costs and market rigidities, could imply that in a trade crisis adjustments along the intensive margin are preferable to extensive margin adjustments. If some adjustment along the extensive margin is required, then this could be preponderant for arm's length trade. For example, Bernard *et al.* (2009) measure a larger negative extensive margin adjustment for arm's length compared to intra-firm trade during the East-Asian crisis of 1997. The margin decomposition, distinguishing between intra-firm and arm's length transactions, is a further dimension of heterogeneity in the collapse explored in this work.

> **Corollary 1***: intensive margin adjustments are more pronounced for intra-firm trade than arm's length trade; vice versa for the extensive margin adjustments.*

Bernard *et al.* (2009) is to my knowledge the only paper to date performing such a decomposition, analysing US trade during the 1993-2003 period.

3 Data

The analysis necessitates high frequency firm-level trade data matched with ownership information. The availability of this kind of data is restricted to a limited set of countries; here I look at Slovenia.

Slovenia is a small, open and fast developing economy, with well-established trade and production relations with the major European countries, besides the group of ex-Yugoslavian economies. The European process of east-west integration triggered the emergence of international networks of production, involving states of Central and Eastern Europe (CEECs) and Western European economies, mainly Germany and Italy. A further statistic confirming the relevance of *GVCs* for this country is that Slovenian trade is dominated by intermediate goods (72% of imports). Looking deeply at the trade dynamics for this particular country appears therefore of interest.

I use matched datasets from three sources[14]:

[13] A main determinant of intra-firm trade vs outsourcing has been shown to be the share of inputs provided by the headquarter firm relative to the share of inputs provided by the subsidiaries. In case the bargaining between the parties of an outsourcing agreement breaks down after investment in inputs and production by the two parties took place, the degree of control on the outside options is what induces the firm providing the larger share of inputs to integrate with the foreign supplier in order to minimise losses. (Antràs 2003, Nunn and Trefler 2013).

[14] The data from all three sources can be matched using a common firm identifier.

a. Trade data: the Statistical Office (*SURS*) and the Custom Administration (*CARS*) provide transaction-level data, recording all foreign transactions of Slovenian firms, at a monthly frequency, disaggregated at the CN-8 level. For each shipment I extracted the value of imported and exported product in EUR currency, the physical quantity in units of output (pieces or kilograms), the *CN* and the Broad Economic Categories (*BEC*) codes, as well as origin and destination country codes.

b. Firm characteristics: the Agency of the Republic of Slovenia for Public Legal Records (*AJPES*) provides balance-sheet and income statements for all Slovenian firms. These data include complete financial and operational information, among which domestic and foreign sales, costs of intermediate goods, materials and services, physical capital, value of assets, number of employees, and the NACE 4-digit industry code.

c. Ownership: this information is extracted from *ORBIS* (Bureau Van Dijk). This database allows to track the proprietary network of affiliates belonging to the same headquarter and located worldwide, up to the 10th level of subsidiarity[15]. I identify, for each firm, whether it belongs to a Slovenian or a foreign multinational group, or whether it is an independent firm. If transactions are undertaken by independent firms there is no doubt that this is arm's length trade, but shipments by Slovenian affiliates can include both a component of trade with related parties and a component with non-related parties. To solve this problem I follow the approach of Altomonte *et al.* (2012). Bas and Carluccio (2009) show that 88% of trade by affiliates to/from a certain destination/origin is made either by following a pure arm's length or a pure intra-firm strategy, with the remaining 12% following a mixed strategy. I therefore assume that transactions are intra-firm when they are directed to/come from a country where there is a subsidiary belonging to the same business group. On the other hand, if transactions are directed to a country with no co-affiliates, they are certainly going to be arm's length shipments[16].

All data span from 2000 to 2012, except for the ownership information which describes the status of proprietary networks in 2011[17].

[15] These levels are defined depending on the immediate owner of a subsidiary. A firm might in fact own another one while being owned by a headquarter firm at a higher level. The full ownership information used in this paper includes chains up to the 10th level.

[16] The assumption by which intra-firm and arm's length trade are identified introduces some measurement error. It is asymmetrical (consisting of a fraction of arm's length shipments being wrongly labelled as intra-firm), but it can be argued to be random, causing an attenuation bias in estimation, as I do not have reasons to think of factors causing a systematic misallocation of these shipments. In Appendix I provide figures that provide some insight about the size of the bias.

[17] The reasons for this are explained in Appendix.

4 Slovenian trade in the crisis

Slovenia's economic activity is dominated by small and medium enterprises, whose trade participation is high compared to larger countries[18]. The custom data allow a detailed picture of the impact of the crisis on Slovenian trade to be drawn: the shock had a sudden and deep impact on both exports and imports, with the deepest point reached in mid-2009, but with growth rates remaining negative for over a year and reverting to positive values only in 2010.

Figure 2: Year on year growth rates of exports and imports, 2000-2011.

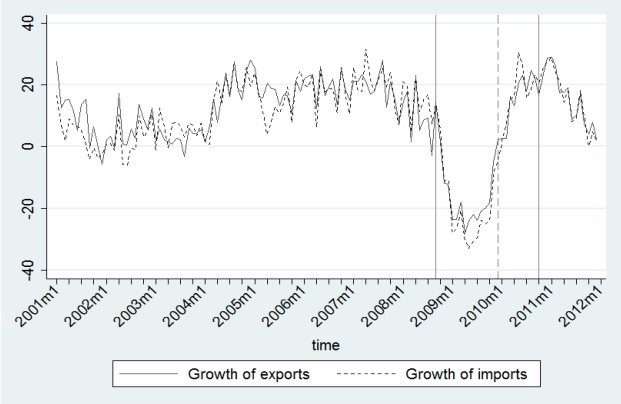


Figure 3 illustrates growth rates of consumption, capital and intermediate goods separately (BEC). Consumption goods showed a higher degree of resilience relative to the other categories; while intermediates dipped less and for a shorter period than capital goods.

Figure 3: Exports (left) and imports (right) of consumption, capital and intermediate goods.

This visual inspection shows evidence of compositional effects emerging from the heterogeneous response of the three aggregates; however, what is not immediately evident is a preponderant role

[18] Export participation in the manufacturing sector in 2002 was 48%; the same figure for the US was 18% (Bernard *et al.* 2012).

of intermediates in the collapse. The larger fall of trade in intermediates, to which the literature attributed part of the responsibility in accelerating the trade crisis (Yi 2009) does not immediately appear to be dominant in the Slovenian case.

Of interest for this work is firm ownership and the decision of a firm to relocate part of the production abroad with the establishment of affiliates, or to licence an unaffiliated supplier outside its boundary of activity to source intermediate inputs[19]. Panel A of Table 1 reports export and import activity of firms belonging to multinationals[20] regardless of the recipient of the shipments.

Table 1: Activity of multinationals and intra-firm trade in Slovenia, 2007-10.

	Firms		Number Transactions		Value transactions*	
Panel A: activity of multinationals						
	Groups	Not in groups	Groups	Not in groups	Groups	Not in groups
Exports	1,362	9,425	1,558,152	1,458,629	48,066	18,428
Imports	1,444	8,301	2,567,242	4,319,398	47,135	25,814
Panel B: Intra-firm trade						
	Intra Firm	Arn's Length	Intra Firm	Arn's Length	Intra Firm	Arm's length
Exports	757	10,401	827,731	2,189,050	32,750	33,744
Imports	998	9,574	1,308,626	5,578,014	32,799	40,151

Source: AJPES, CARS, SURS and author's calculations.
*Note: value of transactions is in millions of Euros.

Firms belonging to groups perform 51.6% of export and 37.2% of import transactions corresponding to, respectively, 72% and 64% of the total value of flows, despite them being only 12% of exporters and 15% of importers. In terms of a comparison with previous findings, the UNCTAD (2000) report estimates that, at the world level, intra-firm trade accounts for one third of total trade, while another third is accounted for by transactions that see multinationals at one of the two sides of the exchange, bringing the percentage of transactions operated by groups to about 60% of the total value. A comparison with country-level figures, most of which focus on U.S. firms, is influenced by the peculiar structure of the Slovenian trade: participation to trade is high in Slovenia, and is a less concentrated activity relative to larger countries. This explains the larger figure reported by Bernard *et al.* (2009) for the US – 90% of US trade being mediated by multinationals, compared to the about 70% measured for Slovenia – where there is a lower export participation by smaller and independent firms.

[19] Being aware of the imperfect match of the ORBIS data for 2011 with the firm level data for years before 2011, I matched the ownership information to trade data from 2007 onwards only, to reduce the likelihood of wrongly identifying a firm as belonging to a group in case the status of affiliation changed over time

[20] With domestic or foreign headquarter, where the threshold for ownership was set at 50.01%.

Exploiting also the information about the origin/destination of shipments and matching this with the map of network affiliation allows to identify intra-firm trade. These are transactions operated by firms belonging to groups and directed to/originating from destinations with firms belonging to the same group. The share of intra-firm exports in total trade is 49.25%: over the four years this share remained constant, oscillating between 49.09% in 2007 and 49.65% in 2010.

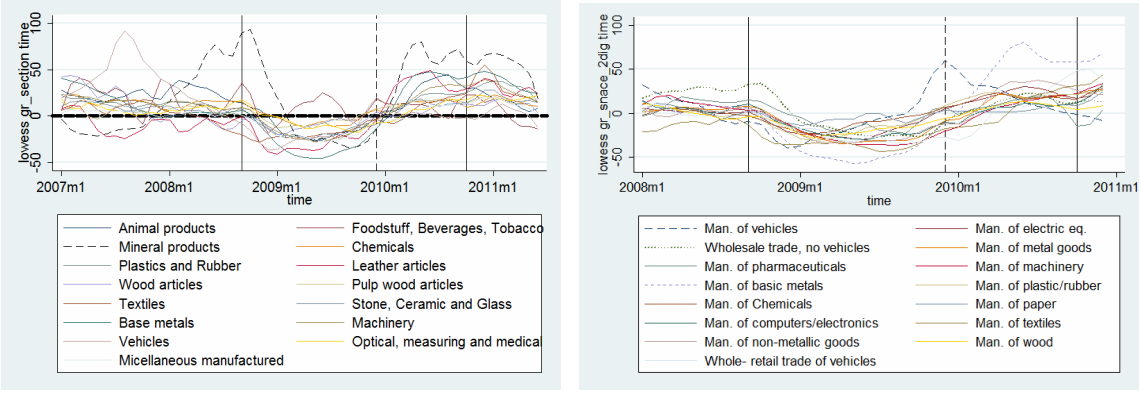
In estimation the period of analysis runs from September 2008 to September 2010, with the trough identified at November 2009, since trade kept growing at a negative rate until then. By September 2010 the overall value of exports and imports had approximately recovered to the pre-crisis level. The identification of the cutoff dates according to the Slovenian experience could spur worries of endogeneity if the Slovenian case was somehow affected by peculiar characteristics of Slovenian firms that I cannot control for in the econometric specification. I could be introducing a selection bias and reduce the degree of exogeneity of the shock. However, I argue that these concerns can safely be excluded here for a variety of reasons, the main one being that the timing used in estimation is highly compatible with the evolution of merchandise trade at the world level during the same period (Asmundson *et al.* 2011b).

Figure 4: total value of Slovenian exports, from 2000 to 2012, in logs.

Secondly, I estimate all regressions with firm fixed effects, thereby controlling for any time invariant unobservable firm characteristics that might have influenced the evolution of the trade crisis. Finally, with its economic size Slovenia could not affect the evolution of the financial and subsequent trade crisis. The shock can thus be considered largely exogenous to Slovenia.

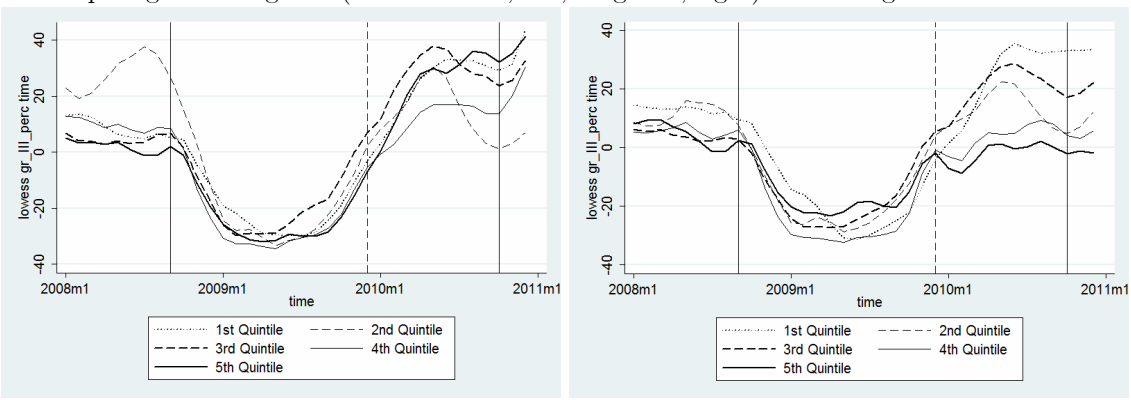
The synchronicity of the 2008-09 collapse further supports the choice of confining the analysis to the above described dates: the behaviour of aggregate exports (Figures 2 and 4) is the outcome of the coincident path of fall and rebound of the various product categories (CN code) and industrial sectors ($NACE$) over the crisis (Figure 5).

Figure 5: year on year growth of exports of products (CN, left) and sectors (NACE rev.2, right).



Disentangling the experience of the trade collapse for goods accounting for different cost-shares in firms' output, this synchronicity is observed again (Figure 6). It is reassuring that the cutoff dates of the crisis were similar across various segments of the cost-share distribution, especially for intermediate goods.

Figure 6: export growth of goods (intermediates, left; all goods, right) accounting for different cost shares.



It follows that the impact of the cost-share on the growth of trade detected in estimation is not due to a different timing of reaction for different inputs (i.e. longer/shorter downturn and recovery) but to a different depth of the trough of the crisis, as one would expect to be caused by a *catalyst* or an *inhibitor* of the trade collapse. Limiting the data between September 2008 and September 2010 leads to the identification of the final sample[21]:

[21] A sample of only exporters and importers might suffer from selection bias. Participation in international trade is rare and far from random (Bernard and Jensen 2004; Bernard *et al.* 2007): prior to entry into international markets, both importers and exporters are found to be larger and more productive, to be more capital- and skill-intensive, to pay higher wages, besides the fact that these activities show persistence. These facts suggest self-selection and OLS yields biased estimates in presence of unobservables affecting both selection into the market and the amount traded (e.g. managerial ability). I attempt to correct for this by estimating all equations with firm fixed effects: if the selection process is constant over time – as it can safely argued to be in this context – the selection effect is going to be differenced out together with the individual-specific effect.

Table 2: Final sample.

	Exports	Imports
Firms	8,425	8,498
Products	7,588	8,733
Destination/Origin	195	227

Source: AJPES, CARS, SURS and author's calculations.

5 Empirical strategy

To assess the role of inputs' cost-share as a *catalyst* of the trade collapse, the growth rate of trade at the firm-product-destination level is regressed against a number of controls. Using monthly growth rates spurs worries of attrition bias[22]; furthermore at a monthly frequency seasonality is potentially important. To cope with this I follow the approach of previous studies[23] and use mid-point growth rates, computed on the single flow x_{ickt} defined as the import/export flow x by a Slovenian firm i to a given destination c for each CN-8 product k in month t. The mid-point growth rate serving as dependent variable is:

$$g_{ickt}=\frac{x_{ickt}-x_{ick(t-12)}}{0.5\left(x_{ickt}+x_{ick(t-12)}\right)} \tag{5}$$

To explore the rationale that a larger cost-share of inputs in firms' sales can generate an accelerated reaction of trade in a recessionary environment, the cost-share (henceforth CS) variable is constructed using:

$$CS_{kj}=\frac{1}{YN}\sum_{y=1}^{Y}\sum_{n=1}^{N}\left(\frac{\sum_{t=1}^{12} im_{kijct}}{S_{ijy}}\right) \tag{6}$$

with im_{kijct} denoting the value of product k imported by firm i, in sector j, from origin c, in month t. N denotes the number of firms, Y the number of years from 2000 to 2007, S the value of sales. The cost share of the imported product (6) has a sectoral dimension since each product k might present a specific relevance depending on the sector j where the firm operates. The resulting measure is therefore specific for each of the 8,733 products in each of the 462 NACE 4-dig. sectors.

As an alternative interpretation, this variable can be seen as a measure of intensity of use of a product as an input. The construction of the CS variable is indeed inspired by input-output (IO) requirement coefficients, corresponding to the technical coefficient of use of inputs in downstream industries[24]. However, since Slovenia provides IO tables only at the 2-digit level and, importantly,

[22] Non-random entries and exits over the the crisis would bias estimates if one were to use standard growth rates.

[23] Davies and Haltiwanger (1992), Buono *et al.* (2008), Bricongne *et al.* (2012)

[24] A similar measure constructed with the US BEA Input-Output tables was used by Levchenko *et al.* (2010): they constructed a measure of *downstream vertical linkages,* by computing the average use of a commodity in all

I am working with trade data at the CN-8 level, the aggregation of such a rich data source to the sectors available in the *IO* tables would eliminate useful variation in the data. Hence, I opted for constructing a measure resemling a requirement coefficient, using all years available in the data up to the year before the crisis (2007): this allows me to compute a possibly exogenous time invariant value of how much, on average, each imported product is worth in total output.

The main equation estimated by the within estimator[25] is:

$$g_{ickt} = \beta_0 + \beta_1 CS_{kj} + \beta_2 Int_{ickt} + \beta_3 (CS_{kj} * Int_{ickt}) + \sum_r \beta_r X_{i,y-1} + \gamma_i + \mu_{jt} + \rho_{ct} + \varepsilon_{ickt}, \qquad (7)$$

where g_{ickt} denotes the mid-point growth rate of imports of product k performed by firm i from origin c in month t, CS_{kj} denotes the cost-share of the product k, Int_{ickt} denotes a binary variable identifying intermediates; γ_i, μ_{jt} and ρ_{ct} denote, respectively, firm, industry-month and origin-month fixed effects. $X_{i,y-1}$ represents a vector of controls that the literature has found to be important for explaining export performance and firms' decision to acquire foreign suppliers[26]: these were lagged by one year in estimation to alleviate reverse causality concerns. The subscripts t and y index month and year, respectively. β_3 tests the hypothesis that relatively more expensive intermediates gave rise to larger adjustments in the crisis. As a robustness check the cost-share variable (6) was re-computed using time spans different from the main one (2000-2007), to reassure that the measure can be considered as a stable characteristic of the product over time. The results are very similar to the benachmark ones.

Estimation of (7) circumscribes the analysis of the collapse to a full cycle of downturn plus recovery. The role of catalysts (or inhibitors) of the trade crisis should however not emerge when observing the growth of trade over the entire span of the event. Growth rates of trade of different products, should, on average, not differ from each other if the observation encompasses the full cycle. The role of the cost-share as a catalyst of the collapse should instead emerge observing the dynamics within the cycle, when separating the reaction between the downturn and the recovery phases. If the cost-share imparts a larger reaction to trade, this is evident with a deeper trough

downstream industries.

[25] The within transformation is operated at the firm level.

[26] The literature on property-rights modes of organisational choices (Antràs, 2003; Antràs and Helpman, 2004) has analysed aspects of why firms keep operations within their boundaries, or prefer to outsource to an external supplier. The empirical literature on this topic is vast (Yeaple 2006, Kohler and Smolka 2009, Bernard *et al.* 2010, Nunn and Trefler 2013, Corcos *et al.* 2013). In a nutshell, firms doing intra-firm trade are more productive, more capital- and skill-intensive, invest more in R&D, produce more complex goods, and are located in capital abundant countries. I control for capital intensity (ratio of firm fixed tangible assets over employment), skill intensity (ratio of the wage bill over employment), TFP (Levinson and Petrin (2003) estimator) and the overall level of employment (proxy for size).

(larger fall in the downturn coupled with larger rebound in the recovery), and not with a different performance over the entire period, which would instead indicate a different length of the cycle for goods accounting for a different CS. Specification (8) controls for the within cycle dynamics:

$$g_{ickt} = \alpha_0 + \alpha_1 \Omega + \alpha_2 \Omega * recovery + \varepsilon_{ickt} \tag{8}$$

where Ω denotes the right hand side of equation (7) and *recovery* is a binary variable picking up shipments after November 2009, identified as the trough of the crisis. The effect of the cost-share as a catalyst is identified by β_3 both during the downturn and the recovery.

To verify that the effect of the cost-share is robust across different degrees of integration of the value-chain (i.e. intra-firm against arm's length trade), I employ specification (9), where I interact the effect of the CS with the effect of firm-ownership: this identifies whether the adjustment differed depending on the relative cost-share of products, when they are traded within the firm boundaries.

$$\begin{aligned} g_{ickt} \quad = \quad & \beta_0 + \beta_1 CS_{kj} + \beta_2 IF_{ickt} + \beta_3 Int_{ickt} + \beta_4 (CS_{kj} * Int_{ickt}) + \beta_5 (IF_{ickt} * Int_{ickt}) + \beta_6 (CS_{kj} * IF_{ickt}) \\ & + \beta_7 (CS_{kj} * IF_{ickt} * Int_{ickt}) + \sum_r \beta_r X_{i,y-1} + \gamma_i + \mu_{jt} + \rho_{ct} + \varepsilon_{ickt} \end{aligned} \tag{9}$$

The right hand side of equation (9) is also interacted with the recovery dummy, as shown in (8).

The literature argued in favour of a differential impact of the crisis on firms with a different degree of access to firm intermediated trade finance (Coulibaly *et al.*, 2011; Antràs and Foley, 2014); for this reason, I expressly control for firms' reliance on trade credit in estimation. Firm level measures of trade credit are constructed following Love *et al.,* (2007): *payables*, a proxy for open-account operations, and *receivables*, proxy for cash-in-advance[27].

Lastly, I account for the fact that a reduced level of expenditure has been shown to be the main determinant of the trade shock (Levchenko *et al.*, 2010; Behrens *et al.,* 2013). The origin-month fixed effects, together with the industry-time and firm fixed effects, are the main way in which I control for the impact of demand changes on trade. The main motivation for controlling for demand is the differential reduction of spending across sectors (Bems *et al.,* 2012), and therefore across firms. I control for this cross-sectional variation that may be correlated with some right hand side variable by estimating all regressions with firm and industry-time fixed effects As firms

[27] Payables are calculated by taking the ratio of short term operating liabilities to sales, receivables are calculated by taking the ratio of short term operating receivables to sales. A drawback of these measures is that they refer to the domestic and foreign position of a firm with respect to these balance sheet items, and not to the financing of international trade only.

are not observed to change sector over the period of analysis, these fixed effects this should capture the heterogeneous impact of the change in spending across sectors. Furthermore, should the impact on Slovenian trade by the *CS* or *IF* trade have been affected by the uneven impact of the crisis across countries, or across time, the origin-time fixed effects should insulate my identification also from this source of correlation.

Table 3: Descriptive statistics of main variables.

	Imports								
	Entire sample			Intra-Firm			Arm's length		
	Obs.	Mean	Std.	Obs	Mean	Std.	Obs.	Mean	Std.
Dep. var. - mid point growth rate (value)	5,672,551	-0.075	1.697	979,168	-0.090	1.645	4,693,383	-0.071	1.708
Dep. var. - mid point growth rate (quantity)	5,454,565	-0.056	1.683	937,733	-0.072	1.627	4,516,832	-0.053	1.694
Intermediates (binary indicator)	5,672,551	0.515	0.499	979,168	0.612	0.487	4,693,383	0.495	0.499
Intra-Firm (binary indicator)	5,672,551	0.172	0.377	979,168	1	0	4,693,383	0	0
Cost-share in output (main measure)	5,388,408	0.030	0.843	932,469	0.020	0.164	4,455,939	0.032	0.924
Capital Intensity	8,498	746.9	3022	929	1826	11858	8,309	626.6	3064
Skill Intensity	8,498	156.4	75.16	929	219.6	128.7	8,309	149.7	79.69
Employment	8,498	47.28	1190	929	237.6	750.9	8,309	26.01	118.1
TFP	8,498	373.8	4246	929	499.1	2775	8,309	359.9	1776
Payables	8,498	1.19	23.06	929	4.232	93.94	8,309	0.841	26.89
Receivables	8,498	0.937	7.365	929	1.628	29.21	8,309	0.860	34.31

Source: SORS, AJPES and author's calculations.

6 Results

In this section I present the estimation results for the behaviour of Slovenian importers in the trade crisis, separating the impact of the shock according to the end use of products, the cost-share of inputs and the type of firm affiliation.

6.1 The cost-share of intermediates, a *catalyst* of the collapse?

Hypothesis 1 is confirmed in table 4: products' cost-share worked as a catalyst of the collapse. Starting from column (1), on average and over the entire period of the crisis, imports of products accounting for a larger *CS* in firms' output grew less, relative to products accounting for a lower *CS*. This is a somewhat unexpected result, because over the entire cycle one would not expect a differential behaviour of different products if the cutoff dates were identified precisely. However, as already evident in Figure 6, for undifferentiated products the path of shipments at different quintiles of the *CS* distribution is rather heterogeneous (especially in the recovery) making it difficult to pin down the end of the cycle with precision.

Table 4. The CS as a catalyst of the collapse.

	(1)	(2)	(3)	(4)	(5)	(6)
	Product-Sector CS in terms of sales					
CS	-0.007***		-0.007***		-0.006***	-0.006***
	(0.001)		(0.001)		(0.001)	(0.001)
Int.		0.027***	0.037***	0.016**		0.033***
		(0.005)	(0.005)	(0.007)		(0.007)
Int. * CS			-0.019			**-0.072*** **
			(0.016)			**(0.028)**
CS * Rec					-0.002	-0.002
					(0.002)	(0.002)
Int. * Rec.				0.028**		0.009
				(0.012)		(0.013)
Int. * CS * Rec.						**0.105** **
						(0.048)
Firm. FE	yes	yes	yes	yes	yes	yes
Origin*Month FE	yes	yes	yes	yes	yes	yes
Industry*Month FE	yes	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes	yes
Constant	-0.036***	-0.001***	-0.037***	-0.002***	-0.037***	-0.036***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	4765832	4996618	4765832	4996618	4765832	4765832

Note: Standard errors clustered at the firm level in parentheses;
* p < 0.1, ** p < 0.05, *** p < 0.01.

In contrast, the path of intermediates is more homogenous, and this is mirrored in the coefficient on the interaction *Int.*CS* in column (3): a higher *CS* did not imply a stark difference for imports of intermediates when no distinction is made between the downturn and the recovery phase.

Observing the within collapse dynamics is more directly informative of the role of the *CS* as a *catalyst* of the trade crisis. For this purpose in columns (5) and (6) I separate the impact of the *CS* on undifferentiated products and on intermediates between the downturn and the recovery period. The overall negative performance of products accounting for a larger *CS*, found in column (1), is the outcome of a more pronounced fall in the downturn, followed by a recovery where the impact of the CS is not found to be significantly different from zero (column 5). For intermediates instead (column 6), the *CS* acted as a strong catalyst, accelerating both the drop of imports in the downturn and their rebound in the recovery. Firms reacted to the shock reducing purchases of inputs accounting for a larger share of their output more than proportionately in the first period of crisis, and then increased them when the cycle picked up, again more than proportionately. This larger responsiveness could possibly be due to larger inventory adjustments by firms trying to downsize the stock of relatively high cost-share intermediates, in an attempt to raise liquidity in a

recessionary period[28].

The differential impact of the crisis across products highlights a relevant role for the cost-share in explaining part of the trade collapse. Notice that the positive coefficient of the intermediate dummy in the downturn (column 4 in table 4) more than doubles when controlling for the cost-share of products, and substantially goes to zero in the recovery phase. Higher-cost share intermediates contributed in a substantial way to the dowturn, performing in a way which is opposite to lower cost-share intermediates. In recovery instead, the positive reaction of higher-cost share intermediates accounts for all of the estimated positive performance of intermediates, further supporting the role of the cost-share as a key source of heterogeneity across products and as a catalyst of the trade collapse.

6.2 Intra-firm versus arm's length trade: a *catalyst* or an *inhibitor*?

A secondary mechanism under examination in this paper is whether the response of trade to a demand collapse differs depending on firm affiliation, that is whether intra-firm trade reacted differently compared to arm's length trade. Overall, the study of the collapse does not reveal a statistically different response between the two organisational modes. Table 5 shows the results for imports, where the impact of *IF* against *AL* trade is observed in isolation.

Table 5: Intra-firm versus arm's length trade.

	(1)	(2)
IF	0.026	0.025
	(0.021)	(0.026)
IF * Rec.		0.005
		(0.031)
Firm. FE	yes	yes
Origin*Month FE	yes	yes
Industry*Month FE	yes	yes
Firm controls	yes	yes
Constant	-0.001***	-0.001***
	(0.000)	(0.000)
N	4996618	4996618

Note: Standard errors clustered at the firm level;
* p < 0.1, ** p < 0.05, *** p < 0.01.

IF trade is not observed to have affected the reaction of trade in the crisis differently from *AL* trade when the effect is averaged over all products, neither over the entire cycle (column 1), nor when separating the effect over the downturn and the recovery (column 2).

[28] A more formal explanation for this mechanism is left to be explained in section 7.

In Table 6 the impact of firm affiliation is interacted with that of the *CS*, as shown in specification (9). Over the entire cycle (first column) it is confirmed that the reaction of *IF* imports was not different from that of *AL* imports, also when interacting the *IF* variable separately with the dummy for intermediates, with the *CS* variable, or both together.

Table 6: Firm affiliation and cost-share.

	(1)	(2)	(3)
IF	0.032	0.026	0.045
	(0.024)	(0.026)	(0.031)
CS	-0.007***	-0.006***	-0.007***
	(0.001)	(0.011)	(0.012)
IF*CS	0.014	-0.021	0.034
	(0.012)	(0.074)	(0.060)
Int.	0.040***		0.040***
	(0.005)		(0.007)
Int. * IF	-0.018		-0.033
	(0.014)		(0.024)
Int. * CS	-0.023		**-0.069****
	(0.016)		**(0.029)**
Int. * CS * IF	0.027		**-0.087**
	(0.070)		**(0.098)**
IF * Rec.		-0.004	-0.031
		(0.031)	(0.040)
CS * Rec.		-0.002	-0.003
		(0.001)	(0.002)
IF * CS *Rec.		0.043	-0.020
		(0.075)	(0.059)
Int. * Rec.			0.001
			(0.013)
Int. * IF * Rec.			0.041
			(0.035)
Int. * CS * Rec.			**0.089***
			(0.046)
Int.* CS * IF *Rec.			**0.249***
			(0.141)
Firm. FE	yes	yes	yes
Origin*Month FE	yes	yes	yes
Industry*Month FE	yes	yes	yes
Firm controls	yes	yes	yes
Constant	-0.037***	-0.037***	-0.037***
	(0.000)	(0.000)	(0.000)
N	4765832	4765832	4765832

Note: Standard errors clustered at the firm level in parentheses;
* p < 0.1, ** p < 0.05, *** p < 0.01.

In columns (2) and (3) the analysis contrasts the two subperiods of the crisis. Without distinguishing between the end use of products (column 2), again IF trade shows no statistically significant impact, although the signs of the coefficients (negative in the downturn and positive in

the recovery) hint at a further accelerating role for IF trade when higher cost-share products are shipped, relative to AL trade. It is only when unpacking the effect of firm affiliation further between intermediates on one side and consumpion and capital good on the other, that some pattern emerges: it appears that *IF* trade conferred to shipment of intermediates accounting for a larger *CS* an enhanced reaction in the both downturn (the coefficient on the *Int.*CS*IF* variable is negative even though insignificant) and in the recovery (the corresponding coefficient *Int.*CS*IF*Rec* is positive, but moderatly significant). The weak degree of precision with which the impact of IF was identified does not allow to draw strong conclusions, but the results nonetheless suggest that *IF* trade might have accelerated the collapse of imports, rather than dampening it. There appears, therefore, to be a cumulative effect imparted by the *CS* and firm affiliation on trade of intermediates, with both factors acting as catalysts of the reaction of trade to the demand shock, within GVCs[29]. Importantly, heterogeneity across the *CS* of inputs seems to be the relevant margin of intervention of firms when attempting to downsize activity in a recessionary environment: the accelerating impact of the CS persists when controlling for the effect of firm affiliation and it is the only margin along which a differential impact between *IF* and *AL* trade is detected, possibly because of a different inventory mangement strategy, or more simply a differential potential to quickly adjust to a shock.

Several factors could explain why the analysis of *IF* against *AL* trade failed to show well defined results. First, all regressions are run with firm fixed effects; so there is likely to be very little within-firm variation to be estimated from between *IF* and *AL* trade. More crucially, clustering the standard errors at the firm level reduces in a dramatic way the number of clusters available to compute the variance of the estimator, especially compared to when clustering at the product level[30]. Secondly, the identification of *IF* and *AL* transactions suffers from measurement error: as explained in the previous section, the misallocation of a fraction of shipments from *AL* to *IF* trade causes the coefficients on these variables to be biased towards zero, again preventing the detection of a significant impact. In this case, however, it can be argued that this limitation works against my identification strategy and that the (weak) differences I detect between *IF* and *AL* trade would just be stronger if I could separate the two groups more precisely. Lastly, even though the stylized (S, s) model offers a simple rationale to expect a larger reaction of IF trade, the presence

[29] Denoted by the relevance of intermediate goods for the results.

[30] Standard errors are about 200-300% larger when clustering at the firm level, rather than at the product level. I nonetheless preferred to conduce the analysis with firm-clustered standard errors and make it considerably more difficult to reject the null of a zero effect because I believe the relevant and more natural dimension of error- and regressor-correlation is indeed the firm, rather than the product.

of alternative mechanisms of opposite sign is well possible in a trade crisis[31]: IF trade links appear more "stable" at the extensive margin, as evident from the analysis of trade margins in section 7, with a considerably lower amount of firm and destination exits. In case these offsetting mechanisms were at work, this can further explain why only a mild gap is uncovered between the response of one trading mode with respect to the other.

6.3 A *bullwhip* effect triggered by the adjustment of intermediates?

The cost-share of imported products imparted to imports of intermediates a more than proportionate response to the change in demand in the 2008-09 collapse, in both the downturn and in the recovery phase. This deeper trough experienced by intermediates hints at a U-shaped reaction for these goods over the crisis. If this path can find an explantion in the dynamics of inventory adjustments by firms along a value chain[32], this U-shaped reaction recalls what the value chain literature defines the *bullwhip* effect (Forrester, 1961), a response induced by demand variability, which is lowest for the most downstream product along a chain of production, and highest for the most upstream producers. Escaith *et al.* (2010) argue that the greater the distance between a firm and the final consumer, the more demand uncertainty the firm faces and the greater its inventory holdings. A demand shock leads downstream firms to reduce orders and run down inventories in expectation of lower future demand: this is reflected in an amplified shock for upstream firms, which are forced to hold more inventories. During the recovery phase the opposite should be observed, with a more than proportional increase of shipments along the chain when inventory stocks go back to the pre-shock level.

The results of Table 4 do not show the existence of a *bullwhip* effect for all intermediate products. In column (4) I expressly control for this effect, which would show with a negative coefficient on the intermediate dummy in the downturn, coupled with a positive one in the recovery. There appears instead to be a faster growth of intermediates' imports in both sub-periods of the crisis, relative to capital and consumption goods. On the other side, importantly, the bullwhip effect emerges when controlling for the *CS* of intermediates: the faster fall in the downturn coupled with the faster rebound in the recovery found for inputs accounting for a larger *CS*, consists in a result corresponding to a bullwhip effect. The additional accelerating impact exerted on trade of high-*CS* inputs by *IF* trade contributes to strengthen the finding that, within GVCs, the relevant source of

[31] IF trade of US firms was reported to be more resilient than AL trade during the East Asian crises of 1997 (Bernard et al. 1997).

[32] This channel is going to be analysed in Section 7.

cross-product heterogeneity acting as a catalyst of the trade collapse is the relative *CS* of the items imported by firms.

6.4 The relevance of buyer-seller trade finance

Here I verify that the role of catalyst of the collapse played by inputs' *CS* is robust to firms' reliance on buyer-seller finance. Table 7 presents the estimates for payables, a proxy for open-account transactions.

Importers that tend to obtain more credit from their foreign partner (i.e higher payavbles[33]) reported a higher growth of imports, over the entire period of the crisis (column 1). This might appear to be an obvious result, however during a crisis it is conceivable that, due to overall increase in counter-party risk, firms relying more on this form of financing might have been harmed more compared to firms reporting lower payables.

More interestingly, the impact of buyer-seller trade finance appears to have worked as a strong inhibitor of the trade collapse (column 3): the overall higher growth of imports reported in column (1) is the outcome of a better performance in the downturn, when bank-intermediated finance became more expensive, coupled with a worse performance in the recovery, when the resumption of banking activity might have conferred an edge to exactly those firms that were hit harder during the downturn. In Table 8 I also interact the effect of payables with IF trade[34]; the extension of buyer-seller credit could be easier within multinationals and this might affect the general impact of IF trade. Over the entire cycle, no significant impact of IF trade is detected for imports of firms relying more heavily on payables (column 2), neither for all products, nor for intermediates. Examining the dynamics within the crisis, it appears again that IF acted as a *catalyst* of the collapse: for undifferentiated products, imports of firms reporting larger payables performed worse in the downturn when traded intra-firm and better in the recovery (*IF*Pay* and *IF*Pay.*Rec.*, column 4), compared to when traded at *AL*. Focusing on trade of intermediates instead does not reveal a clear pattern, due to the insignificant coefficient estimated for the downturn.

Lastly, a key result emerging from Table 8 is that the accelerating effect of the *CS* on trade of intermediates is completely robust to the introduction of the variables controlling for firms' reliance on trade credit (columns 4 and 5). Not only the coefficients remain significant, but also the size is unaffected.

[33] Recall that this variable is lagged by one year in estimation, to alleviate reverse causality concerns.

[34] This is another contribution of this paper, as the relevance of buyer-seller trade finance has not been studied before in its interaction with intra-firm trade.

Table 7: CS, IF trade and Payables.

	(1)	(2)	(3)	(4)	(5)
Pay	0.080***	0.088***	**0.091*** **	0.090***	0.105***
	(0.026)	(0.032)	**(0.023)**	(0.029)	(0.038)
CS-Sect.	-0.007***	-0.007***	-0.007***	-0.007***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
IF		0.017			-0.007
		(0.027)			(0.029)
Int.	0.040***	0.044***	-0.000	-0.000	0.000
	(0.008)	(0.009)	(0.011)	(0.013)	(0.013)
Int. * Pay	-0.047	-0.057		0.0104	0.006
	(0.032)	(0.037)		(0.0198)	(0.026)
Int * CS-Sect	-0.019	-0.021		-0.097***	-0.082**
	(0.016)	(0.016)		(0.037)	(0.034)
Int. * IF		-0.015			-0.024
		(0.020)			(0.0261)
IF*CS-Sect		0.012			0.034
		(0.013)			(0.065)
Int. * CS-Sect. * IF		0.005			-0.136
		(0.073)			(0.115)
IF * Pay		-0.034			-0.061*
		(0.029)			(0.035)
Int. * IF * Pay		0.046			0.022
		(0.037)			(0.032)
Pay. * Rec.			**-0.104*** **	-0.057	-0.082
			(0.027)	(0.059)	(0.062)
CS-Sect. * Rec.			-0.001	-0.002	-0.002
			(0.001)	(0.002)	(0.002)
IF * Rec.					-0.013
					(0.035)
Int. * Rec			0.076***	0.087**	0.078**
			(0.025)	(0.034)	(0.036)
Int. * Pay. * Rec.				-0.067	-0.048
				(0.057)	(0.057)
Int. * CS-Sect * Rec.				0.152**	0.125*
				(0.070)	(0.065)
Int. * IF * Rec.					0.079*
					(0.045)
IF * CS-Sect. * Rec.					-0.021
					(0.065)
Int. * CS-Sect * IF * Rec.					0.349*
					(0.188)
IF * Pay. *Rec.					0.129
					(0.085)
Int.* IF * Pay. Rec.					-0.187
					(0.123)
Firm. FE	yes	yes	yes	yes	yes
Destination FE	yes	yes	yes	yes	yes
Month FE	yes	yes	yes	yes	yes
Firm controls	yes	yes	yes	yes	yes
Constant	0.165	0.161	0.271***	0.269***	0.277***
	(0.112)	(0.111)	(0.095)	(0.095)	(0.086)
N	4764175	4764175	4764175	4764175	4764175

Note: Standard errors clustered at the firm level in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01.

6.5 Quantity or Price?

During the trade collapse the value international trade dropped abruptly: behind this drop there was a reduction in the quantity of products shipped, but a fraction of the overall variation of the

value of trade could have been caused by price changes. The literature so far pointed towards the change in quantity as the main driver of the collapse, with prices only playing a marginal role (Bricongne *et al.,* 2012; Behrens *et al.,* 2013). To control for this, as a robustness test, I ran all the regressions presented in this paper by exploiting as dependent variable the mid-point growth rate of the quantity (in kilograms or units) of imports and exports, instead of the nominal value of shipments. All the estimated effects of the *CS* and *IF* trade are confirmed also when only quantity changes are observed[35]. This strongly reassures that the results showed in this work are not driven by price changes: this could have been a potentially important source of variation, especially for trade within multinationals that could be affected by transfer pricing practices.

6.6 Discussion

Summarising the findings of this section, a safe conclusion is that the *CS* of intermediates is associated with a stronger reaction of firms during the trade collapse. The path of imports of higher cost-share inputs was characterised by a deeper trough in the crisis. This effect is estimated very precisely, with the *CS* variable being computed separately for each of the 8,733 different products in each of the 462 different sectors.

These results are upheld when controlling for firm affiliation and the reliance of firms on buyer-seller trade finance. Concerning the IF versus AL analysis, no statistically significant impact is found, except for the (weakly identified) accelerating effect for *IF* trade estimated when controlling for the *CS* of intermediates. This hints at the relevance for multinationals of their ability to communicate in an effective way and to synchronize production and trade decisions along a value chain in the event of a shock. Introducing the controls for firms' reliance on buyer-seller trade finance reveals an additional result: the path of the trade collapse is characterized by a shallower trough for firms reporting larger payables, proxy for open-account transactions. Reliance on firm intermediated trade finance appears therefore to have worked as an inhibitor of the trade collapse, dampening the responsiveness of trade in the 2008-09 event.

In conclusion, the strongest and most reliable contribution of this paper consists in detecting a new source of heterogeneity across different inputs, able to affect the responsiveness of international trade to the demand shock of 2008-09. The heterogeneity across the *CS* of intermediates seems to be the relevant margin of intervention of firms when attempting to downsize activity and trade in

[35] These results are so similar to those reported in the paper that the tables are not presented here for the sake of brevity, but are available on request.

a recessionary environment, with the opposite mechanism at work in the recovery. Additionally, this is the only margin along which a differential impact between IF and AL trade was detected, possibly because of the different ability and/or possibility to promptly adjust to the shock.

7 Reduced form estimation of the inventory mechanism

In this section I attempt to provide evidence in support of the channel hypothesised as a determinant of the enhanced adjustment of higher cost share intermediates. Hypothesis 1 relates the trade adjustment to the management of inventories. In order to test its implications about the relevance of products' cost-share in determining the stock of inventories (i.e. a higher cost-share corresponding to a higher value of the stock) and the inventory adjustment (i.e. a higher cost-share leading to a larger adjustment), I would ideally need inventory data at the level at which I measure the cost-share (CN-8 product level). Additionally, to properly observe the adjustment over the crisis these data would need to be at a monthly frequency. Having inventory data only at the firm level, recorded at a yearly frequency, I cannot do more than approaching the empirical test of this hypothesis with a reduced form estimation, averaging up to the firm level the CS of the products that a firms imports over a year: $CS_{it} = \frac{1}{K}\sum_{k=1}^{K} CS_{kj}$ where CS_{it} is the CS of firm i in year t[36]. According to (1) the average stock of inventory is negatively related to the unit-cost of the item, but positively to the cost-share (equation (16) in appendix). Taking (1) to the data leads to a specification of this form:

$$N_{it} = \beta_0 + \beta_1 CS_{it} + \beta_2 S_{it} + \gamma_i + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \tag{10}$$

where N denotes the stock of inventories, CS denotes the firm level cost-share ratio, S denotes sales, γ_i and η_t denote firm and year fixed effects, t and t^2 denote a linear and a quadratic time trend[37], i and t index firms and years. Firm fixed effects capture factors that can be considered firm specific and constant over time, like the ordering cost A, the complexity coefficient ω and the carrying charge I; any time varying factor common across firms that determines a change in these costs (e.g. interest rates) is captured by the time fixed effects.

[36] The product level CS_{kj} does not present a time index because the CS is constructed to be time-invariant. The firm level CS_{it} has instead been calculated averaging the product level cost-share for each firm, year by year, over the products imported. This approach for the firm level CS has been chosen for two reasons:

a. it seems realistic to think that the average CS of the stock of inventories of a firm changes from year to year, depending on the adjustments performed by the firm.

b. preserving a time dimension allows the use of firm fixed effects in estimation.

[37] Since the average stock of inventories (1) is a function of the square root of demand and the cost-share, linear and quadratic time trends are consistent with targets that increase with time and its square root.

β_1 and β_2 capture the contemporaneous impact of the *CS* and sales on inventories: the *CS* should be positively associated with the value of the stock, whereas sales could come with a negative coefficient if contemporaneous sales are different from firms' expectations and inventories act like a buffer stock. In order to take into account firm's expectations and the adjustment of inventories due to sales and the average cost-share, specification (10) can be amended in this way:

$$N_{it} = \beta_0 + \beta_1 CS_{it} + \beta_3 CS_{it-1} + \beta_3 S_{it} + \beta_4 S_{it-1} + \gamma_i + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \qquad (11)$$

Table 8 provides the results of the estimation of (10) and (11). The data are taken from firms' balance sheet information (AJPES), for all years between 2000 and 2011. The inventory and sales variables are scaled by firms's value of total assets.

The contemporaneous average firm-level *CS* ratio is always found to be positively associated with the stock of inventories, as expected. In column (1) it also emerges that contemporanous sales are negatively associated with the value of the inventory stock: this seems compatible with the classical interpretation that sees inventories as a buffer against unexpected increases in sales, in order to avoid stockout costs (Hadley and Whitin 1963, Abel 1985, Carpenter *et al.,* 1994, 1998).

Table 8. Inventories as a function of the CS.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Product-Sector CS in terms of sales						
CS_firm$_{(t)}$	0.00087*	0.00144***			0.00165***	0.00165***	**0.00154*** **
	(0.00045)	(0.00042)			(0.00031)	(0.00031)	**(0.00051)**
CS_firm$_{(t-1)}$			-0.00048***	-0.00048***	-0.00101***	-0.00101***	**-0.00084*** **
			(0.00014)	(0.00014)	(0.00020)	(0.00020)	**(0.00032)**
Sales$_{(t)}$	-0.00016***			-0.00022+	-0.00022+		**-0.00021+**
	(0.00005)			(0.00016)	(0.00016)		**(0.00016)**
Sales$_{(t-1)}$		0.00025	0.00020			0.00025	**0.00088'**
		(0.00021)	(0.00021)			(0.00021)	**(0.00055)**
Trend	0.00028	0.00103'	0.00111*	0.00111*	0.00104'	0.00104'	**0.00299*** **
	(0.00063)	(0.00064)	(0.00064)	(0.00064)	(0.0006)	(0.0006)	**(0.00086)**
Trend^2	0.00012**	0.00005	0.000037	0.00003	0.00004	0.00004	**-0.00016** **
	(0.00006)	(0.00006)	(0.00006)	(0.00006)	(0.00006)	(0.00006)	**(0.00007)**
Firm. FE	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes
Constant	0.185***	0.192***	0.192***	0.192***	0.192***	0.192***	0.194***
	(0.00121)	(0.00129)	(0.00130)	(0.00127)	(0.00127)	(0.00129)	(0.00219)
N	110115	81255	81434	81468	81033	80999	63275

Note: Standard errors clustered at the firm level in parentheses; + p < 0.2, ' p < 0.15,* p < 0.1, ** p < 0.05, *** p < 0.01.

The optimal stock (1) increases with sales; hence in column (2) I replace sales with its lag, to control for the adjustment induced by a higher level of past sales: a positive coefficient is detected,

albeit it is not statistically significant. In column (3) and (4) I attempt to control for the adjustmet induced by the *CS*, replacing the contemporaneous *CS* with its one year lag: conditional on sales (or past sales), a past higher average *CS* induces firms to adjust inventory holdings to a lower level in order to minimise carrying costs: this explanation is compatible with the negative coefficient estimated for the lagged *CS* ratio. In columns (5) and (6) I add both the comtemporanous and the past *CS* ratio, alteratively with current sales or past sales. Lastly, in column (7) I control for all factors jointly: all coefficients take the expected signs, including the sales variables, whose level of significance reaches now a somewhat more satisfactory level. Notice that also the trend coefficients take the expected signs and significance levels, only when the full specification (11) is estimated.

The results in column (7) appear therefore to best support the (S, s) model and the prediction of hypothesis 1. Despite the evident caveats arising from the data structure available to test these propositions, the estimates of table 7 provide some - admittedly rudimental - evidence in support of the inventory adjustment channel as an explanation of the role of the *CS* heterogneity in accelerating the trade collapse. A higher average *CS* of imported products is associated with a higher value of inventories, and firms whose average *CS* of imported products is higher appear to reduce their inventory holdings, after controlling for their level of sales: this mechanism could help explaining the accelerating impact of the *CS* on imports of intermediates estimated in tables (4) and (6), and its role as a catalyst of the trade collapse.

8 Intensive and extensive margin of trade in the crisis

The literature attributed the largest fraction of the variation in trade during the crisis to adjustments at the intensive margin, mainly performed by large exporters (Bricongne *et al.* 2012, Wagner 2012, Behrens *et al.* 2013). The availability of monthly transaction level data allows to perform a detailed intensive/extensive margin decomposition, and to separate the extensive margin further along the firm, destination and product dimensions. One of the novelties of this work consists in the possibility of decomposing these four margins further, distinguishing between *IF* and *AL* trade.

The results of section (6) point in direction of a differential reaction during a trade collapse depending on the ownership structure linking agents of international trade. Further in support of a differential impact of shocks between *IF* and *AL* trade, there are the different cost structures relating to the two organisational modes as well as the so-called hold-up problem[38] (Antràs, 2003;

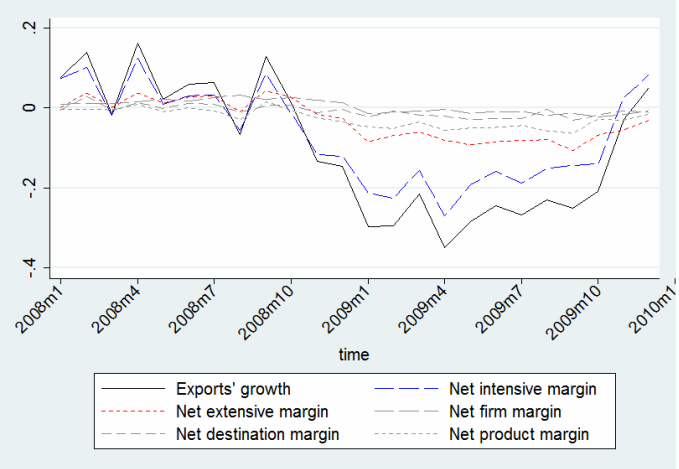
[38] A main determinant of intra-firm trade vs outsourcing has been shown to be the share of inputs provided by the headquarter firm relative to the share of inputs provided by the subsidiaries. In case the bargaining between the

Antràs and Helpman, 2004; Nunn and Trefler, 2013). With respect to trade margins, deeper integration leading to the establishment of multinationals, due to the presence of sunk costs and market rigidities, could imply that in a trade crisis adjustments along the intensive margin are preferable to extensive margin adjustments. If some adjustment along the extensive margin is required, then this could be preponderant for arm's length trade. For example, Bernard *et al.* (2009) measure a larger negative extensive margin adjustment for arm's length compared to intra-firm trade during the East-Asian crisis of 1997.

The margin decomposition, distinguishing between intra-firm and arm's length transactions, is a further dimension of heterogeneity in the collapse explored in this work. Bernard *et al.* (2009) is to my knowledge the only paper to date performing such a decomposition, analysing US trade during the 1993-2003 period. The decomposition applied here is based on Bricongne *et al.* (2012)[39]: for each month I measure the intensive margin and the three extensive margins (firm, destination and product margins), separating then these further between IF and AL transactions. The net margins are given by the sum of the positive and negative contributions.

During the crisis the adjustment of Slovenian trade took place mostly at the intensive margin, with this fraction of the overall variation possibly also underestimated because of the high level of data disaggregation and frequency. From Figure 7 it also is evident that the firm and destination extensive margins play a smaller role compared to the product margin: this confirm the similarity of the Slovenian experience to what the literature showed for France, Belgium and Germany.

Figure 7: Net firm, destination and product extensive margin adjustments, 2007-2011.



parties of an outsourcing agreement breaks down after investment in inputs and production by the two parties took place, the degree of control on the outside options is what induces the firm providing the larger share of inputs to integrate with the foreign supplier in order to minimise losses. (Antràs 2003, Nunn and Trefler 2013).

[39] Since the methodology is borrowed from Bricongne *et al.* (2012) I specify the details in Appendix.

The complete decomposition is presented in Table 11, where the margins' contributions are averaged over the main periods characterising the event[40]. In the pre-crisis period, the contributions of intensive and extensive margins are about similar. During the downturn the intensive margin absorbed over double the share of the overall fall in trade compared to the extensive margin; with also the subsequent recovery being dominated by an increase in the value of continuing links rather the creation of new ones.

Table 11: Net intensive and extensive margin adjustments, 2007-2011, in %.

	Pre-crisis		Downturn		Recovery		Post-crisis	
	Jan 07 - Dec07		Sep 08 - Nov 09		Dec 09 - Sep 10		Oct 10 - Dec 11	
	IF	AL	IF	AL	IF	AL	IF	AL
Firm								
Entry	0.49	3.78	0.40	2.95	0.62	2.92	0.43	3.51
Exit	-0.07	-1.84	-0.91	-3.26	-0.44	-3.34	-0.29	-2.80
Net Firm	0.42	1.94	-0.51	-0.29	0.17	-0.41	0.13	0.70
Destination								
Entry	1.95	5.66	1.46	4.72	1.91	5.88	2.11	5.71
Exit	-1.14	-4.75	-1.99	-5.93	-1.57	-4.87	-1.61	-4.21
Net Dest	0.81	0.90	-0.53	-1.21	0.33	1.01	0.49	1.50
Product								
Entry	4.91	8.92	2.98	4.83	9.03	6.31	6.20	6.49
Exit	-4.61	-8.24	-4.82	-7.38	-8.54	-6.89	-5.80	-5.83
Net Prod	0.30	0.67	-1.83	-2.55	0.49	-0.57	0.40	0.65
Total Extensive								
Pos	7.36	18.3	4.85	12.51	11.5	15.1	8.74	15.7
Neg	-5.83	-14.8	-7.73	-16.57	-10.5	-15.1	-7.70	-12.8
Net Ext	1.53	3.52	-2.88	-4.05	1.00	0.00	1.04	2.86
Total Intensive								
Pos	13.3	10.6	9.01	8.04	13.8	12.3	12.0	13.0
Neg	-8.81	-8.17	-17.3	-15.4	-7.33	-9.34	-7.99	-8.13
Net Int	4.49	2.43	-8.36	-7.39	6.47	3.04	4.09	4.95
Tot. Exp	6.02	6.00	-11.2	-11.4	7.48	3.06	5.13	7.82

Source: CARS, SURS and author's calculations.

It is the product margin that contributed the most to the extensive margin variation: this is represented by discontinued shipments of products by incumbents within destinations that continued to be served with other products. This is a within firm-destination margin that might appear of secondary importance – and certainly not evident in more aggregate data – which could however represent a first order issue in the light of new findings of the heterogeneous firms trade literature: importing firm's productivity can be harmed in case firms are no longer able to source inputs that

[40] Table 10 includes the figures underlying figure 8. For each sub-period the margins are evaluated separating the contributions to *IF* and *AL* trade, but summing horizontally the within sub-period margins the aggregate figures represented in figure 8 are obtained.

are not perfectly substitutable in the production process (Gopinath and Neiman, 2014); or else, exporters might have suffered in case they were unable to find buyers for the varieties they produce following importers willingness to concentrate purchases from the suppliers best suiting their preferences (Ottaviano *et al.* 2014).

The existing literature on the trade crisis has not explored the disaggregation of trade margins taking into consideration whether shipments are between related parties or not. In all sub-periods, except for the recovery, the contribution of the extensive margin to the overall variation in AL trade exceeds the contribution to the variation in IF trade. A significative comparison can be made especially in the first two sub-periods, because both before the crisis and in the downturn the overall variation is split roughly equally between the two organisational modes, but it is evident that the composition of this variation differs in the direction predicted by *corollary 1*: intensive margin changes are prevalent for IF trade; extensive margin changes prevail for AL trade. Once a firm is integrated with the foreign supplier, in a crisis it might be preferable to reduce the value of the shipments, rather than severing the offshoring link. This could find an explanation in the different cost structures relating to these different modes of cross border production, with larger sunk costs and lower variable cost associated to IF trade; or else, in the reasons why firms decide to acquire the ownership of the foreign supplier, rather than subscribing an outsourcing agreement. The literature triggered by Antràs (2003) explained that intra-firm imports increase in the share of non-contractible inputs provided by the headquarter firm: once investment in customised inputs took place, a firm will have losses if the agreement breaks down. Therefore, the larger this investment the more likely the acquisition of control over the supplier.

This interdependence between the two ends of the production chain could be another reason why intensive margin adjustments were larger for IF trade. Outsourcing contracts, on the other hand, might be less negotiable in case production needs to be cut: this could reduce the extent of intensive margin changes, while increasing the extensive margin share in case a firm defaults on its obligations altogether. A further difference between IF versus AL trade arises when looking at the stability of the extensive margin links over time: even though the net contribution do often not show a stark difference between IF and AL trade – especially for the firm and destination margins –, the creation and destruction of links that went into the creation of the net variation show a much higher variability of AL compared to IF transactions. The channels leading to this different behaviour might again derive from the explanations pushed forward above, and find theoretical support in the property rights approach to organisational modes.

9 Conclusion

This work pointed its attention towards the impact of the 2008-09 financial crisis on international trade. The analysis of high frequency transaction level data matched with firm balance-sheet and ownership information revealed that the experience of Slovenia was, in many aspects, similar to that of other European countries: exports and imports collapsed abruptly at the outburst of the crisis, with the intensive margin absorbing about 70% of the contraction, and the remaining 30% being mostly accounted for by the within firm-destination product margin. Firm exit only marginally increased as a consequence of the crisis.

The main contribution of this paper consists in the identification of a new channel that accelerated the reaction of trade flows to the shock. The cost-share of imported intermediates in firms' sales was identified as a catalyst of the trade collapse, because shipments of higher cost-share inputs fell more than proportionately compared to lower cost-share inputs in the downturn, and rebounded faster in the recovery. Together with the result that no different performance across inputs was detected over the entire crisis cycle, the larger responsiveness of higher-*CS* inputs in both sub-periods of the event suggest that the trough of the collapse was indeed deeper for transactions involving these products.

Notwithstanding being unable to identify the exact source of this behaviour, this phenomenon appears compatible with the hypothesis that firms adjusted more promptly the inventory stock of higher CS inputs, in the attempt to react to the reduced actual and expected level of demand. Inventory adjustments have been shown to be among the causes of the large elasticity of trade to the demand variation in 2008-09 (Alessandria *et al.* 2011): if, plausibly, firms attemped to offset the shock to internal liquidity caused by the demand collapse by reducing the amount of inventories carried, the optimisation of inventory stocks could have been more prompt for higher *CS* intermediates, leading to the larger estimated reaction for these goods. A simple (S, s) type model with fixed ordering costs, constant marginal purchasing costs and rising marginal handling costs gives theoretical support to this intuition.

The degree of integration of GVCs was also examined, with the role of intra-firm trade being analysed from several perspectives. Overall, IF trade was not seen as performing differently from AL trade. Despite this, firm affiliation could have acted as a further accelerating factor in a trade crisis for transactions involving relatively high CS inputs. The lower degree of uncertainty and the more rapid and effective communication characterizing business relations between parties related

by ownership rights, could lead to a more effective management of inventory stocks both in good and in bad times: the size of the inventory buffer is likely to be smaller, but the reaction in case the stock needs to be downsized could be stronger in proportional terms, with this responsiveness being even larger for high cost-share inputs. This hypothesis could explain why a faster adjustment was measured in both the downturn and the recovery for imports of higher CS intermediates when involving related parties, relative to AL trade. For undifferentiated products and without distinguishing across the CS of inputs no particular effect is detected instead.

The reaction of IF trade differed from AL trade also with respect to trade margins: possibly due to the different cost structures relating to the two organisational modes and the ease of adjustment of offshoring (IF) versus outsourcing (AL) agreements, the share of intensive margin relative to extensive margin adjustments was seen to be larger for IF trade; conversely, the share of extensive margin variation was larger for AL trade.

All results were tested controlling also for firms' reliance on buyer-seller trade finance. An additional result emerging from this robustness check is that reliance on firm intermediated trade finance acted as an *inhibitor* of the trade collapse: imports saw a better performance when undertaken by firms reporting larger payables. On average, these transactions grew more in the downturn and less in the recovery, indicating a shallower trough during the trade crisis experienced by these firms. In this work I can't explore whether the crisis induced firms to change their behaviour with respect to their reliance on bank or buyer-seller trade finance (as in Antràs and Foley 2014), but the result that importers obtaining more credit from foreign exporters went through the shock following a shallower path suggest that firms were liquidity constrained in the crisis and that buyer-seller trade finance can work as a mitigating channel in these events.

In conclusion, although the precise mechanisms by which the *CS* of intermediates works in determining a higher elasticity of trade flows to a demand contraction cannot be observed with the data at hand, the identification of this *catalyst* of the collapse is the strongest and most reliable contribution of this paper. This source of heterogeneity across different inputs was able to affect the responsiveness of international trade to the demand shock of 2008-09 and, crucially, it seems to be the relevant margin of intervention by firms when attempting to downsize activity and trade in the recessionary environment.

The fact that different types of products exhibited different performances during the crisis can shed light on the strategies pursued by firms to cope with these events.

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10 Appendix

10.1 A simple model of inventory management

Drawing on the seminal contribution of Arrow et al. (1951) and the extensive work of Hadley and Whitin (1963) I present a simple framework to demonstrate Hypothesis 1, namely that trade of higher cost-share

inputs responds to a fall in demand more than trade of lower cost-share inputs. I exploit the simplest version possible of the so called "lot size-reorder point" model, or (S, s) model, abstracting from uncertainty in the demand pattern for simplicity of exposition.

The aim of the (S, s) model is to derive the optimal quantity S^* of inventory to order and the optimal reorder point r at which to place the order, given a rate of demand δ and a procurement lead time τ. The reorder point defines the safety stock s, which consists of the amount of inventory on hand when the procurement arrives. Here it is assumed that δ and τ are constant over time and deterministic: this makes clear that the same quantity is ordered each time an order is placed, and that the safety stock always has the same value[41]. The optimal values $S^*$and r^*minimise the average annual cost function, which includes the cost of the units purchased, the cost of placing an order, the cost of sourcing and handling inventories and the cost of carrying inventories.

Ordering costs are represented by a fixed cost A, independent of the order size; whereas the cost of the units purchased is represented by a constant marginal cost c. Sourcing and handling costs can instead be conceived to be rising in the quantity purchased[42], and in the simplest formulation, to be rising in a linear way, i.e. ωS^2, such that at the margin this corresponds to $2\omega S$. With a constant rate of demand δ the quantity ordered S is going to be depleted in time $T = S/\delta$: this is the length of a cycle. The inverse of this ratio represents the average number of cycles, i.e. δ/S. Hence ordering and purchasing costs are $(A + cS + \omega S^2)\delta/S = A\delta/S + c\delta + \omega S\delta$. Furthermore, since the unit cost c is assumed to be independent of the quantity ordered, the reordering rule need not to include the variable cost term $c\delta$: the expression for ordering and purchasing costs becomes $A(\delta/S) + \omega\delta S$.

Carrying cost are modelled as a constant instantaneous rate $0 < I < 1$, proportional to the value of the goods stored and to the length of time the goods remain in inventory. Per cycle, inventory carrying costs therefore are: $Ic\int_0^T (S + s - \delta t)\, dt = Ic\left[(S + s)T - \frac{\delta T^2}{2}\right] = IcT[(S/2) + s]$. Multiplying this by the average number of cycles gives $Ic[(S/2) + s]$. Lastly, in this simplified version of the (S, s) model with deterministic demand and procurement time, a firm can minimise its carrying cost by having $s = 0$, so that the system just runs out when a new procurement arrives.

The average variable cost is then:

$$C = A\frac{\delta}{S} + \omega\delta S + Ic\left[\frac{S}{2}\right] \tag{12}$$

[41] The assumption of determinisic and constant demand also rules out the risk for the firm to stock out. This assumption might not appear realistic, but, as mentioned, adding demand uncertainty into the model introduces a layer of complexity which is unnecessary for the purposes of this section.

[42] This marginal cost that I refer to as "sourcing and handling cost" can in reality proxy a variety of factors that make the cost of holding inventories rise with the quantity stored. An example could be rising transportation costs, if the distance from suppliers increases when sourcing additional items from alternative locations that are further away. Alternatively, there can be rising labour costs, related to the operations of receiving, inspecting and handling a larger quantity of items. Also storage costs could be convex in the quantity stored (Chazai et al. 2008). Finally and more generally, this rising cost could capture a higher degree of complexity in coordinating the management of an increasing quantity of items stored.

Minimisation of (12) allows to obtain the optimal quantity to order, S^*:

$$S^* = \sqrt{\frac{2\delta A}{Ic + 2\omega\delta}} \tag{13}$$

Equation (13) is a popular expression in the literature, under the name of lot-size formula, or economic order formula, or Wilson formula.

The optimal reorder point r is derived following again Hadley and Whitin (1963). If m is the largest integer less than or equal to τ/T, then, an order is placed when the on-hand inventory reaches

$$r^* = \delta(\tau - mT) = \delta\tau - mS^*, \tag{14}$$

such that the on-hand inventory is zero at the time the order arrives.

When an optimal policy is used, the average amount of inventory in the system will be:

$$\bar{S}^* = \frac{S^*}{2} = \sqrt{\frac{A\delta}{2\left(cI + 2\delta\omega\right)}} \tag{15}$$

It follows directly from equation (15) that the average inventory increases with the square root of the sales rate δ, and not proportionately with it. Similarly, the average inventory varies inversely as the square root of the marginal cost c, so that the average inventory for high cost products should be lower than for low cost products.

To verify Hypothesis 1 I compute the proportional rate of change of the value of the items in inventory with respect to a change in demand (which is the theoretical counterpart of the mid-point growth rate exploited in estimation), $\frac{\partial\left(\bar{S}^* c\right)/\partial\delta}{\bar{S}^* c}$, and show how this changes with respect to the cost-share.

Notice, however, that the cost-share does not appear directly in (15): the cost-share measures the value of the imported item in sales, whereas (15) relates the average quantity stored with the unit-cost. A higher unit-cost determines a smaller quantity to be stocked, but it can be shown that a higher unit-cost always corresponds to a higher value of the stock, hence to a higher cost-share. Intuitively, this is because the negative effect of the unit-cost on the quantity is less than proportional. Consider two inputs h and l, where h denotes a high unit-cost intermediate and l denotes a low unit-cost intermediate, such that $c_h > c_l$. Although $\bar{S}^*_h < \bar{S}^*_l$,the higher cost input corresponds to a higher value, such that $\bar{S}^*_h c_h > \bar{S}^*_l c_l$, which in turn implies a higher cost-share $\bar{S}^*_h c_h / \left(\bar{S}^*_h c_h + \bar{S}^*_l c_l\right) > \bar{S}^*_l c_l / \left(\bar{S}^*_h c_h + \bar{S}^*_l c_l\right)$. To see this consider that:

$$\frac{\partial\left(\bar{S}^* c\right)}{\partial c} = \frac{\left(cI + 4\delta\omega\right)\left(A\delta\right)^{1/2}}{2^{1/2}\left(cI + 2\delta\omega\right)^{3/2}} > 0, \tag{16}$$

which implies $\bar{S}^*_h c_h > \bar{S}^*_l c_l$, since $c_h > c_l$. Alternatively, consider that the elasticity of S with respect to c is less than unity: $\varepsilon_{S,c} = -\frac{1}{2\left(1+\frac{2dw}{cI}\right)}$.

Finally, to demonstrate hypothesis 1, observe that $\frac{\partial\left(\bar{S}^* c\right)/\partial\delta}{\bar{S}^* c}$ is increasing in the unit cost c and hence

in the cost share, since:

$$\frac{\partial\left(\bar{S}^{*}c\right)/\partial\delta}{\bar{S}^{*}c}=\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\quad\text{and}\quad\frac{\partial}{\partial c}\left(\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\right)=\frac{\omega I}{(cI+2\delta\omega)^{2}}>0. \tag{17}$$

Hypothesis 1 is indeed confirmed by this simple version of the (S, s) model, since inventory adjustments can be shown to lead to changes in import flows. A larger responsiveness of higher cost-share intermediates accelerates the reaction of imports during a crisis, conferring to the cost-share a role of catalyst of the collapse.

10.2 Margin decomposition

I decompose mid-point growth rates, rather than standard growth rates, to correct for attrition bias. Because of the way this variable is computed, each elementary monthly growth rate (g_{ickt}), which is the monthly year on year growth rate of the shipment of each CN-8 digit product k, performed by a firm i, to a certain destination c, in month t, will take a value between -2 and +2. This allows to classify elementary growth rates into four types: increased ($0 < g_{ickt} < +2$) and decreased ($-2 < g_{ickt} < 0$) flows, corresponding to the variation in the value of the shipment of the same product by the same firm to the same destination with respect to the same month of the previous year; and created ($g_{ickt} = +2$) and destroyed ($g_{ickt} = -2$) transactions. These latter ones can correspond to new or destroyed shipments of a product to an already served destination by the same firm (product margin), to an added or dropped destination by a continuing firm (destination margin) or to a firm entering or exiting the export market (firm margin). This method allows to precisely measure the contribution of each margin to the total variation of trade, as the sum of the margins provides a correct approximation of the observed aggregate growth rate (Bricongne et al. 2012). It should be noticed that such a fine level of disaggregation and frequency of observation inflates the contribution of the extensive margin compared to when more aggregate data are used. The intensive margin is in fact only due to continued shipments of the same product to the same destination by a continuing firm, year after year.

To perform the decomposition, each single flow is weighted by its share in total Slovenian shipments during the same period:

$$s_{ickt}=\frac{x_{ickt}+x_{ick(t-12)}}{\sum_{c}\sum_{i}\sum_{k}x_{ickt}+\sum_{c}\sum_{i}\sum_{k}x_{ick(t-12)}} \tag{18}$$

The year on year growth rate of the total value of Slovenian exports is then obtained by summing each flow g_{ickt} weighted by s_{ickt} across all exporters, products and destinations.

$$G_{t}=\sum_{c}\sum_{i}\sum_{k}g_{ickt}*s_{ickt} \tag{19}$$

This aggregation can be made by subsets of the total growth rate, and this is how the decomposition is performed. Once it is identified whether, say, a destroyed flow is due to firm, destination or product exit, simply adding up the corresponding weighted growth rates yields a certain margin. In this way for each month I identified the intensive margin and the three extensive margins, separating these then further for

intra-firm and arm's length transactions. The net margins are given by the sum of the positive and negative contributions.

10.3 Drawback of the related party trade proxy.

The strength of this exercise rests also on the identification of intra-firm trade, which however suffers from some imperfection in its measurement: my strategy is to label shipments as intra-firm when originating from firms belonging to a group and directed to a country where there is a firm belonging to the same business group. This causes some arm's length transaction to be labelled as intra-firm: it happens when, for shipments to a certain destination, a firm belonging to a group ships goods to firms outside the group, opting for a mixed strategy of arm's length and intra-firm in that destination. This would somewhat inflate the related party trade proxy, causing the estimates to be biased towards zero: unfortunately the lack of data about intra-firm trade does not allow to fix this issue in my context.

As a partial validation of this related-party trade variable I can compare the share of intra-firm trade I measure to figures emerging from other works. In 1999 l' "Enquete sur les exchange intra-group", a French survey of firms representing 61% of French exports, estimated that 32% of transactions (not volumes) were among related parties: in Slovenia I measure this to be about 38%. As a further cross country reference, I estimate about 49% of the value of exports in 2007 to be intra firm: this value is extremely close to Altomonte et al.'s estimate of 48% for French exports (obtained using my same related party trade proxy) and, importantly, it is close to the 46.8% measured for US exports (Census Bureau data). Lastly, the most direct validation is possible when considering bilateral trade between Slovenia and the US: Lanz and Miroudot (2011), according to the Related Party database by US Census Bureau, measure 51.3% of imports from Slovenia to be intra-firm, while with my approximation I obtain a figure of about 52.6%.

Given these relatively reassuring similarities between the share of intra-firm trade estimated with the related party trade proxy used in this paper and the quoted figures exploiting the actual measurement by US custom authorities, I feel rather confident is relying on my approximation.

10.3.1 Orbis data for 2011 only

The full ownership data, including links up the 10th level of subsidiarity, was extracted from ORBIS as for 2011: for the crisis years, 2008 and 2009, it was only possible to obtain the status of the ownership network for the 1st level of subsidiarity. Furthermore, the coverage of firms in ORBIS for Slovenia increased substantially from 2008 to 2011: a large number of firms and groups – especially of smaller size – were absent in 2008, and were added over time. This imposed a choice between two "pictures" of the status of ownership links to use in this work: the 2011 data export allows to obtain a great deal more description about firms' affiliation (10 levels of subsidiarity instead of 1) with over 10 times the number of firms about which ownership information is available.

Importantly, this large difference in the number of firms is also due to the increase in coverage. However, this richness of ownership data and the increase in coverage come at the cost of assuming that the 2011 picture is accurate enough to represent the situation in 2008-09. The 2008-09 data extract offers in fact a more up-to-date image of ownership links: despite this, the significantly lower representation of smaller

groups and the absence of information about links beyond the 1st level made me opt for the 2011 extract.

10.4 Geographical disaggregation of Slovenian trade.

In terms of the geographical disaggregation of Slovenian trade, this country finds itself in between of some of bigger EU countries on one side (Germany, Italy and Austria) and the block of former Yugoslavian and eastern-European economies on the other one. This geographical divide is mirrored by the composition of the trade flows departing from Slovenia. The majority of transactions are with countries of the former Yugoslavian republic (over 40% of the exports are directed to Croatia, Bosnia and Serbia), but taking into account the value of shipments completely overturns this ranking, with the three biggest Euro-zone economies (Germany, Italy and France) absorbing about 40% of the value of Slovenian exports. Table 10 provides an overview of the 10 top served destinations, considering both the number and the value of transaction and their disaggregation across intra-firm and arm's length trade.

Table: Geographical decomposition of Slovenian exports.

Destination	Shipments %	Destination	Shipments %	Destination	Shipments %
		Number of Shipments, in %.			
All Flows		Intra-Firm		Arm's Length	
Croatia	19.29	Croatia	6.2	Croatia	13.09
Bosnia	12.41	Bosnia	3.85	Serbia	10.00
Serbia	10.00	Germany	2.41	Bosnia	8.55
Germany	6.49	Austria	1.79	Germany	4.09
Austria	5.11	Italy	1.25	Italy	3.35
Italy	4.60	Macedonia	0.96	Austria	3.32
Macedonia	3.60	Czeck Republic	0.68	Macedonia	2.63
Montenegro	2.94	France	0.59	Montenegro	2.43
Hungary	2.06	Hungary	0.59	Kosovo	1.89
Kosovo	1.89	Poland	0.56	Hungary	1.47
		Value of shipments: shares in %.			
All Flows		Intra-Firm		Arm's Length	
Germany	19.81	Germany	10.24	Germany	9.57
Italy	11.2	France	7.14	Italy	6.01
France	8.68	Italy	5.19	Austria	4.66
Croatia	8.25	Croatia	4.27	Croatia	3.97
Austria	7	Russia	2.9	Serbia	3.36
Russia	3.72	Austria	2.34	Bosnia	1.99
Serbia	3.36	Poland	1.99	France	1.54
Bosnia	3.35	Great Britain	1.43	Hungary	1.34
Poland	2.99	Bosnia	1.36	Great Britain	1
Great Britain	2.44	Czeck Republic	1.31	Poland	1

10.5 Additional tables

Table 6C: CS, IF trade and Receivables. Imports.

	(1)	(2)	(3)	(4)	(5)
REC	0.080**	0.089**	0.092**	0.101**	0.117**
	(0.036)	(0.042)	(0.043)	(0.045)	(0.057)
CS-Sect.	-0.007***	-0.007***	-0.007***	-0.006***	-0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
IF		0.012			-0.013
		(0.029)			(0.030)
Int.	0.044***	0.048***	-0.0007	-0.002	0.001
	(0.009)	(0.009)	(0.011)	(0.014)	(0.015)
Int. * REC	-0.072**	-0.087**		0.018	0.002
	(0.035)	(0.040)		(0.040)	(0.044)
Int * CS-Sect	-0.019	-0.020		-0.099***	-0.083**
	(0.016)	(0.015)		(0.037)	(0.034)
Int. * IF		-0.032			-0.036
		(0.021)			(0.031)
IF*CS-Sect		0.013			0.037
		(0.013)			(0.064)
Int. * CS-Sect. * IF		0.0007			-0.142
		(0.074)			(0.113)
IF * REC		-0.020			-0.047
		(0.039)			(0.049)
Int. * IF * REC		0.129***			0.080
		(0.050)			(0.085)
Rec.			-0.141***	-0.156***	-0.102***
			(0.049)	(0.053)	(0.038)
REC * Rec.			-0.078	-0.0003	-0.016
			(0.048)	(0.071)	(0.078)
CS-Sect. * Rec.			-0.0006	-0.002	-0.0024
			(0.002)	(0.002)	(0.002)
IF * Rec.					-0.003
					(0.043)
Int. * Rec			0.078***	0.100***	0.092**
			(0.024)	(0.035)	(0.037)
Int. * REC * Rec.				-0.126*	-0.112
				(0.075)	(0.078)
Int. * CS-Sect * Rec.				0.156**	0.129**
				(0.071)	(0.065)
Int * IF * Rec					0.040
					(0.062)
IF * CS-Sect. * Rec.					-0.024
					(0.064)
Int. * CS-Sect * IF * Rec.					0.354**
					(0.180)
IF * REC * Rec.					0.084
					(0.133)
Int* IF * REC * Rec					-0.013
					(0.225)
Firm. FE	yes	yes	yes	yes	yes
Destination FE	yes	yes	yes	yes	yes
Month FE	no	no	no	no	no
Firm controls	yes	yes	yes	yes	yes
Constant	0.172	0.167	0.283***	0.278***	0.282***
	(0.112)	(0.111)	(0.097)	(0.095)	(0.087)
N	4764175	4764175	4764175	4764175	4764175

Note: Standard errors clustered at the firm level in parentheses; * p < 0.1, ** p < 0.05, *** p < 0.01. REC denotes the Receivables/turnover ratio