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Product Cost-Share: a Catalyst of the Trade Collapse

Mattia Di Ubaldo

Department of Economics, University of Sussex, Falmer, UK

M.Di-Ubaldo@sussex.ac.uk

Abstract: I study the responsiveness of Slovenian trade during the collapse of 2008-2009 and shed light on channels that enhanced the sensitivity of international trade to the demand shock.The responsiveness of intermediate goods.trade is found to be associated with the cost-share of inputs; i.e., 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. This rationale is supported theoretically by a simple (S,s) model of inventory management and, empirically, by reduced form estimations of the main model predictions. Moreover, products' cost-share is found to be associated with an enhanced reaction of the frequency of shipments at the product level, a proxy for inventory adjustments. Conditioning the results on the type of firm ownership, i.e. intra-firm or arm's length trade,does not reveal a differential response between the two organisational modes, except for imports of higher cost-share products for which intra-firm trade acted as further catalyst of the collapse.

JEL classification: D22, D23, F14

Key words: Trade collapse; Product cost-share; Imports; Firm behaviour; Inventory adjustment.

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 a source 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[2]. My primary aim is not, therefore, 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. Besides 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 is 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 resilient than arm's length trade during the 1997 East-Asian crisis, and Altomonte *et al.* (2012), estimating an enhanced reaction of trade of French firms in the 2008-09 collapse when shipments took place within firms' boundaries.

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

[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 with respect to firms' costs, as explained in Section 5.

This highly disaggregated dataset allows a detailed examination of the trade crisis[3]. To the best of my knowledge no previous work explores the cost-share hypothesis, a channel that can induce a higher elasticity of trade flows to a demand collapse and the explanation for which may lie in the dynamics of inventory adjustments.

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 for 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 a mechanism that can enhance 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 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

[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 differ to that of the other two countries.

[4] The deviation of the trade time series from 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.

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 therefore attribute some relevance to firm intermediated finance for understanding the heterogeneity in responses to the financial crisis. In order to insulate the identification of the impact of products' costs-share on trade from the effects of the credit-crunch and the lack of trade finance, a proper set of firm-month-origin fixed effects is exploited in estimation.

My paper adds to this literature by unpacking the dynamics of the trade collapse along its product dimension and observing the responsiveness of shipments depending on products' cost-share. 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 responsiveness of higher cost-share inputs' trade.

A secondary contribution of this paper arises from conditioning the results on the degree of integration of the value chain. 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 resilience - especially at the extensive margin - given the different cost structures and depth of integration pursued to overcome the hold-up problem (Antràs, 2003). The contemporaneous presence of offsetting channels could explain why no significantly different performance between intra-firm and arm's length trade is detected in my estimation.

The rest of the paper is organised as follows. Section 2 provides and exposition of a possible mechanism underlying the unequal trade adjustment of different products. Sections 3 and 4 present the data and describe 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 presents reduced form estimates in support of the main channel hypothesised in Section 2. Section 8 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 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 costs 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 share in firm's total costs.*

This hypothesis is supported by a model of inventory management[6]. I exploit the "lot size-reorder point" model, or (S, s) model, originally 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[7] 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, 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[8].

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[9] 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

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

[7] 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.

[8] 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.

[9] See Appendix for full derivation.

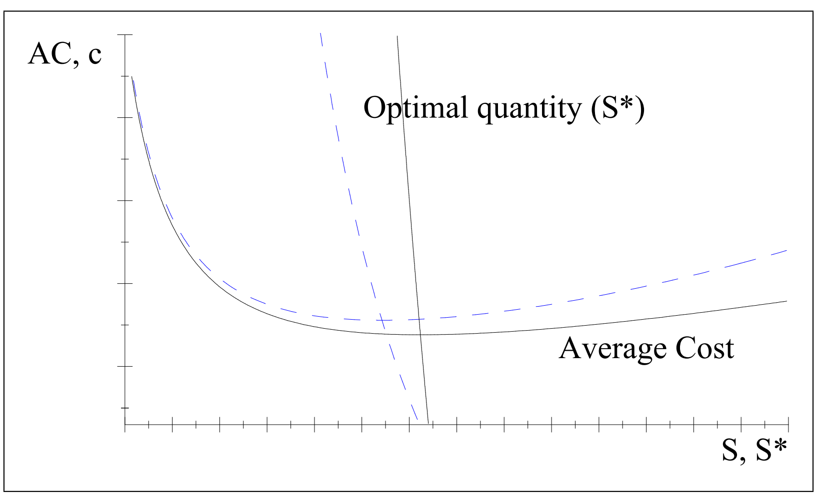
is because the elasticity of average inventory quantity to cost is less than 1.

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[10], Hypothesis 1 is confirmed in the model since $\frac{\partial(\bar{S}^*c)/\partial\delta}{\bar{S}^*c}$ is increasing in c. In particular:

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

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



[10]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.

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). A reduction in demand causes the average cost curve to shift inwards (dashed line), such that its 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 regardless 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 potentially 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; i.e. 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:

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

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 2: *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 that 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[11]. The findings reported in the empirical section are, in fact, consistent with this theoretical framework, but, with the data at hand, other explanations cannot be ruled out.

3 Data

The analysis necessitates high frequency transaction-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[12]:

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 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 sales, costs of intermediate goods,

[11] 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.

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

materials and services 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[13]. 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[14].

All data span from 2000 to 2011, except for the ownership information which describes the status of proprietary networks in 2011[15].

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[16]. The customs 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 (left panel of Figure 2). The right panel of Figure 2 illustrates growth rates of consumption, capital and intermediate goods separately (BEC). Consumption goods showed a higher degree of resilience relative to the

[13] 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.

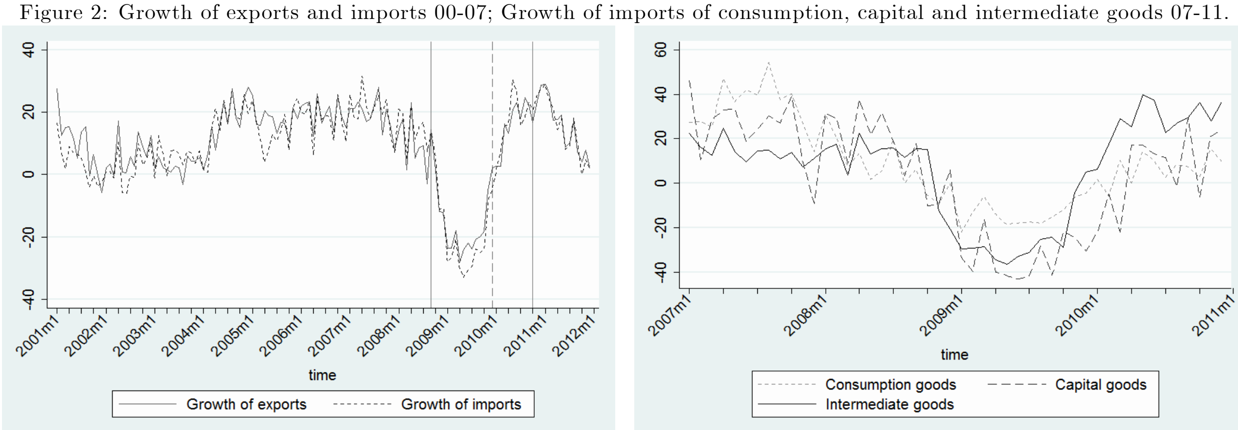
[14] The assumption by which intra-firm and arm's length trade are identified introduces some measurement error. It is asymmetrical (consisting of a fraction of arm's length shipments being wrongly labelled as intra-firm), but it can be argued to be random, causing an attenuation bias in estimation, 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.

[15] The reasons for this are outlined in Appendix.

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

other categories; while intermediates dipped less and for a shorter period than capital goods.

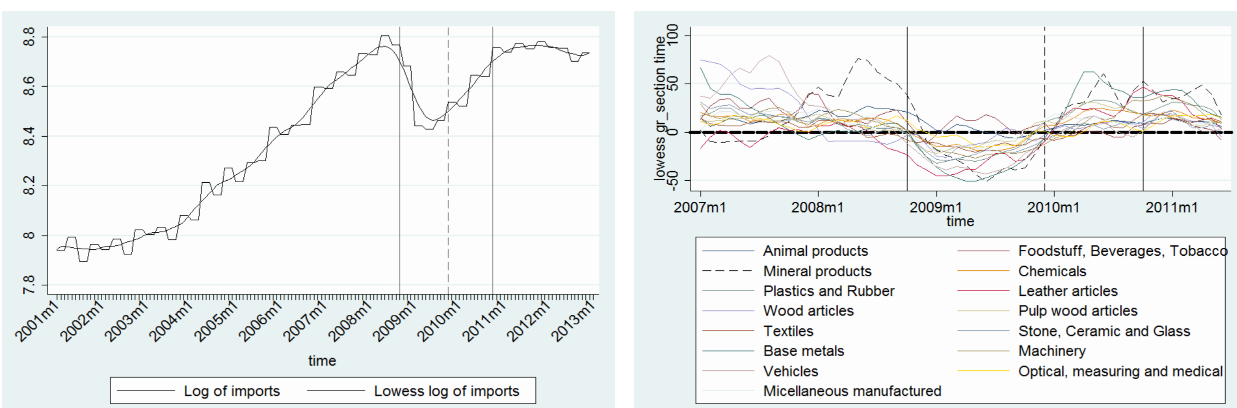
Figure 2: Growth of exports and imports 00-07; Growth of imports of consumption, capital and intermediate goods 07-11.



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 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.

In estimation the analysis runs from September 2008 to September 2010, with the trough identified at November 2009, as trade kept growing at a negative rate until then. By September 2010 the value of imports had approximately recovered to the pre-crisis level (Figure 3, left).

Figure 3: Value of total Slovenian imports in logs 00-12; Growth of imports by CN categories, 00-11.



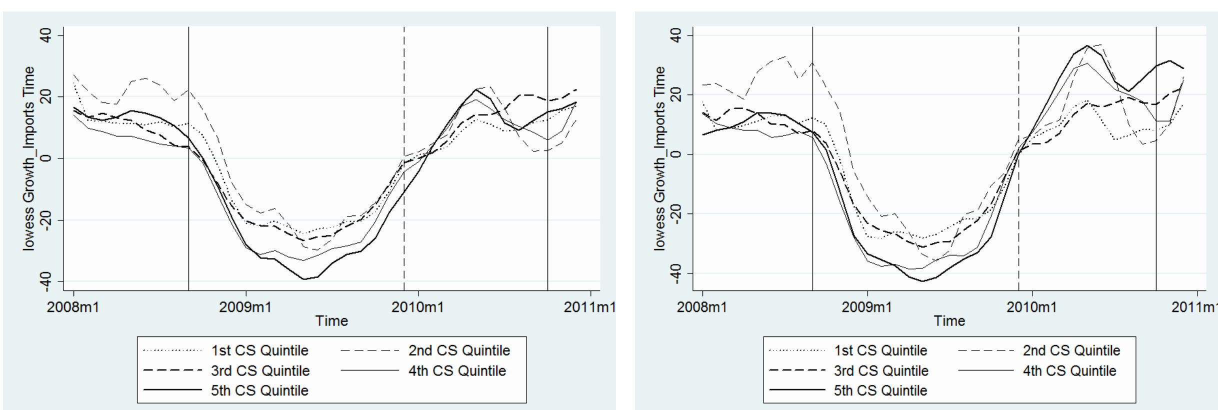
The identification of the cutoff dates according to the Slovenian experience could spur worries of endogeneity if the Slovenian case was somehow affected by peculiar characteristics of Slovenian firms that I cannot control for in the econometric specification[17]. However, these concerns can safely

[17] I could be introducing a selection bias and reduce the degree of exogeneity of the shock.

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.* 2011). Secondly, I estimate all regressions with firm-month-origin fixed effects, thereby controlling for any firm and origin specific unobservable shock, which is common across products imported by each firm from each country in each month. Finally, given 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 imports is the outcome of the coincident path of fall and rebound of the various product categories over the crisis (Figure 3, right).

Disentangling the experience of the collapse across goods accounting for different shares in firms' costs, this synchronicity is observed again (Figure 4). It is reassuring that the crisis cutoff dates were similar across various segments of the cost-share distribution: this suggest that the impact of the cost-share on trade detected in estimation is not due to a different timing of reaction for different products (i.e. longer/shorter downturn and recovery) but to a deeper trough of the crisis, as one would expect to be caused by a catalyst of the collapse.

Figure 4: Growth of imports across quintiles of the cost-share distribution, for all goods (left) and intermediates (right).



The right panel of Figure 4 is particularly eloquent in terms of the key finding of this paper: for intermediates it is immediately evident that higher cost-share products (5th CS quintile) experienced a larger fall over the downturn and a correspondingly higher rebound in the recovery.

Limiting the data between September 2008 and September 2010 leads to the identification of a final sample of 8,498 firms importing 8,733 different products from 227 origins.

Of interest for this work is also 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[18]. Panel A of Table 1 reports the import activity of firms belonging to multinationals[19] regardless of the sender 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
1,444	8,301	2,567,242	4,319,398	47,135	25,814
Panel B: Intra-firm trade					
Intra Firm	Arm's Length	Intra Firm	Arm's Length	Intra Firm	Arm's length
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 37.2% of import transactions, corresponding to 64% of the total value of flows, despite them being only 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 it 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 60% measured for Slovenia – where there is a lower export participation by smaller and independent firms.

Exploiting also the information about the origin 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 originating from destinations with firms belonging to the same group. The share of intra-firm imports in total trade is 44.96%: over the four years this share remained constant.

[18] 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

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

5 Empirical strategy

To assess the role of products' cost-share as a catalyst of the trade collapse, the growth rate of imports at the firm-product-origin level is regressed against a number of controls. Using monthly growth rates spurs worries of attrition bias[20]; furthermore, using standard growth rates would not allow to take into account the extensive margin variation, since all firm-product-origin triplets that are not observed between two consecutive periods (i.e. the same month of two consecutive years) would be dropped from the analysis. To cope with this, I follow the approach of previous studies[21] and use mid-point growth rates, computed on the single flow $M_{kic,t}$ defined as the import flow M of each CN-8 product k, by a Slovenian firm i, from a given origin c in month t. The mid-point growth rate serving as dependent variable is:

$$mp_{kic,t} = \frac{M_{kic,t} - M_{kic,t-12}}{0.5\left(M_{kic,t} + M_{kic,t-12}\right)}. \tag{5}$$

However, all the results are also presented exploiting as dependent variable the log change of imports: $\Delta \ln(M_{kic,t}) = \ln(M_{kic,t}) - \ln(M_{kic,t-12})$. This provides considerable robustness to the results as it shows that the transformation by which the mid-point growth rates are computed does not affect findings; furthermore, it reassures about the stability of the findings when investigating only the intensive margin of imports and, finally, it provides more directly interpretable coefficients[22].

In addition to import values, I also present estimates using the growth rates (mid-point or log-change) of import volumes and unit values (value/volume). This allows me to evaluate how much of the effects that I estimate are a consequence of the change in the quantity shipped or of the change in prices over the crisis.

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

$$CS_{kj}^{\text{costs}} = \frac{1}{YN} \sum_{y=2000}^{2007} \sum_{n=1}^{N} \left(\frac{\sum_{t=1}^{12} im_{kic,t}}{C_{iy}} \right), \tag{6}$$

where im_{kict} denotes the value of product k imported by firm i, from origin c, in month t. N denotes the number of firms, Y the number of years, C costs of goods, materials and services. The

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

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

[22] Since the mid-point growth rate is by contruction bound between -2 and 2, the interpretation of the coefficients is more direct when exploiting the log-difference as dependent variable.

cost-share of the imported product (6) has a sectoral dimension j since each product k might present a specific relevance depending on the sector j where the firm operates. The firm level cost-share is therefore averaged over all firms within each sector, with the resulting measure being specific for each of the 8,733 products in each of the 462 NACE 4-digit sectors. Using all years available in the data up to the year before the crisis (2007) allows me to compute a possibly exogenous time invariant value of how much, on average, each imported product is worth in firms' costs.

I also compute an alternative cost-share measure, to show that the cross-product heterogeneity unveiled by the CS variable does not strictly depend on the aggregate against which the value of the product is measured, i.e. costs. The sales-based measure is given by:

$$CS_{kj}^{\text{sales}} = \frac{1}{YN} \sum_{y=2000}^{2007} \sum_{n=1}^{N} \left(\frac{\sum_{t=1}^{12} im_{kic,t}}{S_{iy}} \right), \tag{7}$$

where S denotes total sales. (7) can be seen as a measure of intensity of use of a product as an input since it approximates an input-output (IO) requirement coefficient, i.e. the technical coefficient of use of inputs in downstream industries[23]. Furthermore, the cost-share variables (6 and 7) are re-computed using only the last two years preceding the crisis, to reassure that the measure can be considered a stable product characteristic over time. Table 2 presents some core statistics relating to the cost-share variables:

Table 2: Cost-share variables

	Unique values	Mean	Std.
Cost-Share (w.r.t. costs)	142,817	0.041	0.989
Cost-Share (w.r.t. sales)	142,817	0.031	0.682
Cost-Share (w.r.t. costs - only last 2 years)	121,597	0.030	0.145
Cost-Share (w.r.t. sales - only last 2 years)	121,565	0.024	0.257

Source: SORS, AJPES and author's calculations.

The main equation estimated by OLS is:

$$g_{kic,t} = \beta_0 + \beta_1 CS_{kj} + \beta_2 Int_{kic,t} + \beta_3 \left(CS_{kj} * Int_{kic,t} \right) + \gamma_{ic,t} + \varepsilon_{kic,t}, \tag{8}$$

where $g_{kic,t}$ denotes either the mid-point growth rate of imports (5) or the log-change of imports of product k performed by firm i from origin c in month t; CS_{kj} denotes the cost-share variable, $Int_{kic,t}$ denotes a binary variable identifying intermediates; $\gamma_{ic,t}$ denotes firm-origin-month fixed

[23] 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 downstream industries.

effects. β_3 tests the hypothesis that relatively higher cost-share intermediates gave rise to larger adjustments in the crisis.

Estimation of (8) circumscribes the analysis of the collapse to a full cycle of downturn plus recovery. The role of catalysts of the trade crisis could however emerge more neatly when observing the dynamics within the cycle, rather that the growth of trade over the entire span of the event. The impact of the cost-share has therefore also been separated between the downturn and the recovery phases. If the cost-share imparts a larger reaction to trade, this should be evident with a deeper trough, i.e. a larger fall in the downturn coupled with larger rebound in the recovery - as descriptively shown in Figure 4, right panel. Specification (9) controls for the within cycle dynamics:

$$g_{kic,t}= \alpha_0+\alpha_1 \Omega + \alpha_2 \Omega * recovery + \varepsilon_{kic,t} \tag{9}$$

where Ω denotes the right hand side of equation (8) 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 a negative β_3 in downturn and a positive one in 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 (10), 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.

$$\begin{aligned} g_{kic,t} = {} & \beta_0+\beta_1 CS_{kj}+\beta_2 IF_{ki,t} + \beta_3 Int_{kic,t}+\beta_4 \left(CS_{kj}*Int_{kic,t}\right)+\beta_5 \left(IF_{ki,t}*Int_{kic,t}\right)+\beta_6 \left(CS_{kj} * IF_{ki,t}\right) \\ & +\beta_7 \left(CS_{kj} * IF_{ki,t}*Int_{kic,t}\right) + \gamma_{i,t}+\varepsilon_{kic,t} \end{aligned} \tag{10}$$

The right hand side of equation (10) is also interacted with the recovery dummy, as shown in (9). In (10) I can only exploit firm-month fixed effects because for each firm the *IF* indicator does not vary within origin.

It is to be observed that the firm-origin-month fixed effects account for a great deal of unobserved confounding factors and that I am only exploiting within firm-origin-month cross-product variation in estimation. Any demand or supply shock that had aggregate, firm or origin specific effects in any time period is thereby controlled for: these include the change in real expenditure (Levchenko *et al.*, 2010; Behrens *et al.,* 2013), the credit-crunch (Chor and Manova, 2012) and the reduction in the availability of firm intermediated trade finance (Korinek *et al.,* 2010, Coulibaly *et al.,* 2011), other than firm constant and firm time varying characteristics such as size, capital intensity, employment and productivity. Standard errors are always clustered at the firm level.

Table 3: Descriptive statistics of main variables.

	Imports								
	Entire sample			Downturn			Recovery		
	Obs.	Mean	Std.	Obs	Mean	Std.	Obs.	Mean	Std.
Dep. var. - mid point growth rate (value)	5,672,551	-0.075	1.697	3,395,569	-0.079	1.695	2,276,982	-0.067	1.701
Dep. var. - mid point growth rate (quantity)	5,454,565	-0.056	1.683	3,294,607	-0.059	1.688	2,159,958	-0.051	1.675
Dep. var. - mid point growth rate (unit value)	5,454,565	-0.046	1.632	3,294,607	-0.035	1.629	2,159,958	-0.063	1.636
Dep. var. - log change (value)	1,784,484	-0.068	1.452	1,095,030	-0.130	1.458	689,454	0.030	1.436
Dep. var. - log change (quantity)	1,780,387	-0.088	1.607	1,092,570	-0.153	1.161	687,817	0.015	1.588
Dep. var. - log change (unit value)	1,780,387	0.020	0.803	1,092,570	0.023	0.812	687,817	0.015	0.788
Intermediates (binary indicator)	5,672,551	0.515	0.499	3395569	0.512	0.499	2,276,982	0.512	0.499
Intra-Firm (binary indicator)	5,672,551	0.173	0.377	3395569	0.172	0.377	2,276,982	0.174	0.378

Source: SORS, AJPES and author's calculations.

6 Results

This section presents the estimates of the behaviour of Slovenian importers in the crisis, separating the impact of the shock according to the cost-share of products and the type of firm affiliation.

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

Table 4 reports the results from estimating specifications (8) and (9) for the value (Panel A), quantity (Panel B) and unit-values (Panel C) of imports. In columns (1)-(6) the dependent variable is the mid-point growth rate (5), which allows to take into account every single shipment at the product-firm-origin level of disaggregation, even if discontinued with respect to the same month of the previous year. In columns (7)-(12) I instead exploit standard growth rates defined as the log-difference of the shipment: this implies that only product-firm-origin triplets that are present in at least two consecutive time periods (the same month of two consecutive years) are included in the analysis. In other words, using standard growth rates only exploits the intensive margin of trade, with the mid-point growth rate picking up a great deal more data points given the relevance of extensive margin changes at this level of disaggregation. Despite this difference, the results are strikingly similar across the two variables.

Hypothesis 1 is confirmed very strongly in Table 4: for imports of intermediates, products' cost-share worked as a catalyst of the collapse. Starting from columns (1) and (7), on average and over the entire period of the crisis, imports of products accounting for a larger share in firms' costs grew less, but significantly so only for the mid-point growth rate.

Table 4: The Cost-Share as a Catalyst of the Collapse

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Mid-Point Growth Rates						Standard Growth Rates (Log-change)					
PANEL A: Imports - Values												
CS	-0.004***		-0.004***	-0.004***		-0.004***	-0.002		-0.002	-0.002		-0.001
	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.004)		(0.004)
Int		0.027***	0.034***		0.030***	0.046***		0.008**	0.010**		0.013**	0.016***
		(0.004)	(0.004)		(0.00539)	(0.006)		(0.004)	(0.004)		(0.006)	(0.006)
Int*CS			-0.003			**-0.049*** **			-0.029*			**-0.100*** **
			(0.015)			**(0.017)**			(0.015)			**(0.027)**
CS*Rec				-0.000		-0.001				-0.000		-0.002
				(0.001)		(0.002)				(0.007)		(0.007)
Int*Rec					-0.008	-0.029***					-0.011	-0.016*
					(0.006)	(0.007)					(0.009)	(0.009)
Int*CS*Rec						**0.117*** **						**0.159*** **
						(0.024)						**(0.043)**
PANEL B: Imports - Quantity												
CS	-0.004***		-0.004***	-0.004***		-0.004***	-0.002		-0.002	-0.001		-0.000
	(0.001)		(0.001)	(0.001)		(0.001)	(0.001)		(0.001)	(0.004)		(0.003)
Int		0.024***	0.032***		0.026***	0.043***		0.000	0.000		0.004	0.006
		(0.005)	(0.005)		(0.006)	(0.006)		(0.005)	(0.005)		(0.006)	(0.006)
Int*CS			-0.009			**-0.041** **			-0.019			**-0.065** **
			(0.016)			**(0.019)**			(0.016)			**(0.026)**
CS*Rec				-0.000		-0.001				-0.001		-0.003
				(0.002)		(0.002)				(0.006)		(0.006)
Int*Rec					-0.006	-0.027***					-0.009	-0.013
					(0.006)	(0.007)					(0.010)	(0.009)
Int*CS*Rec						**0.081*** **						**0.103*** **
						(0.025)						**(0.039)**
PANEL C: Imports - Unit Values												
CS	-0.003***		-0.004***	-0.003***		-0.003***	-0.000		-0.000	-0.001		-0.000
	(0.001)		(0.001)	(0.001)		(0.001)	(0.000)		(0.000)	(0.001)		(0.001)
Int.		0.030***	0.037***		0.036***	0.049***		0.009**	0.009***		0.009**	0.010**
		(0.004)	(0.004)		(0.005)	(0.006)		(0.003)	(0.003)		(0.004)	(0.004)
Int*CS			0.025**			**0.014**			-0.010			**-0.035*** **
			(0.011)			**(0.012)**			(0.009)			**(0.012)**
CS*Rec				-0.000		-0.000				0.001*		0.001
				(0.001)		(0.001)				(0.001)		(0.001)
Int*Rec					-0.012*	-0.031***					-0.002	-0.003
					(0.006)	(0.007)					(0.006)	(0.006)
Int*CS*Rec						**0.023**						**0.056*** **
						(0.018)						**(0.018)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5380701	5672551	5380701	5380701	5672551	5380701	1750854	1784484	1750854	1750854	1784484	1750854

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

Over the entire cycle one would not expect a differential behaviour across products if the cutoff dates were identified precisely; however, as evident in Figure 4, the path of shipments at different quintiles of the *CS* distribution is rather heterogeneous in the recovery, making it difficult to pin down the end of the cycle with precision.

In contrast, the path of intermediates is more homogenous, and this is mirrored in the coefficient on the interaction *Int.*CS* in columns (3) and (9): a higher *CS* did not imply a stark difference for imports of intermediates when no distinction is made between the downturn and the recovery.

Observing the within collapse dynamics is more directly informative of the role of the *CS* as a catalyst of the crisis. For this purpose in columns (4)-(6) and (10)-(12) 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 higher *CS* products found in column (1), is the outcome of a more pronounced fall in the downturn, with no significant difference detected in the recovery (column 4).

For intermediates instead, for both mid-point and standard growth rates and for both the value and the quantity of trade (column 6 and 12), the *CS* acted as a strong catalyst, accelerating the drop of imports in the downturn, with a significant and large rebound in the recovery. Firms reacted to the shock reducing purchases of inputs accounting for a larger share of their costs 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[24]. The differential impact of the crisis across products highlights a relevant role for the cost-share in explaining part of the trade collapse. For mid-point growth rates, a 10 percentage points increase in the cost-share (two and a half times the mean, but only about one tenth of a standard deviation) corresponds to a 0.49% faster fall of trade in the downturn and a 0.68% faster growth in the recovery (-0.049 + 0.177), accounting for 6.8% and 10% of the average growth in the two subperiods. For standard growth rates, a 10 percentage points increase in the cost-share lead to a 1% faster drop in the downturn and a 0.59% faster rebound in the recovery, accounting for 7.6% and 19% of the average growth in the two subperiods. Finally, notice that the positive coefficients of the intermediate dummy in the downturn (columns 5 and 11) increase by 25-50% when controlling for the cost-share of products, whereas the coefficients in the recovery phase become more negative and acquire significance. In

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

both subperiods of the event it therefore appears that higher-cost share intermediates performed in a way which is opposite to lower cost-share intermediates.

Table 5: The Cost-Share as a Catalyst of the Collapse - CS^{sales}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: Imports - Values								
CS	-0.006***	-0.005***	-0.006***	-0.005***	-0.003	-0.002	-0.004	-0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)
Int		0.035***		0.046***		0.010**		0.016***
		(0.005)		(0.006)		(0.004)		(0.006)
Int*CS		-0.027*		**-0.086*** **		-0.077***		**-0.164*** **
		(0.015)		**(0.032)**		(0.018)		**(0.046)**
CS*Rec			0.000	-0.001			0.001	-0.002
			(0.002)	(0.002)			(0.010)	(0.010)
Int*Rec				-0.029***				-0.018**
				(0.007)				(0.009)
Int*CS*Rec				**0.116** **				**0.289*** **
				(0.054)				**(0.076)**
PANEL B: Imports - Quantity								
CS	-0.006***	-0.006***	-0.006***	-0.006***	-0.003	-0.002	-0.002	-0.000
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.005)	(0.005)
Int		0.032***		0.043***		0.002		0.006
		(0.005)		(0.006)		(0.005)		(0.006)
Int*CS		-0.031**		**-0.075** **		-0.061***		**-0.127*** **
		(0.016)		**(0.028)**		(0.023)		**(0.035)**
CS*Rec			0.000	-0.000			-0.001	-0.003
			(0.002)	(0.002)			(0.009)	(0.010)
Int*Rec				-0.026***				-0.014
				(0.007)				(0.009)
Int*CS*Rec				**0.084* **				**0.218*** **
				(0.045)				**(0.062)**
PANEL C: Imports - Unit Values								
CS	-0.005***	-0.005***	-0.005***	-0.005***	-0.000	0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Int		0.036***		0.049***		0.009***		0.010**
		(0.004)		(0.006)		(0.003)		(0.004)
Int*CS		0.025**		**0.029**		-0.016		**-0.037* **
		(0.012)		**(0.019)**		(0.013)		**(0.021)**
CS*Rec			0.000	-0.000			0.002*	0.001
			(0.001)	(0.001)			(0.001)	(0.001)
Int*Rec				-0.030***				-0.003
				(0.007)				(0.006)
Int*CS*Rec				**-0.007**				**0.071* **
				(0.029)				**(0.037)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5388408	5388408	5388408	5388408	1749482	1749482	1749482	1749482

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

Table 5 presents the results from estimating the same specifications of table 4 replacing the cost-share in terms of costs (6) with the cost-share variable computed in terms of sales (7).

The two measures have a somewhat different interpretation because equation (7) represents rather an average *intensity of use* of a product across firms in an industry. Despite this, it is noticeable that the main results are fully confirmed when exploiting the cost-share in terms of sales: this suggests that the findings are stable regardless of the main aggregate - costs or sales - against which the value of inputs is measured.

In conclusion, for both Table 4 and 5, I present also the results from estimating the impact of the *CS* on the growth of the quantity of shipments (mass in kg or units) and the growth of unit-values (value/quantity). Comparing the coefficients across the three panels within the tables allows to disentangle whether the results are due to a change in the quantity shipped, or to changes in prices over the crisis. 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): the same conclusion is confirmed in this work. The effects of the *CS* on the value of trade are detected also when only quantity changes are observed. For unit-values instead, proxying the price of products, in the mid-point growth rate regressions all the relevant coefficients are insignificant. In the regressions exploiting the log-change of imports, given that unit-values equal the ratio between values and quantity, the coefficients are, by construction, equal to the difference between the coefficient for import values and the coefficient for import quantities. All together, these results hint at the fact that price changes are not significantly associated to the effects under examination in this work.

6.1.1 Stability of the cost-share measures over time

As mentioned in Section 5, I recomputed the *CS* measures (6) and (7) using only the last two years of data preceding the trade crisis, i.e. 2006 and 2007, rather than all available years in the data. This reduces the number of observations since products that are not imported in the 2006-07 period do not enter the calculation of the *CS* measures, while the measures become less dispersed (e.g. the standard deviation for (6) falls from 0.98 to 0.14), providing a further robustness check[25].

All the main coefficients remain statistically significant with their size increasing between 20% and 100%. These results provide robustness for the main findings of Table 4, considering also that they are obtained from a measure whose variability is reduced in a significant way.

[25] Here I show the table for the CS in terms of cost; the table for the CS in terms of sales is in Appendix.

Table 6: The Cost-Share as a Catalyst of the Collapse - Only 2006-07 for CS calculation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: Imports - values								
CS	-0.044***	-0.036***	-0.041***	-0.030***	-0.070***	-0.063**	-0.097**	-0.065**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.027)	(0.031)	(0.006)	(0.036)
Int		0.034***		0.044***		0.008*		0.015**
		(0.005)		(0.006)		(0.004)		(0.006)
Int*CS		-0.050**		**-0.095*****		-0.021		**-0.124****
		(0.025)		**(0.030)**		(0.046)		**(0.059)**
CS*Rec			-0.020	-0.040			0.131**	0.031
			(0.026)	(0.037)			(0.057)	(0.068)
Int*Rec				-0.027***				-0.016**
				(0.007)				(0.009)
Int*CS*Rec				**0.152****				**0.212****
				(0.058)				**(0.093)**
PANEL B: Imports - quantity								
CS	-0.046***	-0.037***	-0.042***	-0.031***	-0.052**	-0.041	-0.068*	-0.042
	(0.015)	(0.012)	(0.013)	(0.008)	(0.025)	(0.027)	(0.038)	(0.029)
Int.		0.032***		0.041***		0.001		0.006
		(0.005)		(0.006)		(0.005)		(0.006)
Int*CS		-0.058**		**-0.089*****		-0.031		**-0.101***
		(0.026)		**(0.028)**		(0.040)		**(0.052)**
CS*Rec			-0.025	-0.038			0.078	0.013
			(0.028)	(0.037)			(0.049)	(0.066)
Int*Rec				-0.025***				-0.013
				(0.007)				(0.009)
Int*CS*Rec				**0.110***				**0.151***
				(0.056)				**(0.086)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5267877	5267877	5267877	5267877	1734962	1734962	1734962	1734962

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

6.1.2 A firm level cost-share measure

The results presented in Tables 4, 5 and 6 explore the trade adjustment of products accounting for a different share of firms' costs (or firms' sales), where the *CS* measure is specific for each CN-8 product in each NACE (4-digit) sector.

In order to explore the *CS* heterogeneity further, an attempt has been made to compute the *CS* measure at an even finer level of disaggregation, making the *CS* ratio product-firm specific, rather than product-industry specific[26]. The main results (Table 14) are broadly confirmed, with the *CS* of imported products being associated with a larger response of imports in both the subperiod of the crisis. One noticeable difference, relative to the main results of Tables 4 and 5, is that when exploiting the firm-product level *CS* measure this accelerating impact appears to be driven by

[26] Full details about the CS measures and the results are provided in Appendix.

non-intemerdiate products. However, when analysing only the subsample of intermediates (Table 15) a sign pattern compatible with the *CS* acting as a catalyst of the collapse is detected again.

Despite the similarity of results between the product-industry and the product-firm *CS* measures, the variable that is preferred in terms of the main finding of this paper remains the product-industry measure. This is because it can be better interpreted as a stable characteristic of the product and it is less likely to be determined by idiosyncratic firm-level features. Overall, it is very reassuring to find that products' *CS* is associated with an enhanced trade adjustment across such a large variety of amendments of the *CS* measure.

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 the demand collapse differed depending on firm affiliation; that is, whether intra-firm trade reacted differently compared to arm's length trade. Table 7 shows the results for mid-point and standard growth rates, where the impact of *IF* against *AL* trade is observed in isolation and in interaction with the intermediate dummy. Overall, the study of the collapse does not reveal a statistically different response between the two organisational modes[27].

Table 7: Intra-firm versus arm's length trade.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	-0.009	-0.001	0.009	0.015	-0.014	-0.008	-0.012	-0.019
	(0.021)	(0.023)	(0.029)	(0.029)	(0.010)	(0.012)	(0.013)	(0.017)
Int		0.022***		0.021***		0.007		0.005
		(0.004)		(0.005)		(0.004)		(0.006)
IF*Int.		-0.017		-0.014		-0.010		0.013
		(0.016)		(0.022)		(0.010)		(0.015)
IF * Rec.			-0.044	-0.039			-0.003	0.030
			(0.033)	(0.035)			(0.020)	(0.024)
Int* Rec				0.005				0.006
				(0.008)				(0.010)
IF*Int*Rec				-0.008				-0.061***
				(0.023)				(0.022)
FEs.	yes	yes	yes	yes	yes	yes	yes	yes
N	5672551	5672551	5672551	5672551	1784484	1784484	1784484	1784484

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 or when separating the effect for intermediates; neither over the entire cycle (columns 1, 2, 5 and 6), nor when separating the effect over the

[27] For brevity's sake, I only report results for nominal imports. No significant impact is found also in the regressions for the quantity of imports.

downturn and the recovery (columns 3,4, 7 and 8). Only for standard growth rates it appears that, in the recovery, there was a negative premium for shipments of intermediates when taking place intra-firm relative to arm's length: too little to conclude anything in favour of an accelerating or dampening impact of *IF* trade.

In Table 8 the impact of firm affiliation is interacted with that of the *CS*, as shown in specification (10).

Table 8: Firm affiliation and cost-share.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	-0.012	-0.00690	0.007	0.009	-0.013	-0.005	-0.008	-0.013
	(0.022)	(0.024)	(0.029)	(0.030)	(0.010)	(0.012)	(0.013)	(0.016)
CS	-0.005***	-0.005***	-0.005***	-0.005***	-0.003*	-0.002	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.016)	(0.002)	(0.002)	(0.004)	(0.003)
IF*CS	-0.014**	-0.021***	**-0.018*** **	**-0.018*** **	-0.031	-0.133*	**-0.147** **	**-0.211** **
	(0.006)	(0.05)	**(0.004)**	**(0.003)**	(0.026)	(0.078)	**(0.063)**	**(0.086)**
Int		0.029***		0.035***		0.008*		0.009
		(0.004)		(0.005)		(0.004)		(0.006)
Int*IF		-0.013		-0.008		-0.015		0.006
		(0.018)		(0.024)		(0.012)		(0.015)
Int*CS		-0.007		**-0.040** **		-0.041**		**-0.111*** **
		(0.015)		**(0.019)**		(0.019)		**(0.026)**
Int*CS*IF		0.076**		0.038		0.152*		0.175
		(0.036)		(0.061)		(0.084)		(0.113)
IF*Rec			-0.040	-0.035			-0.013	0.022
			(0.035)	(0.036)			(0.021)	(0.024)
CS*Rec			0.001	0.000			-0.001	-0.003
			(0.001)	(0.002)			(0.006)	(0.006)
IF*CS*Rec			**0.077** **	-0.288*			**0.248** **	0.252
			(0.037)	(0.162)			**(0.098)**	(0.194)
Int*Rec				-0.015*				-0.000
				(0.008)				(0.009)
Int*IF*Rec				-0.016				-0.055**
				(0.024)				(0.022)
Int*CS*Rec				**0.087*** **				**0.162*** **
				(0.026)				**(0.044)**
Int*CS*IF*Rec				**0.347** **				-0.154
				(0.175)				(0.225)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5380701	5380701	5380701	5380701	1750854	1750854	1750854	1750854

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

Over the entire cycle (columns 1,2 5 and 6) it appears that higher *CS* products grew less when traded intra-firm compared to when traded at arm's length, with this effect being driven by consumtion and capital goods rather than intermediates, which instead show a better performace (*Int*CS*IF* coefficients). These effects are larger when the standard growth rate is used as dependent variable, but they are estimated more precisely when exploiting the mid-point growth rate.

In columns (3), (4), (7) and (8) the analysis contrasts the two subperiods of the crisis and reveals two key findings: first, the accelerating effect of the *CS* on imports of intermediates, discussed in the previous section, is fully robust to controlling for the impact of firm affiliation (*Int*CS* and *Int*CS*Rec* coefficients in columns 4 and 8); second, *IF* trade might have worked as an additional catalyst of the trade collapse for higher *CS* products. This latter finding appears strongly in columns (3) and (7), with higher CS products experiencing a faster fall in the downturn coupled with a faster rebound in the recovery. However, this effect doesn't look to be specific to trade of intermediates, at least not in the downturn where the negative coefficient on *IF*CS* is unchanged (or even becomes larger) when controlling for the impact on intermediates (columns 4 and 8). In the recovery instead, the positive rebound of higher *CS* products (relative to *AL* imports) appears to be driven by intermediates. In Table 8 this is evident for the mid-point growth rate regressions, however, when the alternative *CS* measure is exploited (Table 8B in Appendix) the positive rebound for *IF* imports of higher *CS* intermediates is found for both the mid-point and the standard growth rate[28].

Summarizing the findings of this section, *IF* trade did not affect the reaction of trade differently from *AL* trade when the impact is averaged over all products, or when products' cost-share is not controlled for. The only margin along which some action is detected is when contrasting the performace of shipments accounting for a larger share of firms' costs between the two subperiods of the crisis. These results suggest that *IF* trade might have accelerated the collapse of imports, relative to *AL* trade. There appears, therefore, to be a cumulative effect imparted by the *CS* and firm affiliation, with the difference that the *CS* shows its impact neatly on trade of intermediates (and this results is robust to controlling for firm ownership) whereas the differential impact of *IF* with respect to *AL* trade is mostly evident for capital and consumption goods in the downturn and for intermediates in the recovery.

Several factors can explain why the analysis of *IF* against *AL* trade failed to show well defined results. First, all regressions are run with firm-month fixed effects; so there is likely to be little within firm-month variation to be estimated from between *IF* and *AL* trade. Secondly, the identification of *IF* and *AL* transactions suffers from measurement error: as explained in Section 3, the misallocation of a fraction of shipments from *AL* to *IF* trade causes the coefficients on these variables to be biased

[28] Tables 7, 8 and 8B *(in Appendix) show the results for nominal imports. For the sake of brevity I do not show the tables for quantity, but results are extremely similar to those for the value of imports.

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 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 of alternative mechanisms of opposite sign is well possible in a trade crisis[29]. In case 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.

Importantly, heterogeneity across the *CS* of imported products 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.

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[30], 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 5 do not show the existence of a *bullwhip* effect for all intermediate prod-

[29] IF trade of US firms was reported to be more resilient than AL trade during the East Asian crises of 1997 (Bernard *et al.* 2009).

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

ucts. In columns (5) and (11) I expressly control for this effect, which would result in 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 the downturn, with no significant difference in the recovery. 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* products by *IF* trade contributes to strengthen the finding that, within GVCs, the relevant source of cross-product heterogeneity acting as a catalyst of the trade collapse is the relative *CS* of the items imported by firms.

7 Empirical tests of the inventory mechanism

In this section I provide evidence in support of the channel hypothesised as a determinant of the enhanced trade adjustment of higher *CS* products and the larger reaction of *IF* relative to *AL* trade.

Hypotheses 1 and 2 relate the trade adjustment to the management of inventories. In order to test their implications about the relevance of products' cost-share and firm affiliation in determining the stock of inventories (i.e. a higher *CS* corresponding to a higher value of the stock and *IF* trade firms accumulating less inventories than *AL* trade firms) and the inventory adjustment (i.e. a higher *CS* leading to a larger adjustment and IF trade adjusting faster than *AL* trade), I would ideally need inventory data at the level at which I measure the cost-share (CN-8 product level). Additionally, to observe the adjustment over the crisis these data would need to be at a monthly frequency. Having inventory data only at the firm level, at a yearly frequency, an empirical test of the hypotheses can be approached only indirectly. Because of this weakness of the data and in order to provide more robustness to the inventory adjustment channel, I pursue two alternative strategies.

7.1 Frequency of shipments as a proxy for inventory adjustments

The change in the frequency of shipments at the transaction level can be an indication that firms are changing the stock of inventories of a certain product (Chen and Juvenal, 2015). With transaction level data, I can compute the growth of the frequency of imports of each product, in each sector, in each month[31]. As in the main specifications of this work, both the mid-point growth rate and the log-change of the frequency of shipments at the product-sector-month level has been computed. These have then been exploited to replace the growth of imports on the left-hand-side of specifications (8), (9) and (10) to test whether higher CS products underwent larger inventory adjustments and whether IF trade lead to a faster adjustment of trade relative to AL trade. Table 9 shows the results of these regressions, for both the CS^{costs} and the CS^{sales} measures.

Table 9: Frequency of shipments - Inventory adjustment. Cost-share.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Mid-Point Growth Rates						Standard Growth Rates (Log-change)					
PANEL A: Frequency of shipments. CS^{costs}												
CS	-0.002***		-0.002***	-0.002***		-0.002***	-0.000		-0.000	-0.001*		-0.001
	(0.003)		(0.003)	(0.004)		(0.003)	(0.000)		(0.000)	(0.000)		(0.001)
Int		0.017***	0.022***		0.017***	0.031***		0.007***	0.007***		0.006***	0.007***
		(0.002)	(0.003)		(0.003)	(0.004)		(0.002)	(0.002)		(0.002)	(0.002)
Int*CS			-0.007			**-0.035***			-0.022**			**-0.025****
			(0.011)			**(0.018)**			(0.001)			**(0.012)**
CS*Rec				0.000		-0.001				0.002**		0.002**
				(0.000)		(0.001)				(0.001)		(0.001)
Int*Rec					0.000	-0.021***					0.017	0.001
					(0.004)	(0.005)					(0.004)	(0.004)
Int*CS*Rec						**0.069*****						**0.005**
						(0.020)						**(0.010)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5313521	5578068	5313521	5313521	5578068	5313521	837575	856555	837575	837575	856555	837575
PANEL B: Frequency of shipments. CS^{sales}												
CS	-0.003***		-0.002***	-0.003***		-0.002***	-0.001		-0.000	-0.002***		-0.001*
	(0.000)		(0.000)	(0.000)		(0.000)	(0.001)		(0.000)	(0.001)		(0.001)
Int.		0.018***	0.022***		0.017***	0.031***		0.007***	0.008***		0.006***	0.008***
		(0.002)	(0.002)		(0.003)	(0.004)		(0.002)	(0.002)		(0.002)	(0.002)
Int*CS			-0.001			**-0.056****			-0.055**			**-0.058***
			(0.016)			**(0.028)**			(0.028)			**(0.031)**
CS*Rec				0.000		0.000				-0.003**		-0.003***
				(0.000)		(0.001)				(0.006)		(0.001)
Int*Rec					0.000	-0.021***					0.017	0.001
					(0.004)	(0.005)					(0.004)	(0.004)
Int*CS*Rec						**0.095*****						**0.006**
						(0.041)						**(0.013)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
N	5309737	5578068	5309737	5309737	5578068	5309737	837032	856555	837032	837032	856555	837032

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

What emerges is that the growth of the frequency of shipments is significantly associated to the CS of products. In particular, shipments of intermediates accounting for a higher CS contracted

[31] It has also been experimented with the computation of this variable at the firm level, but the level of product disaggregation and the monthly frequency do not allow to have meaningful variation when disaggregating the growth of the frequency by products, sector, and firms.

more in the downturn and grew back more in the recovery phase. For standard growth rates this result is found also without distinguishing between the end use of products (column 10).

The findings in Table 9 mirror therefore closely those of Table 4 and 5: if the change in the frequency of shipments can be considered a good proxy for inventory adjustments, it can be inferred that the accelerating impact of product's cost-share in the trade collapse was likely driven by a reduction in the stock of inventories in the downturn and to a corresponding increase in the recovery.

Table 10 shows the results for IF trade: I only present the estimates where the effect of *IF* and the *CS* are interacted, given that in isolation *IF* shows no impact in the crisis (Table 7)[32].

Table 10: Frequency of shipments - Inventory adjustment. Firm affiliation and CS^{costs}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	0.024	-0.008	0.011'	0.011	-0.002	0.004	0.000	0.006
	(0.058)	(0.080)	(0.007)	(0.010)	(0.005)	(0.006)	(0.001)	(0.007)
CS	-0.002***	-0.002***	-0.002***	-0.002***	-0.001***	-0.001***	-0.002***	-0.001***
	(0.001)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
IF*CS	-0.012**	-0.015***	**-0.013*** **	**-0.013*** **	-0.020	-0.187***	**-0.039**	**-0.228** **
	(0.004)	(0.03)	**(0.002)**	**(0.001)**	(0.024)	(0.051)	**(0.035)**	**(0.056)**
Int		0.022***		0.031***		0.008*		0.007**
		(0.003)		(0.011)		(0.002)		(0.0029)
Int*IF		-0.001		-0.003		-0.010**		-0.011*
		(0.009)		(0.011)		(0.005)		(0.005)
Int*CS		-0.004		**-0.037** **		-0.024**		**-0.026* **
		(0.009)		**(0.015)**		(0.010)		**(0.014)**
Int*CS*IF		0.035		0.026		0.204***		0.236***
		(0.025)		(0.043)		(0.055)		(0.064)
IF*Rec			-0.021	-0.019			-0.004	-0.006
			(0.017)	(0.020)			(0.021)	(0.011)
CS*Rec			0.000	-0.000			0.002**	-0.002**
			(0.001)	(0.000)			(0.001)	(0.001)
IF*CS*Rec			**0.021**	-0.276*			**0.042**	0.132'
			(0.029)	(0.155)			**(0.029)**	(0.088)
Int*Rec				-0.021***				-0.004
				(0.006)				(0.005)
Int*IF*Rec				0.004				0.003
				(0.016)				(0.009)
Int*CS*Rec				**0.089*** **				**0.006**
				(0.020				**(0.014)**
Int*CS*IF*Rec				**0.276**				-0.113
				(0.163)				(0.091)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5313521	5313521	5313521	5313521	837575	837575	837575	837575

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

The effect of IF trade on the change in the frequency of shipments is less clearcut than the effect detected on the growth of trade. Most of the coefficients in Table 10 take the same sign as

[32] When exploiting the change in frequency of shipments as dependent variable this result is confirmed. Furthermore, Table 10 shows the results for the CS^{costs} variable, Table 10B in Appendix shows the results for CS^{sales}.

those in Table 8, but the accelerating impact of IF trade on imports of higher CS product is not always statistically significant at the conventional levels (columns 3, 4, 7 and 8). Hence, I cannot draw strong conclusions about the channel driving the effect of IF relative to AL trade; however more evidence in support of the inventory adjustment channel is provided in Section 7.2.

7.2 Reduced form estimation of inventory adjustments at the firm level

A second way in which I attempt to support the rationale of hypotheses 1 and 2 is by attempting a reduced form estimation of the main results of the (S, s) model exposed in Section 2.

As I am limited by the lack of inventory data at the level at which I measure the CS (CN-8), and in order to be able to run a firm level regression, I average 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[33]. According to equation (1) the average stock of inventory is negatively related to the unit-cost of the item, but positively to the cost-share (equation (18) in appendix). Taking (1) to the data leads to a specification of this form:

$$N_{it} = \beta_0 + \beta_1 CS_{it} + \beta_2 S_{it} + \gamma_i + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \tag{11}$$

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[34], 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.

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 firms' expectations and the adjustment of inventories

[33] 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.

[34] 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.

due to sales and the average cost-share, specification (11) can be amended in this way:

$$N_{it} = \beta_0 + \beta_1 CS_{it} + \beta_3 CS_{it-1} + \beta_3 S_{it} + \beta_4 S_{it-1} + \gamma_i + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \tag{12}$$

Concerning hypothesis 2 and the unequal inventory management strategy between IF and AL trade firms, an indirect test has been attempted by exploting specification (13):

$$N_{it} = \beta_0 + \beta_1 Group_i + \beta_2 S_{it} + \beta_3 S_{it-1} + \sum_r \beta_r X_{i,t} + \eta_t + \delta_1 t + \delta_2 t^2 + \varepsilon_{it} \tag{13}$$

where *Group* denotes a dummy variable taking value 1 if the firm belongs to a multinational group, S denotes sales and X denotes a vector of firm level controls[35] included because, as the *Group* dummy time-invariant, it is not possible to exploit firm fixed effects likewise in the above specifications.

Table 11 provides the results of the estimation of (11) and (12), for both CS measures. 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. 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).

The optimal stock (equation 1 in the model) increases with sales; hence in columns (2) and (6) 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 (3) and (7) I control for all factors jointly: all coefficients take the expected signs, including the sales variables, whose level of significance does however not reach the conventional levels.

Lastly, in order to control whether the inventory adjustment behaviour was enhanced during the trade collapse, in columns (4) and (8) I interact the firm level *CS* and its one year lag with a dummy picking up the difference between these coefficients for all the other years and 2009.

[35] The controls are capital intensity, skill intensity, number of employees and TFP, computed by use of the Levinsohn and Petrin (2003) estimator.

Table 11. Inventories as a function of the CS.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CS^{costs}				CS^{sales}			
CS_firm$_{(t)}$	0.00051**		0.00078***	0.00054***	0.00087**		0.00165***	0.00137***
	(0.00021)		(0.00014)	(0.00018)	(0.00044)		(0.00031)	(0.00040)
CS_firm$_{(t-1)}$		-0.00032***	-0.00059***	-0.00045***		-0.00048***	-0.00101***	-0.00066***
		(0.00010)	(0.00011)	(0.00017)		(0.00014)	(0.00019)	(0.00028)
Sales$_{(t)}$	-0.00026+	-0.00023+	-0.00023+	-0.00024+	-0.00016***	-0.00023+	-0.00022+	-0.00024+
	(0.00018)	(0.00016)	(0.00016)	(0.00017)	(0.00005)	(0.00017)	(0.00016)	(0.00018)
Sales$_{(t-1)}$		0.00022	0.00027+	0.00034+		0.00022	0.00027+	0.00033+
		(0.00021)	(0.00021)	(0.00024)		(0.00021)	(0.00021)	(0.00024)
CS_firm$_{(t)}$*Crisis				0.00014				-0.00083
				(0.00040)				(0.00080)
CS_firm$_{(t-1)}$*Crisis				-0.00103***				-0.00027
				(0.00056)				(0.00098)
Trends	yes	yes	yes	yes	yes	yes	yes	yes
Firm. FE	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes	yes	yes
Constant	0.192***	0.192***	0.192***	0.188***	0.185***	0.192***	0.192***	0.188***
	(0.00127)	(0.00133)	(0.00133)	(0.00133)	(0.00121)	(0.00133)	(0.00127)	(0.00133)
N	110169	81448	81020	86734	110115	81434	80999	86705

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 contemporanous *CS* doesn't show a significant difference during the crisis, but the lagged *CS* is associated with a negative premium for the crisis year (signifcant only for the *CS* in terms of firms' costs). This suggests that if firms tend to respond to a higher *CS* by reducing the stock of inventories, they did so more strongly during the trade collapse.

Table 12 presents the results from estimating specification (13). In line with hypothesis 2, firms belonging to multinational groups are found to accumulate a lower stock of inventories, on average, relative to independent firms. Furthermore, the interaction between the group and the crisis dummy shows an additional negative coefficient, confirming the possibility that firms trading intra-firm might have undertaken larger inventory adjustments during the crisis.

The results in Table 11 and 12 appear to broadly endorse the (S, s) model and the predictions of hypothesis 1 and 2. Despite the evident caveats arising from the data structure available to test these propositions, there is some - admittedly rudimentary - 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 (5), and its role as a catalyst of the trade collapse.

Table 12. Inventories and firm affiliation.

	(1)	(2)
Group	**-0.025*** **	**-0.023*** **
	(0.005)	**(0.005)**
$\text{Sales}_{(t)}$	0.002	0.002
	(0.001)	(0.001)
$\text{Sales}_{(t-1)}$	0.004*	0.004*
	(0.002)	(0.002)
Group*Crisis		**-0.006** **
		(0.003)
Trends	yes	yes
Firm. FE	no	no
Firm Controls	yes	yes
Year FE	yes	yes
Constant	0.247***	0.247***
	(0.0068)	(0.0068)
N	23849	23849

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

Also the *IF* versus *AL* hypothesis obtains support in this section: a sizeable gap is detected in the amount of inventories that affiliated and unaffiliated firms carry, with a further premium during the crisis year.

8 Conclusion

This work addresses the impact of the 2008-09 financial crisis on international trade by analysing high frequency transaction level data matched with firm balance-sheet and ownership information.

The main contribution of this paper consists of the identification of a new channel that accelerated the reaction of trade flows to the shock. The share of imported intermediates in firms' costs 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. This larger responsiveness in both sub-periods of the event suggests that the trough of the collapse was indeed deeper for transactions involving higher *CS* products. This result is robust to expoiting only the intensive margin variation of trade; or to the amendment of the cost-share measure (from the share in total costs to the share in total sales).

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* products. 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 products. This hypothesis could explain why a faster adjustment was measured in both the downturn and the recovery for imports of higher *CS* products when involving related parties, relative to AL trade. This result is mostly driven by consumption and capital goods.

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 products affected 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.

References

[1] **Abel, Andrew B.**, 1985. "Inventories, Stock-Outs, and Production Smoothing", *Review of Economic Studies*, vol. 52(2): 283-93.

[2] **Alessandria, George, Joseph P. Kaboski, and Virgiliu Midrigan**. 2010a. "The Great Trade Collapse of 2008-2009: An Inventory Adjustment?" *IMF Economic Review*, 58(2): 254–294.

[3] **Alessandria, George, Joseph P. Kaboski, and Virgiliu Midrigan**. 2010b. "Inventories, Lumpy Trade, and Large Devaluations." *American Economic Review*, 100(5): 2304–2339.

[4] **Alessandria, George, Joseph P. Kaboski, and Virgiliu Midrigan**. 2011. "U.S. Trade and Lumpy Inventory Dynamics." *American Economic Review: Papers and Proceedings*, 101(3): 303–307.

[5] **Altomonte, Carlo, Filippo Di Mauro, Gianmarco Ottaviano, Armando Rungi, and Vincent Vicard**. 2012. "Global Value Chains during the Great Trade Collapse: A Bullwhip Effect?" European Central Bank Working Paper No.1412

[6] **Amiti, Mary, and David Weinstein**. 2011. "Exports and Financial Shocks." *Quarterly Journal of Economics*, 126(4): 1841–1877.

[7] **Antràs, Pol.** 2003. "Firms, Contracts and Trade Structure," *Quarterly Journal of Economics*, 118, 1375-1418.

[8] **Antràs, Pol and Fritz C. Foley**. Forthcoming. "Poultry in Motion: A Study of International Trade Finance Practices." *Journal of Political Economy.*

[9] **Arrow Kenneth J., Theodore Harris and Jacob Marschak.** 1951. "Optimal Inventory Policy". *Econometrica*, Vol. 19, No. 3 (Jul., 1951) , pp. 250-272.

[10] **Asmundson, Irena, Thomas Dorsey, Armine Khachatryan, Ioana Niculcea, and Mika Saito**. 2011. "Trade and Trade Finance in the 2008-2009 Financial Crisis." IMF Working Paper No. 11/16.

[11] **Baldwin, Richard, and Simon Evenett**, ed. 2009. The Collapse of Global Trade, Murky Protectionism, and the Crisis: Recommendations for the G20. VoxEU.org.

[12] **Bas, Maria and Juan Carluccio**. 2009. "Wage Bargaining and the Boundaries of the Multinational Firm", mimeo.

[13] **Behrens, Kristian, Gregory Corcos, and Giordano Mion**. 2013. "Trade Crisis? What Trade Crisis?" *The Review of Economics and Statistics*, 95(2), 702-709.

[14] **Bems, Rudolfs, Robert C. Johnson, and Kei-Mu Yi**. 2010. "Demand Spillovers and the Collapse of Trade in the Global Recession." *IMF Economic Review*, 58(2): 295–326.

[15] **Bems, Rudolfs, Robert C. Johnson, and Kei-Mu Yi**. 2011. "Vertical Linkages and the Collapse of Global Trade." *American Economic Review: Papers and Proceedings*, 101(3): 308–312.

[16] **Bems, Rudolfs, Robert C. Johnson, and Kei-Mu Yi**. 2012. "The Great Trade Collapse." NBER Working Paper No. 18632.

[17] **Bernard, Andrew B., Bradford J. Jensen, Stephen J. Redding and Peter K. Schott**. 2009. “The Margins of US Trade”, *American Economic Review: Papers & Proceedings*, vol. 99(2), 487-93.

[18] **Bernard, Andrew B., Bradford J. Jensen, Stephen J. Redding and Peter K. Schott**. 2012. "The Empirics of Firm Heterogeneity and International Trade," *Annual Review of Economics, Annual Reviews*, vol. 4(1), pages 283-313, 07.

[19] **Bricongne, Jean-Charles, Lionel Fontagné, Guillaume Gaulier, Daria Taglioni, and Vincent Vicard**. 2012. “Firms and the Global Crisis: French Exports in the Turmoil.” *Journal of International Economics*, 87(1): 134–146.

[20] **Buono, Ines, Harald Fadinger and Stefan Berger**. 2008. “The micro dynamics of exporting: Evidence from French Firms”, MPRA Paper 12940, University Library of Munich, Germany.

[21] **Bussière, Matthieu, Giovanni Callegari, Fabio Ghironi, Giulia Sestieri, and Norihiko Yamano**. 2013 “Estimating Trade Elasticities: Demand Composition and the Trade Collapse of 2008-2009.” *American Economic Journal: Macroeconomics*, 5(3): 118-51.

[22] **Carpenter Robert, Steven M. Fazzari and Bruce C. Petersen**. 1994. "Inventory Investment, Internal-Finance Fluctuation, and the Business Cycle," *Brookings Papers on Economic Activity*, Economic Studies Program, The Brookings Institution, vol. 25(2): 75-138.

[23] **Carpenter Robert, Steven M. Fazzari and Bruce C. Petersen**, 1998. "Financing Constraints And Inventory Investment: A Comparative Study With High-Frequency Panel Data," *The Review of Economics and Statistics*, vol. 80(4): 513-519.

[24] **Chen, Natalie and Luciana Juvenal.** 2015. "Quality and the Great Trade Collapse", mimeo.

[25] **Chor, Davin and Kalina Manova**. 2012. “Off the Cliff and Back? Credit Conditions and International Trade during the Global Financial Crisis.” *Journal of International Economics*, 87(1): 117–113.

[26] **Coulibaly, Brahima, Horacio Sapienza, and Andrei Zlate**. 2011. “Trade Credit and International Trade during the 2008-2009 Global Financial Crisis.” Unpublished Manuscript, Federal Reserve Board.

[27] **Corcos, Gregory, Delphine M. Irac, Giordano Mion and Thierry Verdier**. 2013. "The Determinants of Intrafirm Trade: Evidence from French Firms," *The Review of Economics and Statistics*, vol. 95(3): 825-838.

[28] **Davis Steve J. and John C. Haltiwanger**. 1992. “Gross job creation, gross job destruction, and employment reallocation”. *The Quarterly Journal of Economics,* 107 (3), pp. 819-863.

[29] **Eaton, Jonathan, Samuel Kortum, Brent Neiman, and John Romalis**. 2011. “Trade and the Global Recession.” NBER Working Paper 16666.

[30] **Escaith, Hubert, Lindenberg, Nannette, and Miroudot, Sébastien**, 2010. “International Supply Chains and Trade Elasticity in Times of Global Crisis”, World Trade Organization (Economic Research and Statistics Division) Staff Working Paper ERSD 2010-08.

[31] **Forrester, J**. 1961. Industrial Dynamics. Cambridge, MA: The MIT Press.

[32] **Hadley George, Thomson Whitin**. 1963. "Analysis of inventory systems". Prentice Hall.

[33] **Korinek, Jane, Jean Le Cocguic, and Patricia Sourdin**. 2010. “The Availability and Cost of Short-Term Trade Finance and its Impact on Trade.” *OECD Trade Policy Papers*, No. 98, OECD Publishing.

[34] **Lanz, Rainer and Sebastien Miroudot.** 2011. “Intra-Firm Trade: Patterns, Determinants and Policy Implications”, OECD Trade Policy Working Papers, No. 114.

[35] **Levchenko, Andrei A., Logan T. Lewis, and Linda L. Tesar**. 2010. “The Collapse of International Trade during the 2008-2009 Crisis: In Search of the Smoking Gun.” *IMF Economic Review*, 58(2): 214–253.

[36] **Levinsohn James and Amil Petrin.** 2003. “Estimating Production Functions Using Inputs to Control for Unobservables” *Review of Economic Studies*, 70 (2003), 317-342.

[37] **Malouche, Mariem.** 2011. “World Bank Firm and Bank Surveys in 14 Developing Countries, 2009 and 2010.” In Trade Finance during the Great Trade Collapse. Ed. Jean-Pierre Chauffour and Mariem Malouche, Chapter 5, 89–116. Washington, DC: The World Bank.

[38] **Paravisini, Daniel, Veronica Rappoport, Phillip Schnabl, and Daniel Wolfenzon.** 2012. “Dissecting the Effect of Credit Supply on Trade: Evidence from Matched Credit- Export Data.” Unpublished Manuscript, Columbia University.

[39] **Petropoulou, Dimitra and Kwok Tong Soo**. 2011."Product durability and trade volatility," Globalization and Monetary Policy Institute Working Paper 94, Federal Reserve Bank of Dallas.

[40] United Nations Conference on Trade and Development. 2000. “World Investment Report: Cross-border Mergers and Acquisitions and Development”. Geneva: The United Nations.

[41] **Udenio Maximiliano, Jan C. Fransoo, Robert Peels**. 2015. "Destocking, the bullwhip effect, and the credit crisis: Empirical modeling of supply chain dynamics". *International Journal of Production Economics*, Volume 160, February 2015, Pages 34-46.

[42] **Yi, Key Mu**. 2009. “The collapse of global trade: the role of vertical specialization”, in Baldwin and Evenett (Eds.). The collapse of global trade, murky protectionism, and the crisis. Recommendations for the G20, CEPR.

9 Appendix

9.1 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[36]. 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[37], 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 $A\left(\delta/S\right) + \omega\delta S$.

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: $Ic\int_0^T \left(S + s - \delta t\right) dt = Ic\left[\left(S + s\right)T - \frac{\delta T^2}{2}\right] = IcT\left[(S/2) + s\right]$. Multiplying this by the average number of cycles gives $Ic\left[(S/2) + s\right]$. 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.

[36] 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.

[37] 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.

The average variable cost is then:

$$C = A\frac{\delta}{S} + \omega\delta S + Ic\left[\frac{S}{2}\right] \tag{14}$$

Minimisation of (14) allows to obtain the optimal quantity to order, S^*:

$$S^* = \sqrt{\frac{2\delta A}{Ic + 2\omega\delta}} \tag{15}$$

Equation (15) 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

$$r^* = \delta(\tau - mT) = \delta\tau - mS^*, \tag{16}$$

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:

$$\bar{S}^* = \frac{S^*}{2} = \sqrt{\frac{A\delta}{2\left(cI + 2\delta\omega\right)}} \tag{17}$$

It follows directly from equation (17) 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 (17): the cost-share measures the value of the imported item in sales, whereas (17) 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:

$$\frac{\partial\left(\bar{S}^* c\right)}{\partial c} = \frac{\left(cI + 4\delta\omega\right)\left(A\delta\right)^{1/2}}{2^{1/2}\left(cI + 2\delta\omega\right)^{3/2}} > 0, \tag{18}$$

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:

$$\frac{\partial\left(\bar{S}^{*}c\right)/\partial\delta}{\bar{S}^{*}c} = \frac{1}{2\delta(1+\frac{2\delta\omega}{cI})} \quad \text{and} \quad \frac{\partial}{\partial c}\left(\frac{1}{2\delta(1+\frac{2\delta\omega}{cI})}\right) = \frac{\omega I}{\left(cI+2\delta\omega\right)^{2}} > 0. \tag{19}$$

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.

9.2 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.

9.2.1 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.

9.3 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.

Table 13: 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

9.3.1 A firm level cost-share measure

The results presented in Tables 4, 5 and 6 explore the unequal trade adjustment of products accounting for a diffent share of firms' costs (or firms' sales), where the CS measure is specific for each CN-8 product in each NACE (4-digit) sector.

In order to explore the CS heterogeneity further, an attempt has also been made to compute the CS measure at an even finer level of disaggregation, making the CS ratio product-firm specific. The CS variables (6) and (7) therefore become:

$$CS_{ki}^{\text{costs-firm}} = \frac{1}{Y} \sum_{y=2000}^{2007} \left(\frac{\sum_{t=1}^{12} im_{kic,t}}{C_{iy}} \right), \quad CS_{ki}^{\text{sales-firm}} = \frac{1}{Y} \sum_{y=2000}^{2007} \left(\frac{\sum_{t=1}^{12} im_{kic,t}}{S_{iy}} \right) \tag{20}$$

Table 14 shows the results from estimating specification (8) and (9) exploting the firm level CS measures.

Table 14: The Cost-Share as a Catalyst of the Collapse - Firm level measures

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: $CS^{\text{costs-firm}}$								
CS	-0.026*	-0.043***	**-0.040***	-0.055***	-0.024	-0.046***	**-0.046'**	-0.070***
	(0.015)	(0.013)	**(0.022)**	(0.017)	(0.019)	(0.012)	**(0.030)**	(0.020)
Int		0.046***		0.053***		0.019***		0.023***
		(0.005)		(0.011)		(0.007)		(0.008)
Int*CS		-0.026'		0.025		-0.031		0.041
		(0.015)		(0.031)		(0.021)		(0.039)
CS*Rec			**0.033'**	0.031			**0.055**	-0.120***
			(0.021)	(0.026)			**(0.039)**	(0.036)
Int*Rec				-0.019***				-0.010
				(0.007)				(0.009)
Int*CS*Rec				-0.001				-0.088*
				(0.039)				(0.049)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	4711097	4711097	4711097	4711097	1680951	1680951	1680951	1680951
PANEL B: $CS^{\text{sales-firm}}$								
CS	-0.012'	-0.011	**-0.018'**	-0.010'	-0.072**	-0.050	**-0.091****	-0.056
	(0.008)	(0.009)	**(0.011)**	(0.071)	(0.028)	(0.040)	**(0.040)**	(0.047)
Int		0.046***		0.053***		0.019***		0.025***
		(0.005)		(0.011)		(0.006)		(0.008)
Int*CS		-0.001		-0.021**		-0.040		-0.069
		(0.003)		(0.010)		(0.049)		(0.067)
CS*Rec			**0.015****	-0.003			**0.011****	0.072
			(0.007)	(0.021)			**(0.004)**	(0.070)
Int*Rec				-0.019***				-0.013
				(0.007)				(0.090)
Int*CS*Rec				0.034				0.071
				(0.034)				(0.090)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	4707816	4707816	4707816	4707816	1784484	1784484	1784484	1784484

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

The results support the main finding of this work: even when the CS is computed at the firm-product level it appears that imports of products accounting for a larger CS underwent a larger fall in the downturn and a larger rebound in the recovery. This is shown for both the $CS^{\text{ sales-firm}}$ and the $CS^{\text{ costs-firm}}$ measures in columns (3) and (7). A noticeable difference compared to the results exploiting the product-industry CS measures (Table 4 and 5), is that in Table 14 the accelerating impact of the CS appears to be driven by non-intermediate goods rather than intermediates.

This however does not exlcude that also for intermediates a higher CS (measured at the firm level) implied an accelerated reaction during the trade collapse. Table 15 shows the results from reestimating the specifications in Table 14 on the subsample of intermediates. The sign pattern in columns (2) and (4) is consistent with the hypothesis that higher CS intermediates underwent a larger adjustment, even though results are statistically significant at the conventional levels only for the CS measure in terms of firms' sales (Panel B)[38].

Table 15: The CS as a Catalyst - Firm level measures- Intermediates

	(1)	(2)	(3)	(4)
	Mid-Point Growth Rates		Standard Growth Rates	
PANEL A: $CS^{\text{ costs-firm}}$				
CS	-0.017	**-0.033**	-0.013	**-0.025**
	(0.014)	**(0.026)**	(0.018)	**(0.034)**
CS*Rec		**0.037**		**0.025**
		(0.029)		**(0.035)**
FEs	yes	yes	yes	yes
N	2478335	2478335	888694	888694
PANEL B: $CS^{\text{ sales-firm}}$				
CS	-0.012'	**-0.033***	-0.079***	**-0.120****
	(0.008)	**(0.017)**	(0.026)	**(0.048)**
CS*Rec		**0.033***		**0.132****
		(0.017)		**(0.054)**
FEs	yes	yes	yes	yes
N	2477753	2477753	888607	888607

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

[38] For the sake of brevity I omitted the tables showing the results for the quantity and the unit values of imports. These results are in line with what found in the other sections of this paper, and namely that quantity adjustments show very similar coefficients to value adjusments, and with unit-values being mostly insignificant.

9.4 Additional tables

Table 6B: The Cost-Share as a Catalyst - CS^{sales}.Only 06-07 for CS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rates				Standard Growth Rates (Log-change)			
PANEL A: Imports - values								
CS	-0.004	-0.003	-0.011	-0.006	-0.023*	-0.018	-0.045*	-0.030
	(0.005)	(0.004)	(0.073)	(0.006)	(0.013)	(0.014)	(0.026)	(0.022)
Int		0.033***		0.043***		0.009**		0.014**
		(0.005)		(0.006)		(0.004)		(0.006)
Int*CS		-0.004		**-0.022**		-0.014		**-0.046**
		(0.011)		**(0.019)**		(0.025)		**(0.041)**
CS*Rec			0.012	0.004			0.049	0.025
			(0.008)	(0.007)			(0.034)	(0.021)
Int*Rec				-0.025***				-0.013
				(0.007)				(0.009)
Int*CS*Rec				**0.040***				**0.072**
				(0.023)				**(0.048)**
PANEL B: Imports - quantity								
CS	-0.005	-0.004	-0.009	-0.006	-0.019*	-0.013	-0.039*	-0.022
	(0.005)	(0.005)	(0.007)	(0.006)	(0.010)	(0.010)	(0.020)	(0.018)
Int.		0.031***		0.039***		0.001		0.004
		(0.005)		(0.006)		(0.005)		(0.006)
Int*CS		-0.001		**-0.014**		-0.017		**-0.049**
		(0.011)		**(0.018)**		(0.021)		**(0.042)**
CS*Rec			0.008	-0.003			0.043	0.025
			(0.008)	(0.037)			(0.026)	(0.021)
Int*Rec				-0.024***				-0.013
				(0.007)				(0.009)
Int*CS*Rec				**0.032**				**0.072**
				(0.022)				**(0.048)**
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5269440	5269440	5269440	5269440	1739618	1739618	1739618	1739618

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

Table 7B: Intra-firm versus arm's length trade. Quantity and Unit-Values.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
PANEL A: Import Quantities								
IF	-0.003	-0.005	0.018	0.024	-0.000	0.008	0.001	-0.003
	(0.022)	(0.0234)	(0.029)	(0.030)	(0.011)	(0.013)	(0.013)	(0.017)
Int		0.020***		0.017***		0.001		-0.004
		(0.004)		(0.005)		(0.005)		(0.007)
IF*Int		-0.018		-0.013		-0.017		0.007
		(0.018)		(0.023)		(0.012)		(0.015)
IF*Rec			-0.053	-0.048			-0.004	0.030
			(0.034)	(0.035)			(0.021)	(0.024)
Int* Rec				0.005				0.010
				(0.008)				(0.011)
IF*Int*Rec				-0.011				-0.062***
				(0.022)				(0.022)
PANEL B: Imports - Unit Values								
IF	-0.008	-0.003	0.011	0.016	-0.014**	-0.017*	-0.013	-0.017*
	(0.021)	(0.022)	(0.028)	(0.029)	(0.006)	(0.009)	(0.008)	(0.010)
Int		0.026***		0.027***		0.007**		0.009*
		(0.004)		(0.005)		(0.003)		(0.005)
IF*Int		-0.012		-0.011		0.006		0.006
		(0.015)		(0.022)		(0.008)		(0.009)
IF*Rec			-0.049	-0.047			-0.000	0.000
			(0.033)	(0.035)			(0.012)	(0.013)
Int*Rec				-0.001				-0.003
				(0.008)				(0.006)
IF*Int*Rec				-0.004				-0.001
				(0.025)				(0.014)
FEs.	yes	yes	yes	yes	yes	yes	yes	yes
N	5672551	5672551	5672551	5672551	1784484	1784484	1784484	1784484

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

Table 8B: Firm affiliation and cost-share - CS^{sales}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
PANEL A: Imports - values								
IF	-0.012	-0.007	0.008	0.010	-0.013	-0.007	-0.007	-0.016
	(0.022)	(0.024)	(0.029)	(0.030)	(0.010)	(0.012)	(0.013)	(0.016)
CS	-0.008***	-0.008***	-0.008***	-0.008***	-0.004**	-0.003*	-0.004	-0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)
IF*CS	0.007	0.008	**-0.056**	-0.014	-0.058	-0.051	**-0.207****	-0.075
	(0.006)	(0.017)	**(0.072)**	(0.060)	(0.052)	(0.054)	**(0.103)**	(0.073)
Int		0.029***		0.035***		0.008**		0.009
		(0.004)		(0.005)		(0.004)		(0.006)
Int*IF		-0.011		-0.007		-0.013		0.015
		(0.018)		(0.024)		(0.010)		(0.015)
Int*CS		-0.015		**-0.064****		-0.081**		**-0.160*****
		(0.015)		**(0.025)**		(0.019)		**(0.043)**
Int*CS*IF		0.012		-0.072		0.057		-0.206
		(0.059)		(0.079)		(0.086)		(0.161)
IF*Rec			-0.048	-0.042			-0.016	0.025
			(0.033)	(0.036)			(0.021)	(0.024)
CS*Rec			0.001	0.000			-0.001	-0.004
			(0.002)	(0.002)			(0.008)	(0.008)
IF*CS*Rec			**0.076**	0.025			**0.443****	0.088
			(0.070)	(0.053)			**(0.172)**	(0.115)
Int*Rec				-0.015*				-0.001
				(0.008)				(0.010)
Int*IF*Rec				-0.011				-0.069***
				(0.025)				(0.022)
Int*CS*Rec				**0.096*****				**0.265*****
				(0.045)				**(0.070)**
Int*CS*IF*Rec				0.206**				0.511**
				(0.101)				(0.250)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5388408	5388408	5388408	5388408	1753520	1753520	1753520	1753520

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

Table 10B: Frequency of shipments - Inventory adjustment. Firm affiliation and CS^{sales}

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mid-Point Growth Rate				Standard Growth Rate			
IF	0.024	0.006	0.011	0.011	-0.001	0.004	0.001	0.002
	(0.058)	(0.008)	(0.007)	(0.010)	(0.005)	(0.006)	(0.001)	(0.007)
CS	-0.003***	-0.003***	-0.003***	-0.003***	-0.001***	-0.001***	-0.003***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
IF*CS	-0.003	0.003	**-0.045**	0.003	-0.056*	-0.029	**-0.087**	**-0.049**
	(0.015)	(0.011)	**(0.035)**	(0.025)	(0.032)	(0.022)	**(0.058)**	**(0.039)**
Int		0.023***		0.031***		0.009*		0.008**
		(0.003)		(0.003)		(0.002)		(0.003)
Int*IF		0.003		-0.001		-0.004		-0.003
		(0.009)		(0.011)		(0.005)		(0.006)
Int*CS		0.002		**-0.050***		-0.049		**-0.057***
		(0.015)		**(0.026)**		(0.030)		**(0.031)**
Int*CS*IF		-0.054		-0.103		-0.051		-0.102***
		(0.037)		(0.065)		(0.047)		(0.049)
IF*Rec			-0.022	-0.026			-0.005	-0.004
			(0.016)	(0.020)			(0.088)	(0.011)
CS*Rec			0.001	-0.000			0.004**	-0.004***
			(0.001)	(0.000)			(0.001)	(0.001)
IF*CS*Rec			**0.049**	-0.001			**0.066**	0.046
			(0.031)	(0.026)			**(0.058)**	(0.047)
Int*Rec				-0.021***				-0.004
				(0.006)				(0.005)
Int*IF*Rec				0.009				-0.001
				(0.015)				(0.009)
Int*CS*Rec				**0.111*** **				**0.016**
				(0.042)				**(0.012)**
Int*CS*IF*Rec				**0.103**				0.085*
				(0.087)				(0.046)
FEs	yes	yes	yes	yes	yes	yes	yes	yes
N	5309737	5309737	5309737	5309737	837032	837032	837032	837032

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