Estimating Trade Elasticities: Demand Composition and the Trade Collapse of 2008-09*

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Abstract

This paper introduces a new methodology for the estimation of income trade elasticities based on an import intensity-adjusted measure of aggregate demand. It provides an empirical illustration of this new approach for a panel of 18 OECD countries, paying particular attention to the 2008-09 Great Trade Collapse, which standard empirical trade models fail to account for. In this paper, we argue that the composition of demand plays a key role in the collapse of trade during crises because of a relatively bigger fall in the most import-intensive categories of expenditure (especially investment, but also private consumption), which has a large downward impact on the quantity of imports from the rest of the world. In addition, the fragmentation of production implies high import content of exports and, in turn, strongly synchronized trade fluctuations across countries. We provide evidence in favor of these factors based on the analysis of the new OECD input-output tables and building on a stylized theoretical model. Importantly, we show that our new intensity-weighted measure of demand outperforms alternative measures, during crises but also in normal times, providing import elasticities of demand that are much less volatile across the cycle.

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1 Introduction

The estimation of income trade elasticities is a central question in international economics at least since Houthakker and Magee's (1969) seminal work. The question has received renewed attention, and the debate on the determinants of trade flows has re-heated, as scholars debated the adjustment of the global trade imbalances that emerged in the 2000s and struggled to understand the dynamics of world trade in the aftermath of the global financial crisis of 2008-09. One of the key features of the global recession triggered by this crisis was a sharp contraction in world trade that reached its peak between the end of 2008 and the beginning of 2009. In 2009, global trade fell by 11% in real terms on a year-on-year basis—an unprecedented development since 1945. The recovery of global trade started in the course of 2009 and gained strength in 2010, when global trade rose by nearly 13%. A distinct feature of the Great Trade Collapse (GTC) is that the fall in world trade has been much more pronounced than the fall in world output (real world GDP dropped by 0.5% in 2009). This fact suggested the possibility of a break in the relation between world trade and world output: Data indicate that the change in global trade was higher than that of global output by a factor of 19 in 2009, against an average of 1.9 in the 1990-2008 period (Figure 1). The fall in international trade affected a large number of countries in all main economic regions, albeit to a different extent (Figure 2). The fall in imports between the fourth quarter of 2008 and the first quarter of 2009 was particularly strong in emerging countries, such as China, Taiwan and Mexico, but also in some large industrialized countries such as Japan.

In this paper we provide a new methodology for the estimation of trade elasticities that can replicate the 2008-2009 GTC better than other models and that goes some way into explaining the Houthakker-Magee puzzle. We do so by exploring the role played by the composition of aggregate demand during the crisis using a novel, import intensity-adjusted measure of aggregate demand that we construct from the Input-Output tables produced by the Organization for Economic Cooperation and Development (OECD). Our approach is motivated by the fact that different components of aggregate demand have very different import contents, as shown by the analysis of input-output tables. In particular, the import content of investment is higher than that of private consumption, which in turn is higher than that of government consumption (government spending typically goes to non-tradable or domestically-produced, tradable goods).

The analysis of input-output tables allows us to explore another, related factor that plays an important role, the import content of exports. Specifically, two effects may take place. First, the increasing fragmentation of production chains across countries mechanically raises the share of exports that corresponds to the transformation of imported inputs. Thus, a fall in demand in the United States or other large industrialized countries may affect a broad range of countries directly, by reducing the volume of traded final goods, and indirectly, by reducing the volume of intermediate goods. The fact that Asian countries recorded such large falls in trade is also consistent with this argument, given the close integration of Asian countries with each other and the extent of production sharing across them. Second, even without vertical integration, several key countries' exports generally tend to have a strong import content because many inputs necessary to the production of tradeables are imported (for instance, raw materials or energy products).[1]

The fact that standard elasticity models ignore these different import contents and considers only aggregate demand may explain why they fail to account for the magnitude of the fall in world trade during the 2008-09 financial crisis. In the last quarter of 2008 and the first quarter of 2009, investment fell by a larger extent than aggregate output (in the United States, for instance, the annualized fall in total investment has been of 23.8% and 31.3%, respectively, whereas output—partly supported by government spending—contracted by "only" 9.2% and 6.8%). The design of our new intensity-weighted measure of demand is guided by theoretical considerations: We show that the functional form we take to the data can be rationalized using a translog function following Feenstra (2003a, Chapter 3) and a series of articles by Kohli (1978; 1990a,b; 1993). We then test empirically this new measure and show that it outperforms alternative measures in explaining import fluctuations, during the crisis but also in the long run.

In particular, we run standard trade regressions for a panel of 18 OECD countries where real import flows are modeled as a function of our new intensity-weighted measure of demand and relative import prices.[2] This model, estimated for the period 1985Q1-2010Q2, proves to be superior to models using standard measures of demand in terms of both goodness of fit and stability of parameter estimates. The model performs well in explaining the GTC compared to standard models (e.g., our basic specification is able to explain 85% of the average fall in imports in the G7 countries in 2009Q1 against 51% of a model using GDP as explanatory variable. This number goes up to 93% when the additional demand component 'change in inventories' is added to the model). Moreover, our empirical model outperforms standard models also in the long run (i.e., in normal times and during previous crises), providing import elasticities of demand that are much less volatile across the different phases of the cycle, hence reducing the evidence of structural breaks in the trade-demand relationship during recessions.

According to our model, there is no major "puzzle" in the magnitude of the fall in world trade observed during the last financial crisis: Trade fell mostly because demand crashed globally and did so particularly in its most import-intensive component—investment. Moreover, the strong relationship between exports and imports in each country (in 2005, the average import content of exports was 27% for our sample of countries, and 23% for the G7), linked to the increased internationalization of production and the strong dependence of the tradable sector on imported inputs, certainly

[1] A recent literature explores the role of imported intermediates and production chains in propagating shocks and increasing business cycle synchronization across countries (see, among others, Bergin, Feenstra, and Hanson, 2009, Burstein, Kurz, and Tesar, 2008, and Zlate, 2010).

[2] The choice of countries reflects data availability.

contributed to the simultaneity and the unprecedented severity of the trade collapse. Another important implication of our analysis is that, as already pointed out in Marquez (1999), using standard measures of aggregate demand, such as GDP or domestic demand, in trade equations may be misleading, especially during periods, such as the 2008-09 crisis, in which the more import-intensive GDP components (i.e., investment and exports) shrank much more than the others.[3]

Importantly, our results have broader implications than explaining the outcome of the 2008-09 financial crisis—the application of our methodology on which we focused. As we noted above, the appropriate estimation of (exchange rate and demand) trade elasticities is indeed one of the longest standing questions in international economics. Houthakker and Magee (1969) estimated demand elasticities for U.S. exports and imports such that, in the long run, the U.S. should run an ever growing trade deficit. Much subsequent literature has reached similarly puzzling results, lending robustness to the Houthakker-Magee elasticity puzzle. In more recent academic and policy debates, the estimation of trade elasticities plays a role, in particular, in the context of global trade imbalances and the fluctuations of the dollar that may accompany an adjustment in the trade balance of the U.S. and its trading partners (Obstfeld and Rogoff, 2005, 2006, Blanchard, Giavazzi, and Sá, 2005). Trade elasticities also represent a key parameter in the propagation of shocks across borders. Our results contribute to these debates by providing a better specification of empirical trade equations and a more accurate estimation of trade elasticities. Compared to the existing literature, we find lower short-run and long-run income elasticities, such that the Houthakker-Magee puzzle is substantially reduced: In our preferred specification, the panel estimate for the long-run income elasticity is reduced to 1.3, against nearly 1.7 using standard measure of demand. Our new measure is simple to replicate given the weights we provide in the appendix, and we hope it will be used by practitioners in future work.

The rest of the paper is organized as follows. Section 2 reviews the existing literature, paying particular attention to the ability of standard empirical models to account for the recent fall in world trade. Section 3 provides stylized facts on the import content of investment, exports, private and government consumption and presents our new intensity-weighted measure of demand based on the OECD input-output tables. Section 4 provides a theoretical foundation for a regression import equation with our new measure of demand as the correct measure of aggregate demand. Section 5 turns to empirical evidence for a panel of 18 OECD countries: We present an alternative specification that uses our new measure of demand and improves the fit of the model. We also present the implications of our methodology for the broad question of estimating short-term and long-term trade elasticities. Finally, section 6 concludes.

[3]Marquez (1999) questioned the usefulness of the log-linear model of trade since the elasticities of income varied as trade openness modifies the domestic/foreign composition of expenditure. In our model, the income elasticity is stable because our adjusted demand measure, by including time-varying import intensities and distribution of expenditure across different categories, fully reflects these composition adjustments.

2 Related Research

Our paper relates, both, to the recently emerged literature on the 2008-2009 Great Trade Collapse and to the longer-standing question of how to estimate trade elasticities. Starting with the former, numerous studies have attempted to shed light on the Great Trade Collapse, see in particular Baldwin (2009) for an early assessment and review Using very disaggregated data on U.S. imports and exports, Levchenko, Lewis and Tesar (2010) show that the fall in US imports cannot be explained with a simple import demand model, by a wide margin; They also find that sectors used as intermediate inputs were characterized by higher decreases in both imports and exports. This feature is entirely consistent with our own finding that the fall in domestic investment played a key role, to the extent that intermediate goods are predominantly used in investment. Finally, they do not find evidence that the fall in trade flows was related to trade credit conditions. The same authors further explored the hypothesis that US imports of high quality goods experienced larger falls than low-quality goods, to reject it (Levchenko, Lewis and Tesar, 2011).

Meanwhile, our work is also closely related to Bems, Johnson and Yi (2010) and Eaton, Kortum, Neiman and Romalis (2011). Bems et al. (2010) combine the input-output table as in Johnson and Noguera (2009) with a Leontief production function to study the contribution of changes in the composition of demand and country specific demand shocks in the global trade contraction. They also show that, in line with our conclusions and in contrast with the conclusions of Bénassy-Quéré, Decreux, Fontagné and Khoudour-Castéras (2009), the fragmentation of the production process can actually amplify the impact of demand shocks and justify elasticities to production bigger than one in presence of asymmetric shocks across countries and sectors. Our work differs from theirs on several grounds. First, our baseline decomposition of domestic GDP is based on expenditure components (consumption, investment and exports) instead of commodity groupings (durables, non-durables and services). Second, in our framework changes in each individual component of spending affects imports according to their import intensity (i.e., the share of spending falling on imported goods), while in Bems et al. (2010) the relation between spending components and imports is mostly driven by the share of imports linked to that type of spending on total imports. To better understand this difference, let's consider the case of changes in investment spending. In our framework, a change in investment spending translates into a change in our demand measure according to the share of investment spending that goes to imported goods, while in Bems et al. (2010) the relation between spending and demand of imports is mostly driven by the share of investment goods on *total imports.* Because of the level of detail of their input-output table framework, the extension of their analysis to the time series dimension is practically very difficult. Our framework, on the opposite, can be replicated for all the countries for which expenditure-based input-output tables exist and applied to time series analysis.

Eaton et al. (2011) develop a Ricardian model of trade, where the input-output tables are used to evaluate the value added and derive the component of expenditure falling on intermediate goods. Through the use of counterfactuals, they conclude that the demand composition shock is by far the most important driver of the global trade contraction; trade frictions play a much more limited role and are relevant only in China and Japan. Our work is somehow complementary to their study, by providing an econometric estimate of aggregate demand shocks and compositional shifts by integrating them in our new demand measure.

The composition of domestic demand and its impact on external trade has also been the focus of a part of the DSGE literature. Erceg, Guerrieri, and Gust (2006) use the SIGMA model developed at the Board of Governors of the Federal Reserve System to show that the composition of demand in the U.S. matters for the response of trade to a variety of shocks (they explore in particular the effect of an investment shock). The main difference with our analysis is that they are primarily concerned with the impact of various shocks on investment in the context of global imbalances and their adjustment. Our study, by contrast, aims at studying the impact of the composition effect and a quantification of its importance across countries by relying on theoretically grounded model. In addition, Erceg, Guerrieri, and Gust (2006) focus on the composition of domestic demand only, ignoring the role of the import content of exports.

Our study, however, is general and addresses also the well-known Houthakker-Magee puzzle, according to which the income elasticity of imports is too high in many countries and implies an ever growing increase in the imports to GDP ratio. The puzzle can be seen also from another point of view. With the income export elasticity usually estimated to be lower than the corresponding import elasticity, a worldwide increase in income would translate into a global trade deficit clearly in contradiction with the need to ensure global balanced trade. Several attempts have been made to explain the puzzle by using different measures of domestic demand or of the price indices or by including additional independent variables; These studies have often estimated different individual income elasticities for imports, but always well above one (see Marquez, 2002, for a discussion of the main streams of research). In this paper, we address the puzzle from two different fronts. On the one hand, we show how a translog specification of imports demand or of GDP are both consistent with an income elasticity of imports different than one; On the other hand, we still aim at generating import income elasticity problems that are not too far away from one, in order to avoid the problem linked with ever increasing trade deficit in presence of income growth. Our demand-adjusted measure, indeed, generates income elasticities much smaller than standard demand measures.

The focus on the composition of trade relates our work to Mann and Plück (2005). Their study, centered on improving the estimates of US trade elasticities, follows a disaggregated approach, matching commodity categories of imports with the corresponding domestic expenditure. They study also the impact of changes in the country composition of trade and add an independent variable to take into account the impact of increased variety, as suggested by Feenstra (1994). Their econometric model can explain the *export* dynamics better than the standard elasticity model but it performs worse than the standard model on *imports*. Focusing, as we do, only on *import* dynamics, Leibovici and Waugh (2011) show that an income elasticity bigger than one (together with other statistical features of imports and output behavior) is not puzzling once we consider a trade model including time-to-ship friction and finite intertemporal elasticity of substitution. Our translog specification also allows for income elasticity bigger than one, but without relying on any particular assumption on the timing of payments and shipping.

Finally, the use of input-output tables is not new in international trade analysis. Hummels, Ishii and Yi (2001) relied on Input-Output tables to measure and analyze the nature of vertical specialization while Johnson and Noguera (2009) combined input-output tables with bilateral trade to measure how production is shared across country and type of goods, showing that international trade flows in value added terms are very different than those in gross production terms.[4]

3 A New Measure of Aggregate Demand

This section describes the information contained in the OECD Input-Output (henceforth, I-O) database and the methodology to construct the import contents of final demand expenditure. It also introduces our new measure of aggregate demand, IAD.[5]

3.1 The OECD Input-Output Database and the Import Content of Expenditure Components

The I-O tables describe the sale and purchase relationships between producers and consumers within an economy. The I-O database is thus used as fundamental statistics to estimate industrial figures in national accounts.[6] The growing importance of globalization has increased demand for the information offered by the input-output system. Examples of I-O based globalization indicators include: The import penetration ratio of intermediate and final goods, the import content of exports (an indicator of vertical specialization), and the unit value added induced by exports. While there is a literature on the import content of exports (e.g., see Hummels, Ishii, and Yi, 2001, De Backer and Yamano, 2007, and OECD, 2011), to our knowledge this is the first paper to compute and compare the import content by expenditure component across countries.

The most recently published version of the OECD I-O database includes tables for all OECD countries (except Iceland) and 12 non-member countries for the years 1995, 2000, and 2005, and/or

[4]The use of input-output tables to the estimation of trade elasticities and the forecasting of imports actually dates back to Sundararajan and Thakur (1976), who applied it to Korean data. Differently from our paper, however, they focused only on short term import dynamics and do not generate a synthetic adjusted demand measure.

[5]A more detailed explanation of the OECD I-O database and the methodology to compute import contents is in Yamano and Ahmad (2006), De Backer and Yamano (2007), and Guo, Webb, and Yamano (2009).

[6]This database, with its internationally harmonized tables, is a useful empirical tool for economic analysis of structural change when used in conjunction with other international databases on industrial structures, e.g., bilateral trade, labor and environmental impact statistics, etc.

the nearest years. Comparisons across countries are made possible through the use of a standard industry list based on ISIC Revision 3. The database covers 88% of 2005 world GDP and 64% of 2005 world population. The maximum available number of sectors is 48.[7] Imported intermediates and domestically provided inputs are explicitly separated.

Figure 3 provides a stylized graphical illustration of the information in the OECD I-O database. For each country, there are three main matrices, one including total inter-industy flows of transactions of goods and services (domestically provided and imported) and two detailing separately domestically provided and imported flows.[8] Each matrix is then divided in two main parts: The first part (in blue in the figure) describes the flows of intermediate inputs used in domestic production, the second part (in green) contains instead information on final demand expenditure.

The cells in the Zd section of the "domestic" matrix contain the amount of domestically produced inputs from sector i (row) needed by sector j (column) for production throughout the year of reference, while the cells in the Zm section of the "import" matrix contain the amount of imported inputs from sector i (row) needed by the the sector j (column). In the calculations below, we will use slightly modified input matrices, Ad and Am, where the domestic input coefficients $ad_{i,j}$ contain the amount of domestically produced inputs from sector i needed to produce *one* unit of output in sector j, and the imported input coefficients $am_{i,j}$ contain the imported inputs from sector i needed to produce *one* unit of output in sector j.[9] As far as the other part of the matrices is concerned (in green), Fd reports the final demand of domestically produced goods and services (each column refers to a different expenditure component, such as household consumption, government consumption, exports, gross fixed capital formation, change in inventories, etc.), while Fm reports the direct imports of goods and services by final expenditure component.

We use both the "domestic" and "import" matrices to construct the import contents of four expenditure components.[10] Notice that we aggregate information across sectors and look at the import contents only at a macroeconomic (or country) level. In particular, the matrices allow us to compute, for each expenditure component k, the value of *indirect* imports M_k^{ind}, i.e., the amount of imports "induced" by the expenditure on domestically provided goods and services.[11] These include imports of intermediate inputs from foreign suppliers, as well as imports that are already incorporated in capital and intermediate inputs acquired from domestic suppliers. The "import" matrix, instead, allows us to compute the value of *direct* imports, M_k^{dir}, for each expenditure component k.

Let's assume that in the economy there are S sectors and K final demand components and that domestic output from each sector is used both as an intermediate input by the other sectors and to

[7] Mining 2, Manufacturing 22, Services 23, and Agriculture.

[8] In this section we use the term "industry" and "sector" interchangeably.

[9] These coefficients can be easily derived by dividing the value of each cell in Zd and Zm by the sum of the respective column (total output of sector j).

[10] Private consumption, governement consumption, investment (proxied by gross fixed capital formation) and exports.

[11] Indirect imports are often referred to as vertical specialization.

satisfy final demand. The domestic output from sector i needed to satisfy the final demand from the expenditure component k is then given by:

$$x_{i,k} = \sum_{j=1}^{S} ad_{i,j} x_{j,k} + fd_{i,k}$$

In matrix format this becomes

$$X = AdX + Fd$$

where X is the $S \times K$ matrix of domestic output induced by each spending component k; Ad is the $S \times S$ matrix of domestic input coefficients, and Fd is the $S \times K$ matrix of final demands of domestic goods and services. Domestic output can then be expressed as:

$$X = (I - Ad)^{-1} Fd \tag{1}$$

where $(I - Ad)^{-1}$is commonly referred to as the Leontief inverse.

The imports of intermediate inputs from sector i, induced by the expenditure on domestically provided goods and services, can be calculated for each k as:

$$m_{i,k}^{ind} = \sum_{j=1}^{S} am_{i,j} x_{j,k}$$

or, in matrix format:

$$M^{ind} = AmX$$

or, using equation (1):

$$M^{ind} = Am\,(1 - Ad)^{-1}\,Fd$$

where M^{ind} is the $S \times K$ matrix of indirect imports induced by each spending component k, and Am is the $S \times S$ matrix of imported input coefficients.

Direct imports are given instead directly by the following $S \times K$ matrix:

$$M^{dir} = Fm.$$

Total imports can then be expressed as the sum of direct and indirect imports, that is:

$$M = M^{ind} + M^{dir} = Am\,(1 - Ad)^{-1}\,Fd + Fm$$

The total import content of each expenditure component k is hence computed as:

$$\omega_k = \frac{uM_k^{dir} + uM_k^{ind}}{uFd_k + uFm_k} = \frac{uAm\,(1 - Ad)^{-1}\,Fd_k + uFm_k}{uFd_k + uFm_k}$$

where u is a $1 \times S$ vector with all elements equal to 1 and the subscript k selects the k-th column of each matrix, corresponding to the expenditure component of interest.

In addition to the total import content ω_k, it is also possible to derive a direct and indirect import content for each expenditure component:

$$\omega_k^{dir} = \frac{uM_k^{dir}}{uFd_k + uFm_k},$$

$$\omega_k^{ind} = \frac{uM_k^{ind}}{uFd_k + uFm_k},$$

where the indirect import content tells us the share of intermediate imported inputs per unit of final demand, and the direct import content tells us the share of imported final goods and services. Notice that the direct import content of exports is equal to zero as re-exports of goods and services are excluded from our analysis.[12] Table 1 shows the evolution of import contents (total, direct, and indirect) of the main GDP expenditure components over time for a large set of countries.[13]

3.2 Import Intensity-Adjusted Aggregate Demand

Empirical trade models typically use aggregate foreign and domestic demand, ignoring the fact that different components of expenditure have different import contents. Figure 5 shows the import contents of private and government consumption, investment, and exports for our panel of 18 countries based on the 2005 I-O tables, together with the average across all countries and the G7.[14]

As Figure 5 shows, the import content of government consumption is low (government spending mostly includes non-tradeables, such as services, and a high share of domestically produced goods, e.g., for the defense industry) across all countries. Turning to the other two main components of domestic expenditure, investment has a higher import content than private consumption in all countries but the UK. Finally, exports are also very import-intensive as shown by the purple bars in the figure: On average the import content of exports is 28%, with peaks of about 40% for small open economies such as Belgium or Portugal and some emerging countries (see Table 1 for a comparison across a larger set of countries). The country order of import content shares is mainly determined by two factors: availability of intermediate suppliers (country size) and position in the global production network. Japan and the United States, for instance, have relatively more domestic suppliers for their production network than most European countries, which rely on more foreign products for their production. This explains why the import contents of Japanese and U.S. exports are rather low although, in the case of Japan, rising over time.

Consistent with these findings, imports tend to be strongly correlated on average with exports and

[12] We are aware that for some countries, such as China and other EMEs, the amount of processing trade is relatively big, so that our numbers for the import content of exports are biased downwards. In this paper, however, we have chosen to not look at re-exports in line with other OECD publications (see, among others, OECD, 2011, pp. 178-79). Moreover, in our empirical analysis we focus on advanced economies (with the exception of Korea) for which the amount of re-exports is smaller, so that our results should not be significantly affected.

[13] We report the values for the 1995-2005 period in Table 1. For some countries, 1985 and 1990 values exist and are available upon request.

[14] The countries we focus on are Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, the UK, and the U.S.

investment and, to a lesser extent, with private consumption, while they appear to be uncorrelated with government consumption, as shown in Figure 4.

In this paper, we focus on imports, and we propose a new measure of aggregate demand that reflects the import intensity of the different components of domestic expenditure and the import content of exports. We call this import intensity-adjusted measure of demand IAD, for "import-adjusted demand", and construct it, country by country, as follows:

$$IAD_t = C_t^{\omega_{C,t}} G_t^{\omega_{G,t}} I_t^{\omega_{I,t}} X_t^{\omega_{X,t}},$$

where C stands for private consumption, G for government consumption, I for investment, and X for exports, included to take the import content of export demand into account.[15] In logarithms:

$$\ln IAD_t = \omega_{C,t} \ln C_t + \omega_{G,t} \ln G_t + \omega_{I,t} \ln I_t + \omega_{X,t} \ln X_t.$$

The weights, $\omega_{i,t}$, $i = C, G, I, X$, are the total import contents of final demand expenditures and are constructed as explained in section 3.1. They are time varying and normalized in each period such that their sum is equal to one.[16]

We shall show that IAD represents a better measure of aggregate demand than domestic demand or GDP to explain import fluctuations since it weighs each GDP component according to its import content. For instance, having neglected that investment and exports tend to have larger import content than private consumption and government consumption may explain why the impact of the fall in GDP on trade during the 2008-09 crisis was larger than suggested by commonly estimated elasticities. Two facts are also worth noticing: First, the relative import contents of the main components of GDP are substantially different from their shares in GDP (on average, private consumption represents 60% of GDP in our panel of countries, against 20% of government consumption and investment[17]). Second, different components of aggregate demand showed very different behaviors during the crisis. Indeed, investment and exports fell much more than private and government consumption in most countries. The fact that investment falls more sharply than other categories of expenditure during recessions is a robust stylized fact.[18]

[15] The highly volatile nature of changes in inventories prevented us from including them in IAD, mainly because of the impossibility to construct stable and meaningful import contents for such component of total expenditure. Moreover, changes in inventories represent on average a very small part of GDP (in the United States, for instance, they accounted for 0.3% of GDP on average in the last twenty years). We recognize, however, that changes in inventories may play a bigger role in some phases of the business cycle, in particular during recession episodes, and that their behavior may explain part of the fall in imports registered during the 2008-09 crisis (see, for instance, Alessandria, Kaboski, and Midrigan, 2010). To explore this hypothesis, in the empirical section we perform regressions where changes in inventories are added as a control variable to the basic specifications and we find that their inclusion improves, although marginally, the estimation.

[16] Since the I-O tables allow us to compute import contents for the different demand components only every five years, we linearly interpolate the available points to construct quarterly weights. For the period after 2005, we assume the same weight as in 2005. For some countries, the I-O tables do not provide data before 1995. In these cases, we use the same weight as in 1995 for the period before.

[17] Exports and imports also represent on average 20% of GDP in our panel of countries.

[18] It is consistent with the standard property of the business cycle for many countries that investment is more volatile

Figure 6 shows the typical path of demand components and trade variables during the two years after the start of a recession (defined as two consecutive quarters of negative real GDP growth) for our panel of 18 OECD countries and the G7.[19] Panels A and C show the average loss of each variable during all the recessions that occurred between 1985 and 2007, whereas panels B and D refer to the 2008-09 recession only. The figures also include the behavior of real GDP and our new measure of demand, IAD. As panel A shows, investment is the demand component that exhibits the largest fall during recession periods, dropping by 16% on average two years after the start of a recession. Trade variables also fall substantially in the first year and then gradually recover. Government consumption does not generally fall during recessions (possibly because it is used for counter-cyclical policy), while private consumption falls less than GDP on average. Our adjusted measure of demand falls by 8.3% on average after two years, 2.5 percentage points more than GDP, and its dynamics follow quite closely those of imports during recessions. Focusing on the 2008-09 recession, the first major difference is the scale of the vertical axis, which is almost doubled: Investment fell by more than 20% on average and did not exhibit any sign of recovery after two years. The second major difference is the size of the average fall of trade variables, which in the case of imports is more than twice the size observed during previous recessions and in the case of exports is higher by a factor of five. This last feature illustrates clearly the global nature of the 2008-09 recession: Exports on average fell modestly during previous recessions, partly because external demand was sustained by trading partners in a different phase of the cycle. In contrast, during 2008-09, 17 out of our 18 countries experienced a recession (the only exception being Australia), driving down external demand for each country in our sample. This global effect, together with the propagation/synchronization mechanism implied by increased vertical integration, could help explain why the fall in trade in 2008-09 was exceptionally high and synchronized. Finally, panel B shows that our measure of demand exhibits a drop of about 15% two years after the start of the crisis, reflecting significant export and investment losses, against a realized drop in GDP of "only" 7.5%. The story is rather similar in terms of behavior of different components of demand and differences in magnitude between past recessions and the 2008-09 one once looking at the G7 countries.

Having constructed our new aggregate demand measure and taken an initial look at its empirical properties, we next provide a theoretical foundation for its role in the determination of import demand and its inclusion in trade regressions of the form commonly employed in the literature.

than GDP, while consumption is smoother.

[19] To obtain the lines in Figure 6, we performed panel regressions for each of the variables, where the regressors are an indicator of recession start (equal to 1 in the first quarter of a recession), the lags of such indicator, and country-specific dummy variables. The methodology is similar to that of IMF (2010). The resulting line for each variable can be interpreted as its unconditional average cumulative loss during recession periods.

4 IAD Theory

The traditional theoretical underpinning of much empirical trade literature is the C.E.S. demand system. Under C.E.S. preferences, (log) import demand is determined by

$$\ln M_t = \ln D_t + \beta_P \ln P_{M,t}, \tag{2}$$

where D_t is aggregate demand (a C.E.S. aggregator of domestic and imported goods) and $P_{M,t}$ is the relative import price. In the standard framework, the basket M_t is itself a C.E.S. aggregate of individual imports. Equation (2) restricts the elasticity of imports to aggregate demand to be equal to 1, while β_P can take any negative value (estimates based on aggregate macro data typically put its absolute value at or near 1.5—although Corsetti, Dedola, and Leduc (2008) argue in favor of a value between 0 and 1—while estimates based on more disaggregated data usually find higher absolute values). The C.E.S. demand equation (2) is the foundation of regressions of the form:

$$\Delta \ln M_t = \delta + \beta_D \Delta \ln D_t + \beta_P \Delta \ln P_{M,t} + \varepsilon_t, \tag{3}$$

where Δ denotes first difference (on account of non-stationarity), δ is a constant, and ε_t is the error term. The Houthakker-Magee puzzle is the finding of Houthakker and Magee (1969) and many subsequent studies that the estimated elasticity of imports to aggregate demand, $\hat{\beta}_D$, is significantly above 1, which is especially puzzling in the case of estimated long-run elasticities.

Our goal in this section is to provide a theoretical foundation for a (log) import demand equation that is consistent with the regression equation (3), does not restrict the elasticity of imports to aggregate demand to be 1, and in which aggregate demand takes the form of our IAD aggregator—in levels, a Cobb-Douglas function with time-varying weights—of private consumption, government consumption, investment, and exports.

The theoretical foundation for the regression equation with IAD as the correct measure of aggregate demand and an unrestricted elasticity is a production possibilities frontier with imports understood to be inputs in total output determination and aggregated into a single variable. The construct follows Feenstra (2003a, Chapter 3) and a series of articles by Kohli (1978; 1990a,b; 1993), but we think of output as demand-driven on the way to thinking of imports as demand-driven.[20]

The total output (or GDP) function in Feenstra (2003a, Ch. 3) is usually written as a function of prices. Omitting time indexes to save on notation, let Y be the vector of outputs, P be the price vector of these outputs, M be imports, P_M be the price vector of imports, and F be the vector of primary factors of production.[21] Given a convex technology T (function of Y, M, and F), the efficient economy is assumed to determine outputs of individual goods and imports to maximize total output (GDP) subject to prices and the endowments of primary factors. Let GDP be described by

[20] We are grateful to James Anderson for suggestions that led to the development of this foundation.

[21] All prices are in real terms.

the function $v(\cdot)$ of P, P_M, and F defined as:

$$v(P, P_M, F) \equiv \max_{Y,M} PY - P_M M \mid Y \in T(Y, M, F).$$

In this setup, the demand for imports is given by the partial derivative $-v_{P_M}(P, P_M, F)$, while the supply of output is given by $v_P(P, P_M, F)$.

To think now of imports as demand-driven, we need to use the market clearing condition for output, $v_P(P, P_M, F) = D$, where D is the demand vector. Define the new GDP function $V(D, P_M, F)$ as function of the demand vector D, import prices P_M, and primary factors F as follows. Let

$$\tilde{v}(D, P_M, F) \equiv \min_{P} v(P, P_M, F) - PD.$$

The first-order condition for this problem is the market clearing condition for output, which can be solved for the market clearing price. Then we can write the GDP function as

$$V(D, P_M, F) \equiv \tilde{v}(D, P_M, F) + D\tilde{v}_D(D, P_M, F). \tag{4}$$

Import demand is therefore given by the partial derivative

$$M(D, P_M, F) = -V_{P_M}(D, P_M, F). \tag{5}$$

Given this result, we can obtain our desired import demand equation in two ways: One relies on assuming that the GDP function is approximated by a translog function, in the spirit of Kohli (1978; 1990a,b; 1993) and Feenstra (2003a, Ch. 3). The alternative consists of imposing the translog assumption directly on the import demand function in (5). We show the result for each of these approaches below.[22]

[22] The translog function has been shown to have appealing empirical properties in a variety of contexts in addition to the work reviewed in Feenstra (2003a, Ch. 3). For instance, Bergin and Feenstra (2000, 2001) show that a translog expenditure function makes it possible to generate empirically plausible endogenous persistence in macro and international macro models by virtue of the implied demand-side pricing complementarities. Feenstra (2003b) shows that the properties of the translog expenditure function used by Bergin and Feenstra (2000, 2001) hold also when the number of goods varies. Bilbiie, Ghironi, and Melitz (2007) find that translog preferences and endogenous producer entry result in markup dynamics that are remarkably close to U.S. data. Rodríguez-López (2011) extends the model of trade and macro dynamics with heterogeneous firms in Ghironi and Melitz (2005) to include nominal rigidity and a translog expenditure function. He obtains plausible properties for exchange rate pass-through, markup dynamics, and cyclical responses of firm-level and aggregate variables to shocks.

4.1 Translog GDP Function

Suppose that the GDP function $V(D, P_M, F)$ is described by the following translog function:[23]

$$\begin{aligned}
\ln V(D, P_M, F) &= \alpha + \sum_i \mu_i \ln D_i + \mu_P \ln P_M + \sum_f \mu_f \ln F_f \\
&+ \frac{1}{2}\sum_i \sum_j \lambda_{ij} \ln D_i \ln D_j + \frac{1}{2}\lambda_P^2 (\ln P_M)^2 + \frac{1}{2}\sum_f \sum_h \lambda_{fh} \ln F_f \ln F_h \\
&+ \sum_i \sum_f \phi_{if} \ln D_i \ln F_f + \ln P_M \sum_i \phi_i \ln D_i + \ln P_M \sum_f \phi_f \ln F_f. \qquad (6)
\end{aligned}$$

The translog function (6) implies that the share of imports M in GDP, s_M^V, is linear in the (log) components of aggregate demand:

$$\begin{aligned}
s_M^V &\equiv \frac{\partial \ln V(D, P_M, F)}{\partial \ln P_M} = \frac{P_M V_{P_M}(D, P_M, F)}{V(D, P_M, F)} = \frac{P_M(-M)}{V} \\
&= \mu_P + \lambda_P \ln P_M + \sum_i \phi_i \ln D_i + \sum_f \phi_f \ln F_f. \qquad (7)
\end{aligned}$$

Second-order terms in the translog GDP function are crucial for the import share to deviate from the Cobb-Douglas share μ_P. Note that, since imports are an input to GDP, the import share s_M^V is negative. In (7), we used the short-hand notation $-M \equiv V_{P_M}(D, P_M, F)$ and $V \equiv V(D, P_M, F)$.

Consider now the absolute value of the import share: $P_M M/V$. Differentiating this expression and defining percent deviations from steady state, we have:

$$\left(\hat{P}_M + \hat{M} - \hat{V}\right) \left|\bar{s}_M^V\right|,$$

where, for any variable Z, $\hat{Z} \equiv dZ/\bar{Z}$, d denotes the differentiation operator, and overbars denote levels along the steady-state path. Note that, for small enough perturbations, $\hat{Z} \equiv dZ/\bar{Z} \approx d\ln Z = \ln Z - \ln \bar{Z}$. It follows that:

$$\begin{aligned}
\left(\hat{P}_M + \hat{M} - \hat{V}\right) \left|\bar{s}_M^V\right| &\approx (d\ln P_M + d\ln M - d\ln V) \left|\bar{s}_M^V\right| \\
&\approx -\left(\lambda_P d\ln P_M + \sum_i \phi_i d\ln D_i + \sum_f \phi_f d\ln F_f\right),
\end{aligned}$$

where the second approximate equality follows from differentiating the expression of the import share in (7) after changing sign. Rearranging this equation yields:

$$d\ln M \approx (d\ln V - d\ln P_M) - \frac{1}{\left|\bar{s}_M^V\right|}\left(\lambda_P d\ln P_M + \sum_i \phi_i d\ln D_i + \sum_f \phi_f d\ln F_f\right). \qquad (8)$$

[23] See Feenstra (2003, Ch.3) for the parameter restrictions that are usually imposed on the translog GDP function (as function only of prices and factor endowments) to ensure homogeneity of degree 1 and symmetry. Some restrictions would be different for our transformed function. However, we do not rely on any of these restrictions below, so they can be safely ignored for our purposes.

Differentiating (6), we have:

$$\begin{aligned} d\ln V &= \sum_i \mu_i d\ln D_i + \mu_P d\ln P_M + \sum_f \mu_f d\ln F_f \\ &\quad + d\left[\begin{array}{c} \frac{1}{2}\sum_i\sum_j \lambda_{ij}\ln D_i \ln D_j + \frac{1}{2}\lambda_P^2 (\ln P_M)^2 + \frac{1}{2}\sum_f\sum_h \lambda_{fh}\ln F_f \ln F_h \\ +\sum_i\sum_f \phi_{if}\ln D_i \ln F_f + \ln P_M \sum_i \phi_i \ln D_i + \ln P_M \sum_f \phi_f \ln F_f \end{array}\right]. \end{aligned}$$

For simplicity, assume that all the second order terms in (6) are constant at their steady-state levels (or that their variation around the steady state path is negligible). Then,

$$d\ln V = \sum_i \mu_i d\ln D_i + \mu_P d\ln P_M + \sum_f \mu_f d\ln F_f,$$

and substituting this into (8) yields:

$$\begin{aligned} d\ln M &\approx \left(\sum_i \mu_i d\ln D_i + \mu_P d\ln P_M + \sum_f \mu_f d\ln F_f - d\ln P_M\right) \\ &\quad -\frac{1}{\left|\bar{s}_M^V\right|}\left(\lambda_P d\ln P_M + \sum_i \phi_i d\ln D_i + \sum_f \phi_f d\ln F_f\right) \\ &= \sum_i\left(\mu_i - \frac{1}{\left|\bar{s}_M^V\right|}\phi_i\right) d\ln D_i + \left(\mu_P - 1 - \frac{1}{\left|\bar{s}_M^G\right|}\lambda_P\right) d\ln P_M \\ &\quad + \sum_f\left(\mu_f - \frac{1}{\left|\bar{s}_M^G\right|}\phi_f\right) d\ln F_f. \end{aligned} \tag{9}$$

Introduce time indexes, allow for time variation in the coefficients on aggregate demand components, and define:

$$\begin{aligned} \beta_{i,t} &\equiv \mu_{i,t} - \frac{1}{\left|\bar{s}_M^G\right|}\phi_{i,t}, \\ \beta_P &\equiv \mu_P - 1 - \frac{1}{\left|\bar{s}_M^G\right|}\lambda_P, \\ \beta_f &\equiv \mu_f - \frac{1}{\left|\bar{s}_M^G\right|}\phi_f, \end{aligned}$$

where we impose the restrictions $\beta_{i,t} > 0$ and $\beta_P < 0$. Note that the first definition implicitly assumes that the share of imports in GDP is constant along the steady-state path. Using these definitions,

$$d\ln M_t \approx \sum_i \beta_{i,t} d\ln D_{i,t} + \beta_P d\ln P_{M,t} + \sum_f \beta_f d\ln F_{f,t}.$$

First-differencing this relation yields:

$$\Delta d\ln M_t \approx \sum_i \Delta\left(\beta_{i,t} d\ln D_{i,t}\right) + \beta_P \Delta d\ln P_{M,t} + \sum_f \beta_f \Delta d\ln F_{f,t}.$$

Assume that the effect of growth in the deviations of factor endowments from the steady-state path is also negligible: $\sum_f \beta_f \Delta d \ln F_{f,t} \approx 0$.[24] Then,

$$\Delta d \ln M_t \approx \sum_i \Delta \left(\beta_{i,t} d \ln D_{i,t}\right) + \beta_P \Delta d \ln P_{M,t},$$

or:

$$\Delta \ln M_t - \Delta \ln \bar{M}_t \approx \sum_i \Delta \left[\beta_{i,t} \left(\ln D_{i,t} - \ln \bar{D}_{i,t}\right)\right] + \beta_P \Delta \left(\ln P_{M,t} - \ln \bar{P}_{M,t}\right). \tag{10}$$

Assume that imports, aggregate demand, and import prices are growing at constant rates along the steady-state path. Then, $\Delta \ln \bar{M}_t - \sum_i \Delta \left(\beta_{i,t} \ln \bar{D}_{i,t}\right) + \beta_P \Delta \ln \bar{P}_{M,t}$ is a constant, which we denote δ, and we can rewrite equation (10) as:

$$\Delta \ln M_t \approx \delta + \sum_i \Delta \beta_{i,t} \ln D_{i,t} + \beta_P \Delta \ln P_{M,t}.$$

To a first order, we reduced import growth to an increasing function of aggregate demand growth and a decreasing function of growth in import prices.

Next, assume that $\beta_{i,t} = \beta_D \omega_{i,t}$. Then,

$$\Delta \ln M_t \approx \delta + \beta_D \sum_i \Delta(\omega_{i,t} \ln D_{i,t}) + \beta_P \Delta \ln P_{M,t}.$$

Finally, letting $i = C, G, I, X$; $D_C \equiv C$, $D_G \equiv G$, $D_I \equiv I$, $D_X \equiv X$, and recalling the definition $IAD_t \equiv C_t^{\omega_{C,t}} G_t^{\omega_{G,t}} I_t^{\omega_{I,t}} X_t^{\omega_{X,t}}$ returns:

$$\Delta \ln M_t \approx \delta + \beta_D \Delta \ln IAD_t + \beta_P \Delta \ln P_{M,t}. \tag{11}$$

This—or, more precisely, its stochastic version—is our benchmark regression equation of the same form as (3), with IAD as the correct measure of aggregate demand, and with unrestricted aggregate demand elasticity β_D.[25]

In principle, one could econometrically estimate the individual coefficients $\beta_{i,t}$ by estimating

$$\Delta \ln M_t = \delta + \sum_i \Delta(\beta_{i,t} \ln D_{i,t}) + \beta_P \Delta \ln P_{M,t} + \varepsilon_t,$$

where ε_t is the error term, at the cost of degrees of freedom. Our approach is to impose the coefficients $\omega_{i,t}$ from the input-output tables and use the constructed aggregate variable IAD_t in the stochastic version of (13), identifying the common constant coefficient β_D.

[24] Note that the import demand and regression equations based on C.E.S. demand also abstract from a direct effect of changes in factor endowments.

[25] As Feenstra (2003a, Ch. 3) notes, the approach we followed—treating exports and imports as an output and input, respectively, in the production process, and defining exports and imports independently from consumption—is sensible if exports are differentiated from domestic goods and imports are mainly intermediates. Both are empirically plausible assumptions, as our results confirm.

4.2 Translog Import Function

An alternative to the approach above would be to assume instead that the import function $M = -V_{P_M}(D, P_M, F)$ is directly described by the translog function:

$$\begin{aligned} \ln M &= \alpha + \sum_i \beta_i \ln D_i + \beta_P \ln P_M + \sum_f \beta_f \ln F_f \\ &+\frac{1}{2}\sum_i\sum_j \lambda_{ij} \ln D_i \ln D_j + \frac{1}{2}\lambda_P^2 (\ln P_M)^2 + \frac{1}{2}\sum_f\sum_h \lambda_{fh} \ln F_f \ln F_h \\ &+\sum_i\sum_f \phi_{if} \ln D_i \ln F_f + \ln P_M \sum_i \phi_i \ln D_i + \ln P_M \sum_f \phi_f \ln F_f, \end{aligned} \tag{12}$$

where $\beta_P < 0$.[26]

In this case, the IAD-based regression equation essentially follows from first-differencing (12) under the assumption that second-order terms and factor endowments are constant over time. Introducing time indexes and allowing for time variation in the coefficients β_i, this yields:

$$\Delta \ln M_t = \sum_i \Delta(\beta_{i,t} \ln D_{i,t}) + \beta_P \Delta \ln P_M.$$

Assuming next that $\beta_{i,t} = \beta_D \omega_{i,t}$ and proceeding as in the case of the translog GDP function, we obtain:

$$\Delta \ln M_t = \beta_D \Delta \ln IAD_t + \beta_P \Delta \ln P_{M,t}. \tag{13}$$

Except for the constant included in the regression and the error term, this is again our benchmark regression equation with IAD as the correct measure of aggregate demand in import determination.

The advantage of this approach to obtaining our regression equation is that it does not rely on the approximations used with the translog GDP function and, therefore, it is not restricted to small perturbations around the steady-state path (which certainly do not describe the 2008-09 collapse). On the other hand, the assumption of a translog GDP function is more conventional in the literature. Importantly, though, both approaches provide a justification for the same import demand and regression equation. As we shall show below, using IAD in this standard regression equation outperforms the traditional alternatives.

5 Empirical Analysis

The objective of this section is to test empirically the ability of our new measure of demand to explain the dynamics of import flows. There are two main motivations for turning to econometric models. First, we are interested in investigating whether the fall in world trade is still largely unexplained once the import intensity of aggregate demand components is taken into account (which would call for other factors as primary explanations of the GTC). Second, econometric estimations allow us

[26] We again omit parameter restrictions we do not rely on below.

to distinguish between short-term and long-term import dynamics, with an eye to addressing the broader Houthakker-Magee puzzle.

Results build on a dataset of the 18 OECD countries (all advanced with the exception of Korea), repeated here for the reader's convenience: Australia, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Netherlands, Norway, New Zealand, Portugal, Spain, Sweden, Switzerland, the UK, and the U.S. The data on imports and exports of goods and services, GDP, private and government consumption, investment[27], all in volume, and the series of import prices come from the OECD Economic Outlook database. The time series are at quarterly frequency, and the estimation is performed over the period 1985Q1-2010Q2. Relative import prices have been constructed by dividing the series of import prices of goods and services for each country by the respective GDP deflator.

5.1 Panel Estimation Results

We start by estimating a simple, standard model for imports. In the regression, motivated by theory, the quarterly growth of real imports for each country c, $\Delta \ln M_{c,t}$, is function of contemporaneous values of the quarterly growth of aggregate demand, $\Delta \ln D_{c,t}$, and the quarterly growth of relative import prices, $\Delta \ln P_{M,c,t}$, as well as country dummies δ_c:

$$\Delta \ln M_{c,t} = \delta_c + \beta_D \Delta \ln D_{c,t} + \beta_P \Delta \ln P_{M,c,t} + \varepsilon_{c,t} \quad (14)$$

In the analysis that follows, we compare three models: Two are standard models where either GDP or domestic demand, DD (computed as the sum of private and government consumption and investment), are used as measures of aggregate demand, D, and one is a model using our new import intensity-adjusted measure of demand, IAD. For robustness, we also consider an alternative specification for each model, where import growth is also function of its own lags and lags of the explanatory variables to allow for richer dynamics:[28]

$$\Delta \ln M_{c,t} = \delta_c + \sum_{l=0}^{L} \beta_{D,l} \Delta \ln D_{c,t-l} + \sum_{l=0}^{L} \beta_{P,l} \Delta \ln P_{M,c,t-l} + \sum_{l=1}^{L} \beta_{M,l} \Delta \ln M_{c,t-l} + \varepsilon_{c,t} \quad (15)$$

We estimate panel regressions of the type (14) and (15) using country-specific fixed effects and robust variance-covariance matrix estimates. Table 2 presents the in-sample results of the 6 specifications just described for the full set of 18 countries and the G7 (the U.S., the UK, Japan, Germany, France, Italy, and Canada) for the entire sample period. Estimation results show that the model using IAD is noticeably superior in terms of fit to the other two, and this applies both to the full

[27] We use time series on gross fixed capital formation (GFCF) to proxy investment in the empirical exercise. This is consistent with the fact that, to construct IAD, we use the import content of GFCF computed from the I-O tables. Although aware of the not exact correspondence between the two concepts, in the rest of the paper we will use the term investment instead of GFCF.

[28] We considered $L = 1$ in our preferred specification.

set of countries and the sub-set of G7 countries. Including lags of the dependent and independent variables improves the fit of the models only marginally and does not reveal substantial changes in the elasticity point estimates, especially for the model using IAD as demand variable. The ranking of the three models also remains unchanged.[29]

Figure 7 shows the actual and fitted values of real import growth for a subsample of countries (the U.S., the UK, Japan, Germany, France, Italy, Canada and Spain[30]), where the fitted values are obtained by estimating the panel regression (14) using respectively IAD, GDP, and DD as demand variables. When looking at Figure 7, it is also evident that the IAD model performs better than the GDP model especially in periods of large falls in imports, such as the Great Trade Collapse of 2008-09.

Figures 8 illustrates exactly how much of the fall in imports observed during 2008Q4 and 2009Q1 the three models are able to account for on average and for each individual country (panel A and B refer to the panel regression for all 18 countries, whereas panel C and D to the same regression performed for the G7 only): The last blue bar in each chart, called total, shows the actual fall in aggregate imports in our 18 countries[31] together with the predicted aggregate fall using IAD (black bars), GDP (red bars) and DD (green bars), respectively. In particular, the weighted average of real imports in our sample of countries fell by 5.6% in 2008Q4 and 9.3% in 2009Q1, on a quarterly basis. The model using IAD as explanatory variable captures 67% and 63% of the fall in aggregate imports in 2008Q4 and 2009Q1, respectively, while only 41% and 29% is explained by the GDP model specification. Results for the G7 are even more striking, on average the model using IAD explains 94% and 85% of the average fall in imports in the G7 against 61% and 51% in the GDP is used. In panel C and D an additional bar is included for each country, corresponding to the predictions of the IAD specification controlling also for the component 'changes in inventories'.[32] As shown by the yellow bars, including the changes in inventories helps improving the fit of the model; On average, the model using IAD and controlling for changes in inventories explains 99% and 93% of the average fall in imports in the G7 in 2008Q4 and 2009Q1, respectively.

Since the model using IAD performs well in explaining the 2008-09 Great Trade Collapse, it is important to understand whether the superiority of this model against standard specifications, as shown in Table 2, comes from a better fit only during recession periods, when highly import-

[29] Notice that, in all specifications, we add two dummy variables to capture two episodes of erratic movements in trade in the UK in 2006Q1 and 2006Q3. Concerning these quarters the ONS said: "Erratic and large movements in the level of trade associated with VAT Missing Trader Intra Community (MTIC) fraud have made it especially difficult to interpret movements in imports and exports of goods". The inclusion of such dummies does not change however the essence of the results.

[30] We do not report the results for the other countries to save space, but they are available upon request.

[31] To construct the aggregate values of import growth, we used the respective average import shares of the countries between 2000 and 2009.

[32] In particular, we estimate equation (15) using IAD as demand variable and adding as a control variable the changes in inventories as a percentage of nominal GDP. For this exercise we used the time series of 'change in stocks' and GDP at current prices from the OECD Main Economic Indicator Database. The lack of long span of data for some countries in our sample makes not possible to perform the same exercise for the entire panel of 18 countries.

intensive demand components tend to fall on average more than the components that are relatively less import-intensive (as already shown in Figure 6), or survives also in "normal" times. This is a relevant question, since only in the second case we would be able to conclude that our new measure of demand is in fact superior to standard measures and should be preferred in empirical work aimed at estimating trade elasticities. Table 3 shows the result of the model (14) estimated separately for "normal" and "recession" periods for the full set of countries and the G7.[33] Several results are worth noticing. First, all models do better at estimating real import growth during recession times, i.e., in periods when the fall in demand is particularly crucial to explain the behavior of trade variables. Second, the model using IAD outperforms the others during all times in terms of goodness of fit, hence suggesting that the results in Table 2 are not driven only by extreme events, but they apply over the entire estimation period. Third, the short-term demand elasticity of imports generally varies between recession and non-recession periods, being higher in recessions. However, while the elasticity of demand estimated from the GDP specification is four times bigger in recession times, both for the entire set of countries and the G7, the increase in elasticity from the IAD specification is much lower, roughly one and a half times higher. The model using DD lies somehow in between the other two, showing elasticities of imports to demand that double during recessions. These findings corroborate our idea that using GDP as demand measure in trade equations may be misleading as it may deliver highly volatile estimates of demand elasticities that may suggest the presence of structural breaks even when this is not the case. Our new measure of demand, instead, by taking into account the different import content of demand components, delivers elasticities that are lower in magnitude and more stable across the cycle. As a corollary, the IAD specification also provides higher and more significant estimates for import price elasticities, which is a promising result as few papers find a large and significant role for relative prices in trade equations.

5.2 Estimating Trade Elasticities: Towards a Solution to the Houthakker-Magee Puzzle

A large body of literature in international economics focuses on the estimation of trade elasticities, given its relevance in trade-related policy debates. The estimation of price and income elasticities is indeed crucial to assess, for instance, which factors would play a decisive role in the process of global trade rebalancing, as well as to gauge the effects of exchange rate and relative demand movements on trade flows. The study of income trade elasticities is linked to the so-called "elasticity puzzle," or Houthakker-Magee (1969) puzzle, i.e., the well-known empirical result for the U.S. (but also for other countries) that finds that the demand elasticity is significantly higher on the import side (where it is commonly estimated to be above one) than on the export side (where it is generally equal to one).[34]

[33] As in the previous section, recessions are defined as two consecutive quarters of negative real GDP growth.

[34] This represents a puzzle because it implies that, to prevent the trade balance from permanently moving into deficit, the exchange rate should permanently depreciate (this is also under the condition that foreign and domestic output grow at similar rates). Another puzzling implication of having a demand elasticity above one is that output should be

In this paper, we focus on the estimation of import demand elasticities. A comparison of our results with other empirical work on trade elasticities is difficult since existing papers model differently import equations, featuring different measures for domestic demand and relative prices. In this section, we compare short-term and long-term income trade elasticities of imports from our model using IAD and the traditional GDP specification. For what concerns short-term import elasticities of demand, we compare the estimates of the demand coefficient β_1 in panel equation (14) (as already shown in Table 2), and we estimate the same equation also for the G7 countries individually. Long-term import elasticities for individual G7 countries are obtained by estimating a vector error correction model (VECM) featuring real imports, a measure of real demand, and relative import prices for each country, and taking the cointegration coefficient of demand as a measure of long-run income elasticity. This approach is rather traditional in the empirical literature aimed at estimating trade elasticities, hence making the comparison with previous work on this subject easier. To estimate the panel long-term income elasticity of imports, we follow the methodology in Mann and Plück (2005), which consists in estimating equation (14) also adding the variables in level, to obtain a specification that is similar to the error correction model that we use for the individual country analysis. In practice, we estimate the following panel equation:

$$\Delta \ln M_{c,t} = \delta_c + \beta_D \Delta \ln D_{c,t} + \beta_P \Delta \ln P_{M,c,t} + \beta_{\ell M} \ln M_{c,t-1} + \beta_{\ell D} \ln D_{c,t-1} + \beta_{\ell P} \ln P_{c,t-1} + \varepsilon_{c,t}$$

where the panel long-run income elasticity of imports is given by $\frac{\beta_{\ell D}}{\beta_{\ell M}}$.

We also use a second methodology to compute long-term import elasticities of demand, consisting in estimating equation (14) with the variables in levels instead of first differences, which can be interpreted as the first stage of the two-step cointegration procedure of Engle and Granger (1987). Although we will base our discussion on the first methodology, we report results from this second approach as a robustness check.

Table 4 shows the estimated values of short-term and long-term import demand elasticities for the full set of countries and individual G7 countries over the entire sample period. Results from the panel regressions show a reduction in estimated demand elasticities, both short-term and long-term, when IAD is used. In particular, short-run elasticity estimates are close to unity (1.18 for the entire set of countries and between 0.84 and 1.56 for the individual G7 economies), implying an almost proportional relation between demand and imports at high frequency. Estimates of long-term elasticities are slightly bigger (1.32 for the entire panel) but still lower than the panel demand elasticities of imports to GDP, which is equal to 1.66. Similar results hold for individual G7 countries; Overall, both short-run and long-run elasticity estimates are significantly reduced when our new import intensity-adjusted measure of demand is used instead of GDP. Our results for the U.S. and

completely imported in the long run, barring a permanent depreciating trend.

other G7 countries from the model using GDP are comparable with existing literature, i.e., we find large values of long-term demand elasticities, in the ballpark of 2 for most countries, under both estimation methodologies.[35] The results from the model using IAD are encouraging: Long-term import demand elasticities are lower for all countries, and of the same order of magnitude as export income elasticities found in the literature (see, for instance, Hooper, Johnson, and Marquez, 2000, and Crane, Crowley, and Quayyum, 2007), such that the asymmetry at the heart of the Houthakker-Magee puzzle is substantially reduced. Although a direct comparison with other models is not possible, our results using IAD as demand variable go in the same direction of other papers that found lower long-term income elasticities of imports once import equations are corrected for other factors, such as vertical integration or aggregation bias. Cardarelli and Rebucci (IMF, 2007), for instance, find that once exports of intermediate products are added in the U.S. import equation to account for vertical integration, the resulting income elasticity drops significantly and becomes lower than one. A similar result holds in Bussière, Chudik, and Sestieri (2009) in the context of a global VAR where exports enter in the import cointegration relation. Our approach is in principle more complete, as we do not correct only for vertical integration, but also for the import content of different demand components that is not taken into account when using aggregate demand. Moreover, this approach has the advantage of using a single statistic, our import intensity-adjusted measure of demand, delivering a single demand coefficient of easier interpretation.

6 Conclusion

This paper proposed a new methodology for the estimation of trade elasticities, based on an import intensity-adjusted measure of aggregate demand. Whereas standard empirical trade models typically use an aggregate measure of demand such as GDP, we argue that there is value added in giving different weights to the components of GDP, which typically have very different import intensities. In particular, the analysis of the new OECD input-output tables shows that investment is significantly more import intensive than private consumption, which in turn is more import intensive than government spending. In addition, we also find that exports are very import intensive, which contributes to explaining the synchronicity of the trade collapse across countries.

Carefully disentangling the effects of investment, private and government consumption, and exports turns out to improve the goodness of fit of the model significantly, and is especially important in the context of the 2008-09 crisis, during which these different components of aggregate demand evolved very differently. In particular, investment decreased significantly over this period, whereas government spending remained robust, supported largely by the fiscal packages put in place by gov-

[35] Cardarelli and Rebucci (IMF, 2007), for instance, estimate an OLS import equation in levels for the U.S. and obtain a value of long-term demand elasticity of 1.86 using annual data from 1986 to 2006 and 2.03 for the period 1973-2006. Crane, Crowley, and Quayyum (2007) perform VECM estimation for imports for the G7 and find estimates of the cointegration coefficients of demand similar to ours for most countries. For the U.S., they find a value of the long-term import demand elasticity of 1.93 over the period 1960-2006.

ernments in response to the crisis. To the extent that investment (and, to a lesser extent, private consumption) is more import intensive than government spending, this may explain why standard models typically underestimate the fall in trade that took place in 2008-09. We reported key stylized facts on these developments, put also in historical perspective, and provided formal theoretical and econometric evidence in favor of our novel measure of demand.

Importantly, using the import intensity-weighted measure of demand proposed in this paper can significantly enhance the performance of empirical trade models, helping resolve long standing questions in international economics. The results presented here also have substantial policy implications, related to the likely path of the recovery and the appropriate policy response to the collapse in world trade. For instance, an investment-led recovery could be expected to lift world trade more significantly than a government spending-led recovery due to the much higher import content of investment.

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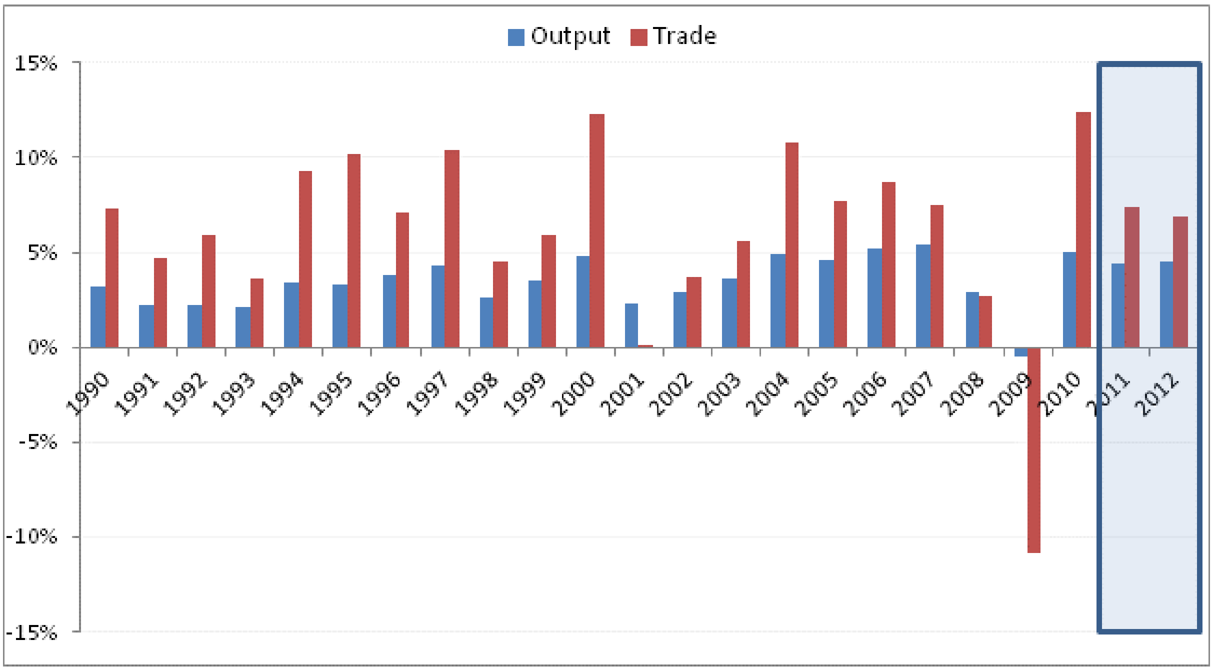
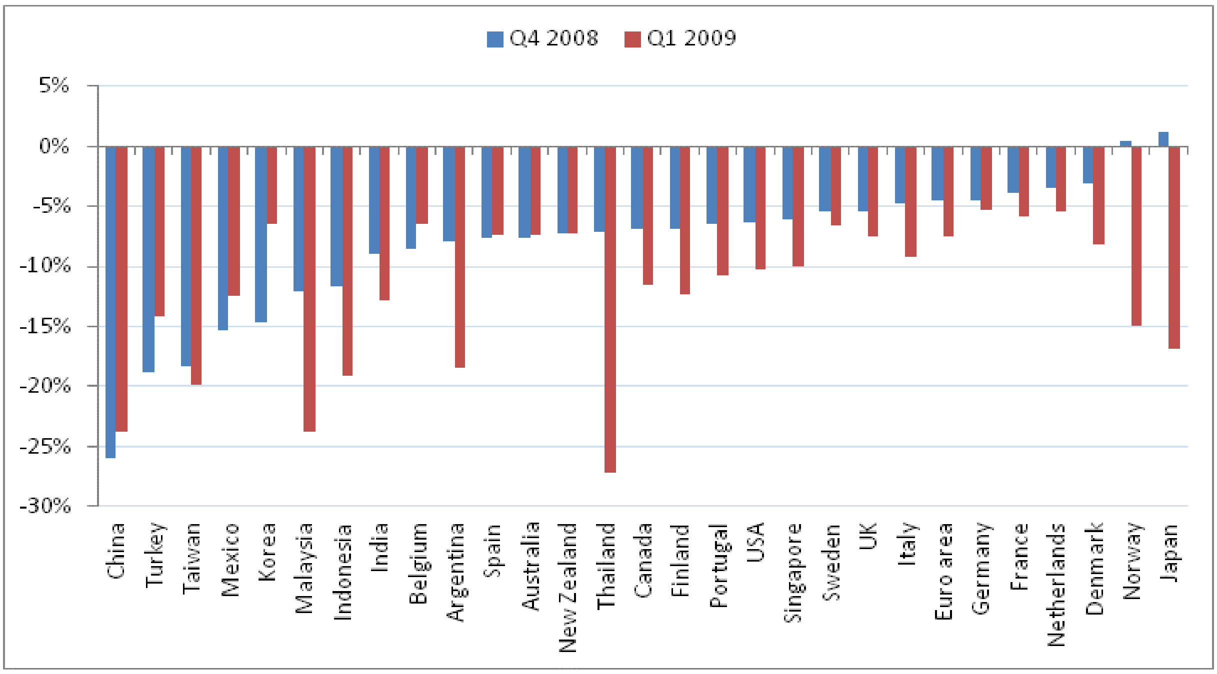
Figure 1: Recent developments and projections in world trade and output (volumes)



Source: IMF World Economic Outlook April 2011.

Figure 2: Growth rate of real imports in 2008Q4 and 2009Q1, q-o-q growth rates



Source: OECD Economic Outlook.

Figure 3: OECD Input-Output tables of total, domestic and import transactions

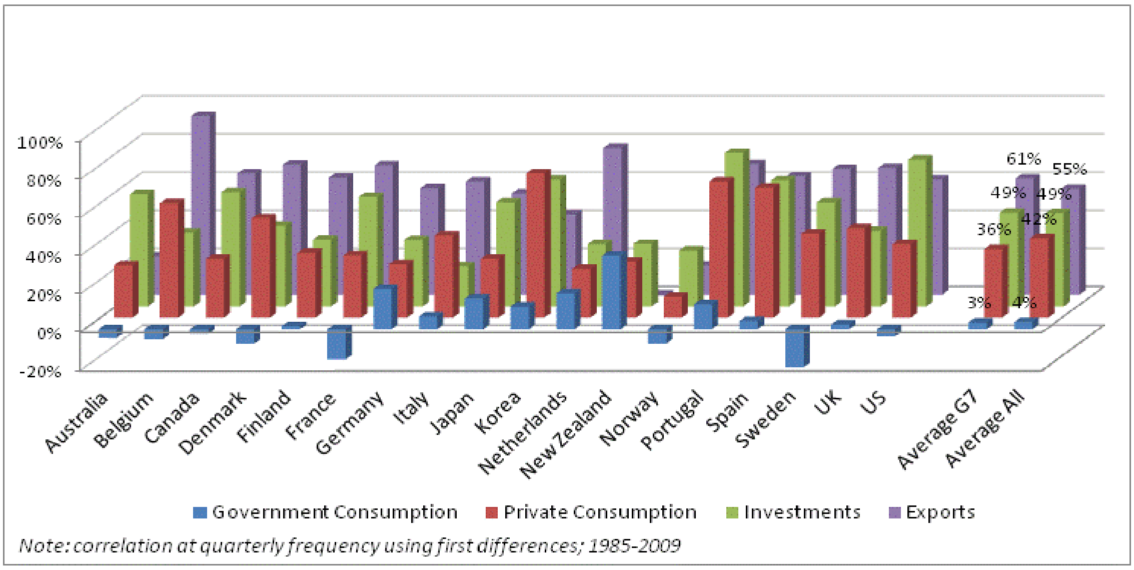
Total	Intermediate		Final demand				
	Ind 1	Ind 2	PC	GC	GFCF	Exports	Imports
Ind 1							
Ind 2							
VA							
Output							

Domestic	Intermediate		Final demand				
	Ind 1	Ind 2	PC	GC	GFCF	Exports	Imports
Ind 1	Zd		Fd				
Ind 2							
Imports							
VA							
Output							

Import	Intermediate		Final demand				
	Ind 1	Ind 2	PC	GC	GFCF	Exports	Imports
Ind 1	Zm		Fm				
Ind 2							

PC : Private consumption by households, GC: Government consumption,
GFCF: Gross fixed capital formation, VA: value added

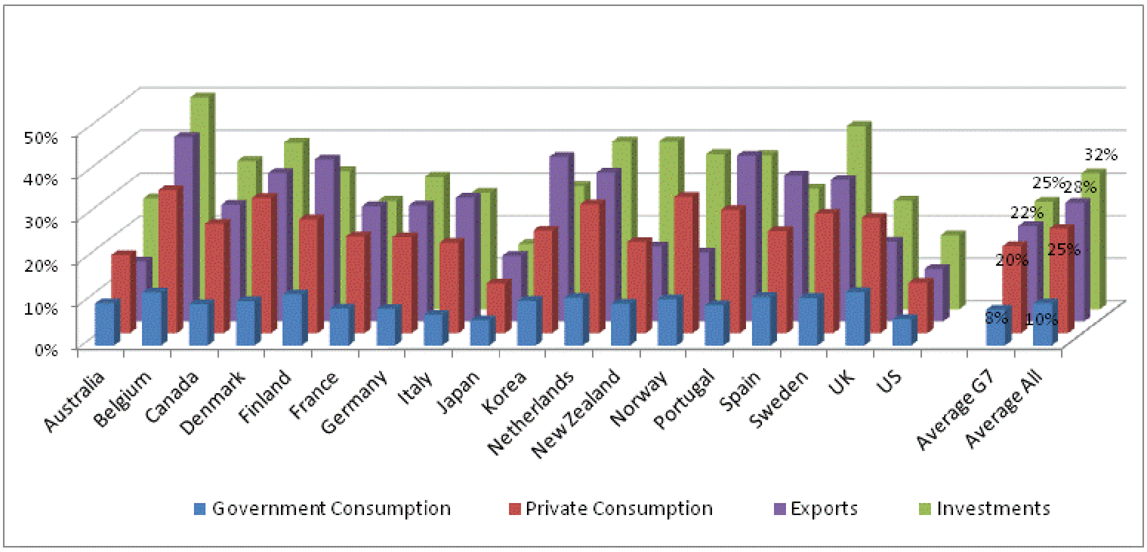
Figure 4: Short-term correlations between imports and main GDP components



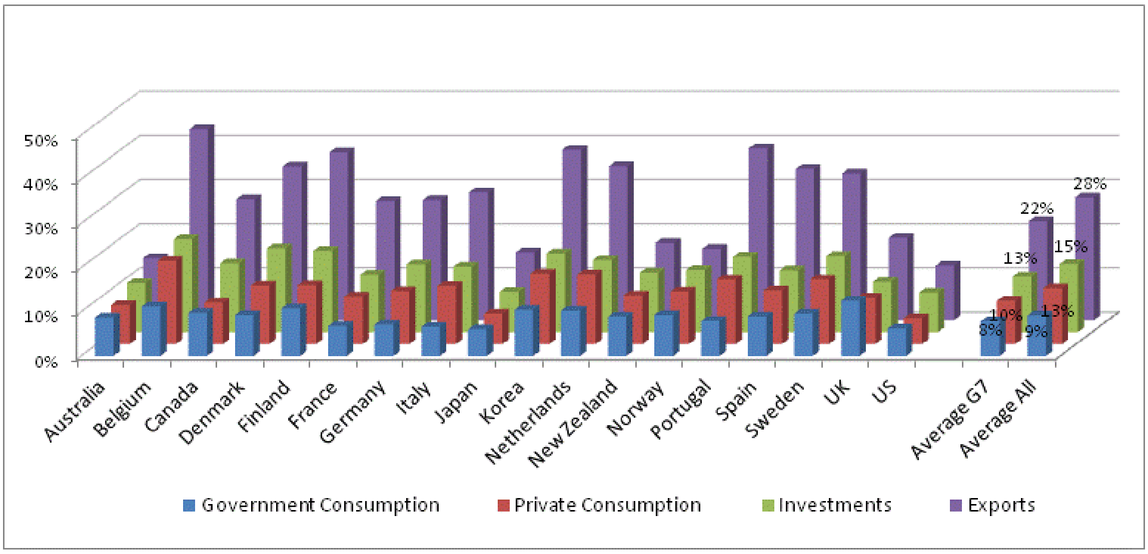
Source: OECD and authors' calculations.

Figure 5: Import contents of main GDP components

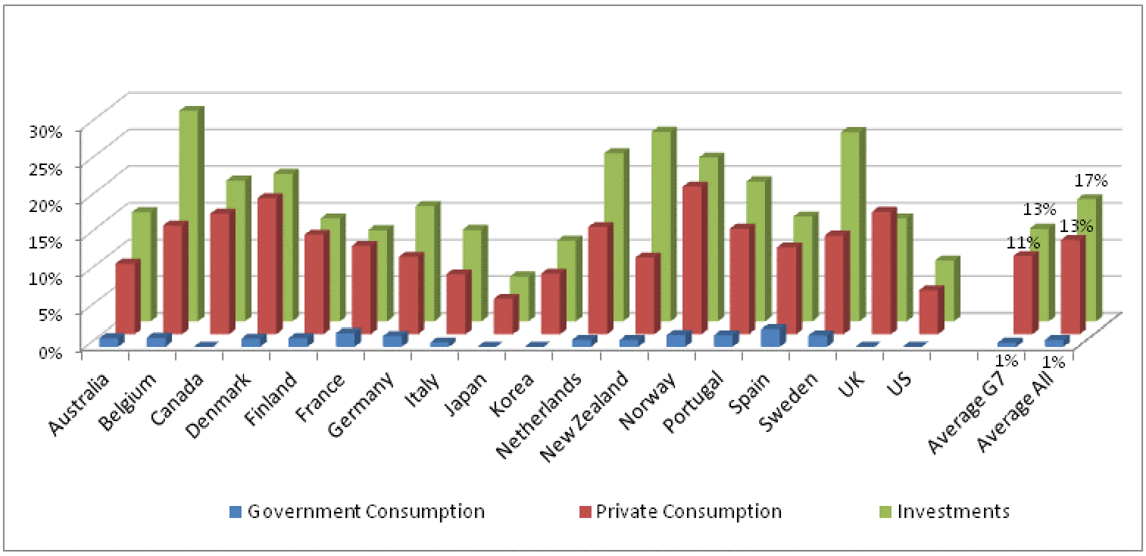
Panel A : Total import contents



Panel B : Induced import contents



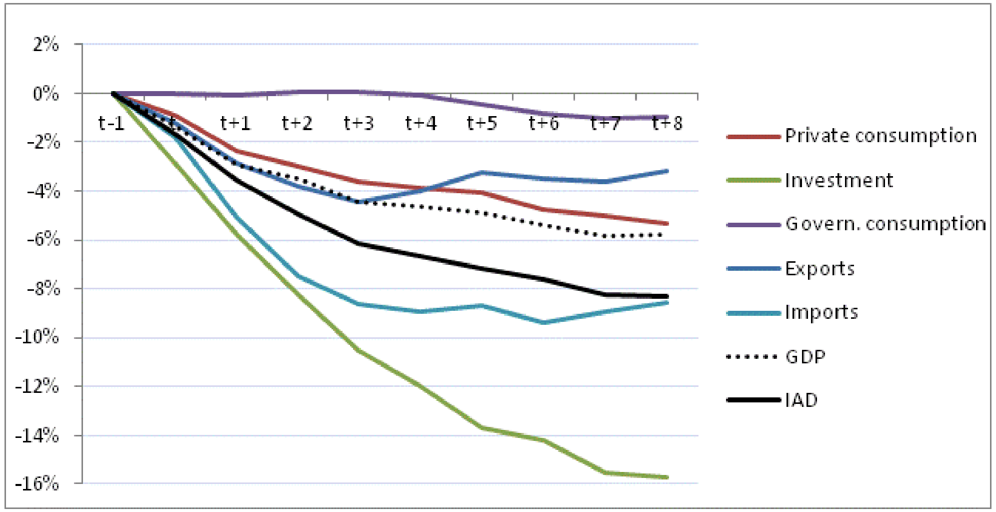
Panel C : Direct import contents



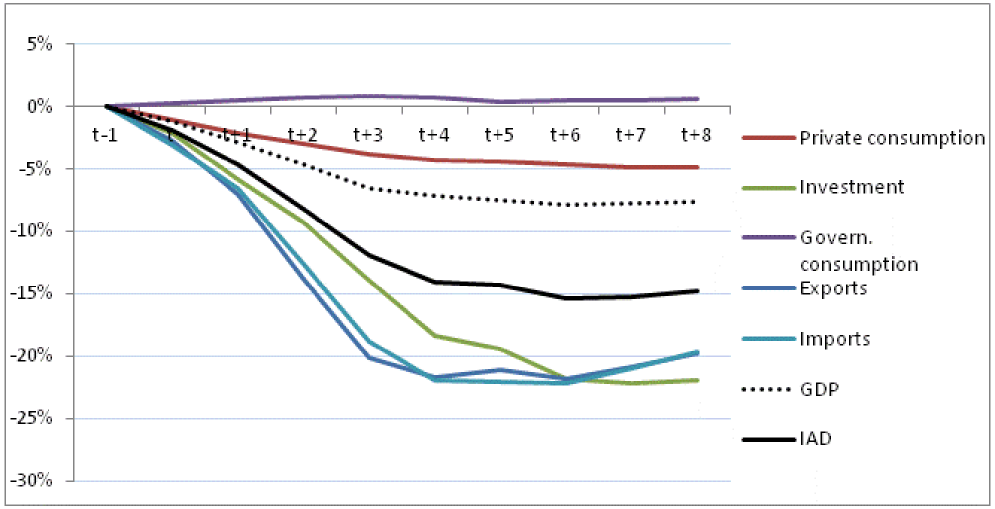
Source: OECD Input-Output Tables and authors' calculations.

Figure 6: Average behaviour of GDP components during recessions (real variables, cumulated fall)

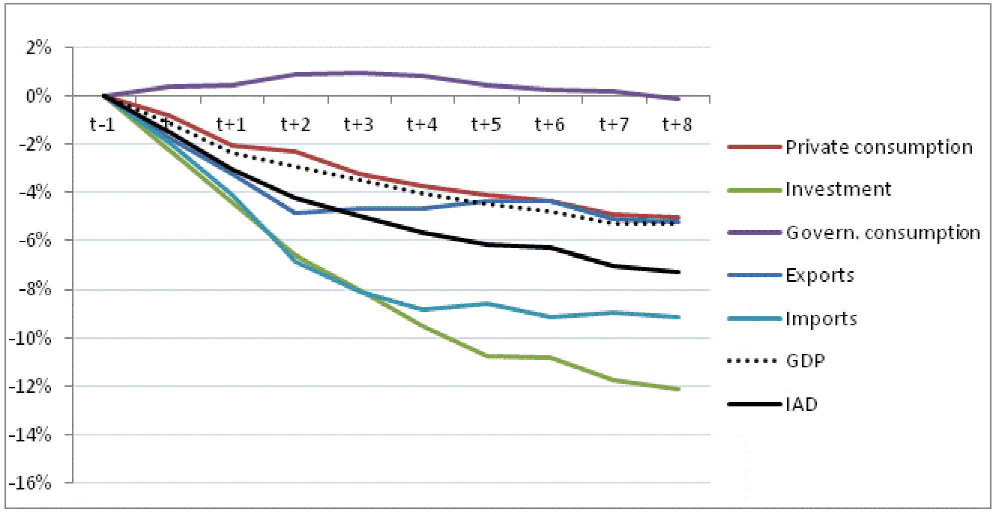
Panel A: All countries - 1985-2007 recessions



Panel B: All countries - 2008-2009 recessions



Panel C: G7 - 1985-2007 recessions



Panel D: G7 - 2008-2009 recessions

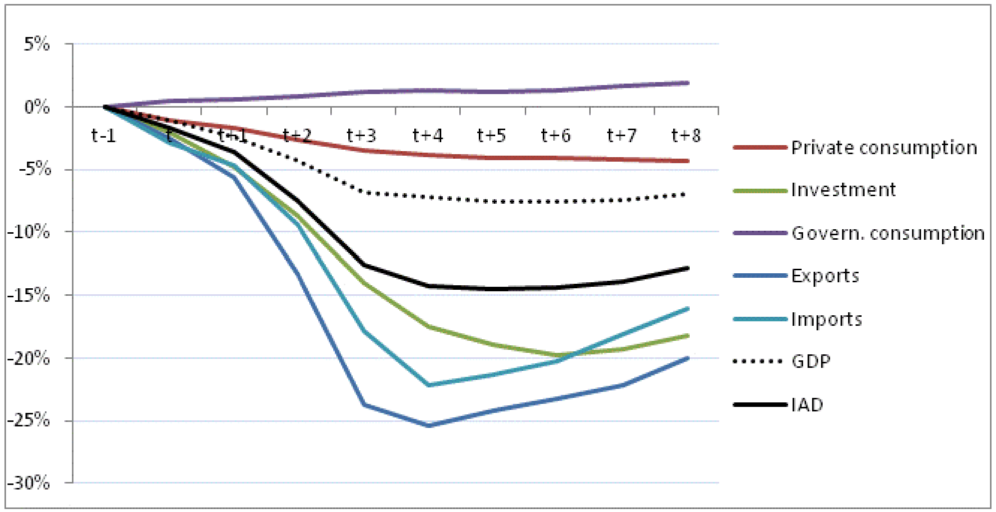
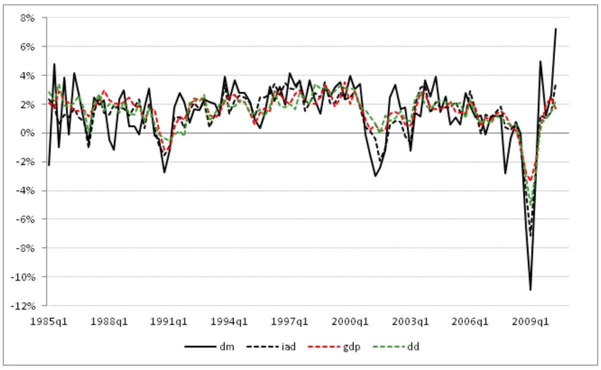


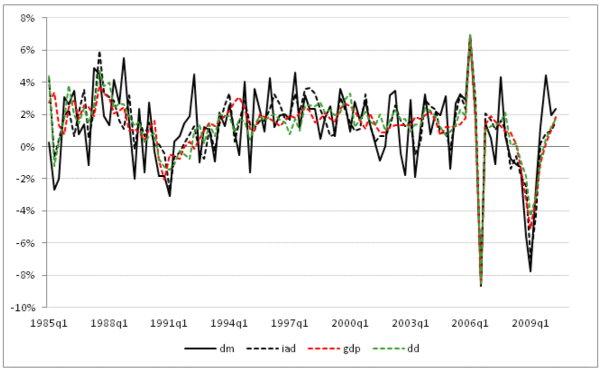
Figure 7: Actual vs. fitted values of real import growth - Selected economies

The charts below show the actual (solid line) vs. fitted values of real import growth for a subsample of countries. The dotted black line shows fitted values from the model using IAD as a measure of demand, the dotted red line from the GDP specification and the dotted green line from the domestic demand specification, DD.

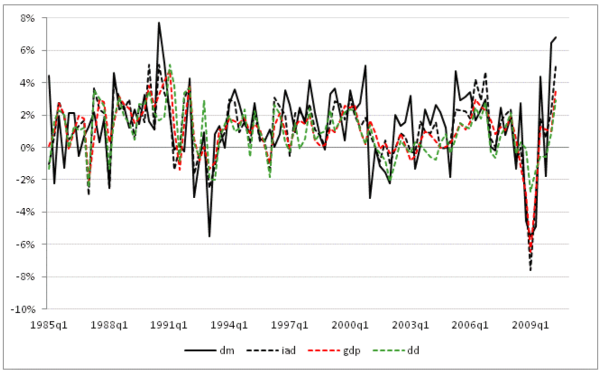
United States



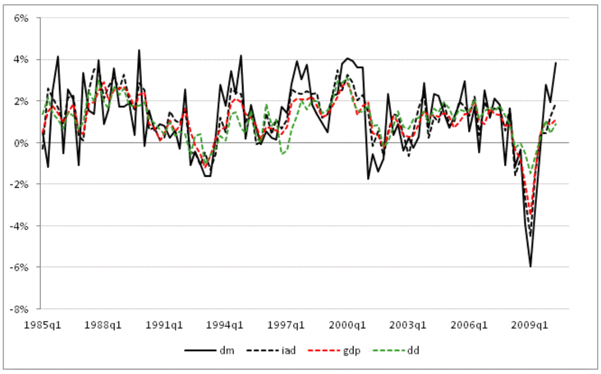
United Kingdom



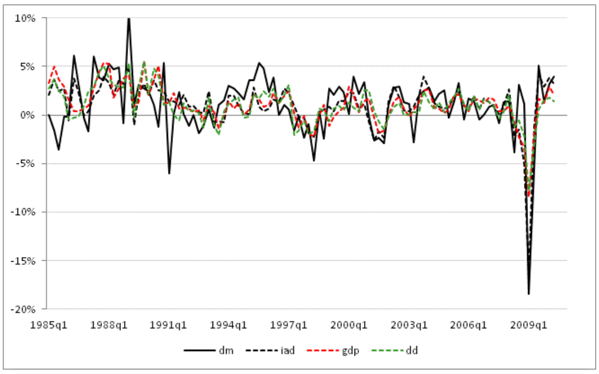
Germany



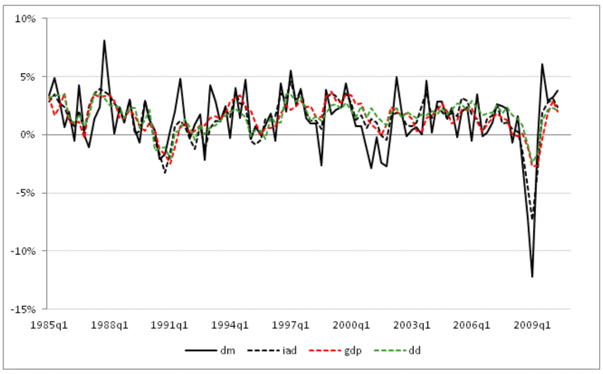
France



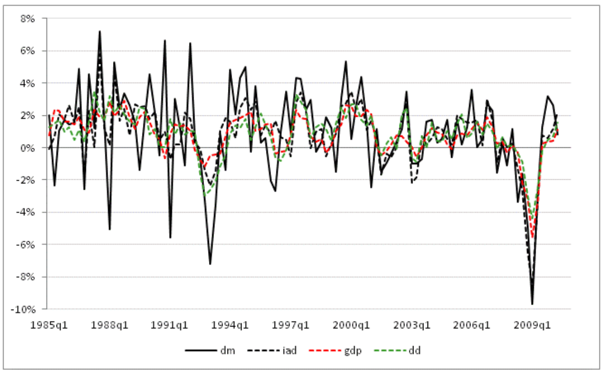
Japan



Canada



Italy



Spain

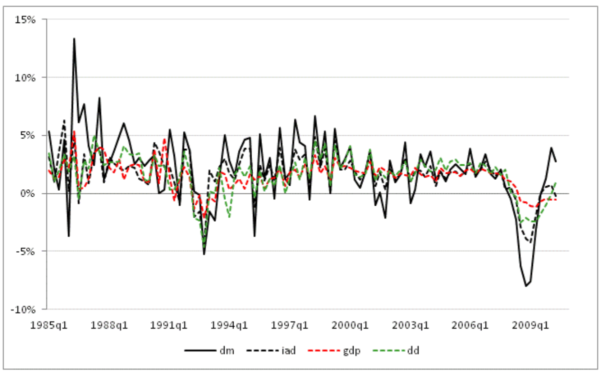
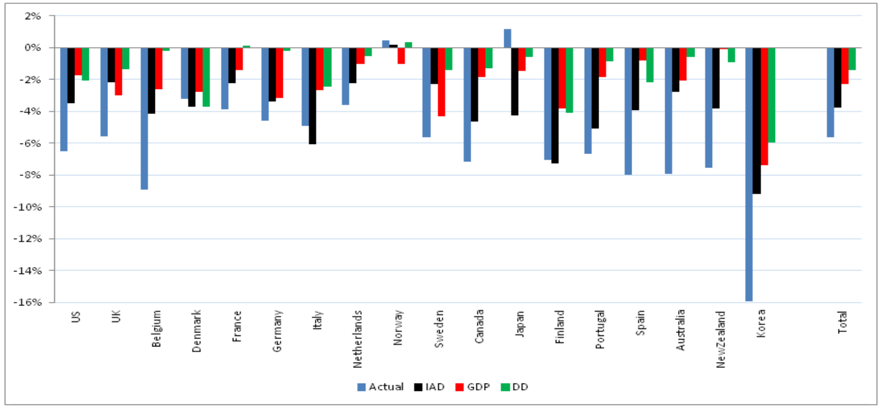


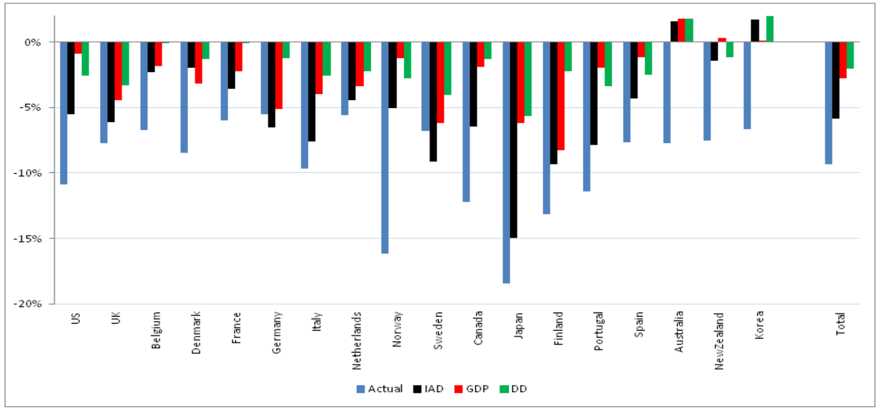
Figure 8: Actual vs. fitted values of real import growth during the GTC

The charts below show the actual vs. fitted values of real import growth during the Grate Trade Collapse from different models. Panel A and B present results for 2008Q4 and 2009Q1, respectively, from our three competing models estimated for the full set of countries from 1985Q1 to 2010Q2. Fitted values from the model using IAD as a measure of demand are given by the black bars, fitted values from the GDP specification by the red bars, while results from the domestic demand specification, DD,are given by the green bars. Panel C and D present the same results from the same models estimated only for the G7 countries. The orange bars in panel C and D represent fitted values from the IAD specification where the GDP component 'changes in inventories' (expressed as a percent of GDP) is also added as explanatory variable.

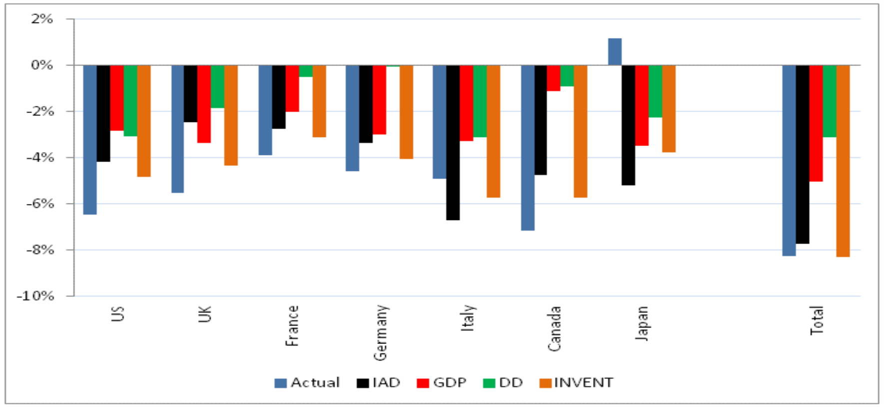
Panel A: All countries - 2008Q4



Panel B: All countries - 2009Q1



Panel C: G7 - 2008Q4



Panel D: G7 - 2009Q1

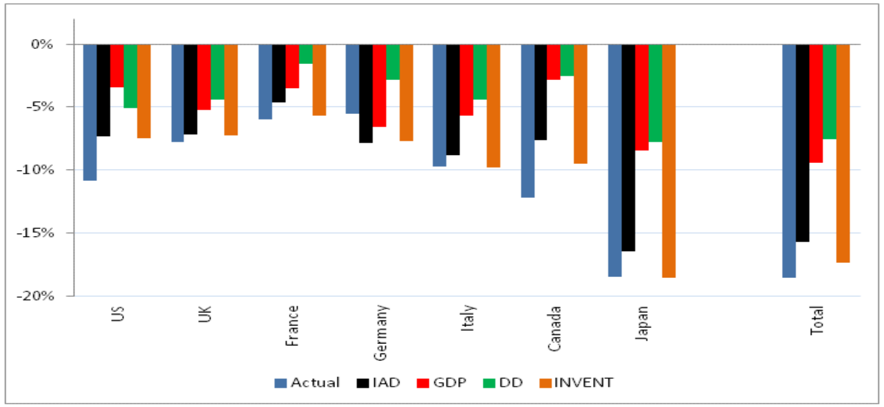


Table 1.a: Total import content of main GDP components

	Import content of private consumption			Import content of government consumption			Import content of total investment			Import content of exports .		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Australia	17,0%	18,6%	18,4%	9,0%	10,0%	9,9%	26,5%	26,6%	26,0%	14,0%	14,1%	14,0%
Austria	24,2%	28,4%	28,7%	9,3%	11,0%	11,5%	36,7%	42,3%	42,7%	30,0%	34,6%	34,7%
Belgium	32,3%	36,5%	33,6%	7,7%	10,6%	12,4%	43,6%	52,6%	49,7%	40,9%	45,9%	43,2%
Canada	25,9%	23,7%	25,8%	10,3%	10,0%	9,8%	39,0%	42,1%	34,8%	30,5%	30,9%	27,4%
Czech Republic	34,0%	39,5%	38,6%	18,8%	20,3%	19,8%	39,2%	53,3%	52,1%	29,1%	45,6%	48,3%
Denmark	21,4%	30,3%	31,8%	7,1%	8,9%	10,4%	34,3%	40,3%	39,1%	27,1%	32,3%	34,9%
Finland	20,6%	22,9%	26,8%	7,9%	10,8%	12,0%	42,4%	34,5%	32,4%	28,8%	33,4%	38,0%
France	19,4%	22,0%	22,7%	8,2%	8,0%	8,7%	24,7%	27,2%	25,4%	19,8%	26,5%	27,0%
Germany	18,3%	22,1%	22,6%	6,3%	8,0%	8,6%	22,7%	30,5%	31,1%	20,4%	25,8%	27,2%
Greece	21,0%	24,4%	24,1%	11,6%	19,4%	9,9%	35,0%	36,5%	35,5%	15,8%	26,9%	25,9%
Hungary	47,1%	35,4%	35,6%	29,2%	16,5%	15,4%	60,0%	53,6%	49,1%	47,4%	58,6%	55,8%
Iceland	30,7%	16,9%	14,8%	17,4%	6,2%	5,5%	41,7%	24,1%	24,4%	26,7%	26,9%	27,1%
Ireland	46,3%	42,0%	37,2%	16,4%	13,8%	14,4%	51,5%	48,6%	41,5%	48,7%	53,3%	50,7%
Italy	18,2%	20,7%	21,3%	5,7%	6,7%	7,2%	25,7%	29,6%	27,3%	23,4%	27,1%	29,0%
Japan	9,1%	9,8%	11,7%	3,0%	2,8%	6,0%	8,2%	10,6%	15,3%	8,4%	9,6%	15,4%
Korea	21,4%	23,8%	24,2%	11,4%	10,2%	10,5%	30,8%	35,5%	28,9%	29,9%	38,1%	38,6%
Luxembourg	45,5%	51,8%	50,3%	15,7%	18,1%	18,4%	49,9%	54,7%	53,6%	41,3%	57,7%	60,4%
Mexico	31,4%	18,6%	17,2%	8,3%	5,0%	4,7%	42,6%	32,0%	30,2%	42,5%	39,3%	33,2%
Netherlands	26,2%	28,5%	30,3%	10,4%	11,2%	11,3%	41,6%	41,6%	39,3%	33,3%	36,9%	34,9%
New Zealand	21,1%	23,8%	21,4%	10,1%	11,6%	9,8%	37,9%	41,2%	39,3%	18,1%	19,2%	17,5%
Norway	29,1%	31,8%	32,0%	11,1%	10,9%	10,9%	42,1%	42,0%	36,4%	21,6%	16,9%	16,2%
Poland	19,7%	26,3%	24,9%	8,0%	6,4%	9,5%	30,0%	45,8%	47,9%	16,8%	24,7%	30,6%
Portugal	27,5%	32,5%	29,0%	8,7%	10,9%	9,5%	35,3%	38,3%	36,1%	35,8%	30,8%	38,9%
Slovak Republic	38,2%	43,1%	44,7%	17,7%	16,3%	21,6%	53,6%	52,2%	57,3%	35,4%	50,3%	48,6%
Spain	18,1%	23,1%	24,0%	7,3%	9,9%	11,3%	26,1%	34,6%	28,3%	26,6%	33,9%	34,2%
Sweden	23,2%	26,4%	28,1%	10,5%	11,3%	11,2%	43,7%	47,8%	43,0%	28,9%	32,3%	33,2%
Switzerland	16,3%	22,5%	24,4%	5,8%	9,2%	9,3%	26,6%	33,1%	33,9%	14,2%	23,1%	25,3%
Turkey	18,1%	15,8%	23,0%	6,0%	10,3%	14,6%	36,8%	33,7%	41,7%	13,9%	13,6%	30,7%
United Kingdom	21,1%	24,9%	27,2%	11,2%	12,7%	12,5%	37,4%	35,0%	25,4%	22,2%	20,3%	18,6%
United States	8,7%	10,5%	11,9%	3,7%	6,0%	6,2%	18,4%	19,1%	17,3%	9,5%	11,0%	12,3%
Argentina	8,2%	7,9%	12,4%	2,2%	1,8%	2,8%	22,6%	22,6%	27,1%	10,3%	10,9%	16,8%
Brazil	9,6%	12,2%	10,4%	3,3%	4,8%	3,7%	13,1%	14,6%	20,9%	10,8%	12,0%	14,4%
China	11,4%	13,4%	19,1%	9,9%	10,8%	13,8%	26,2%	20,8%	28,8%	15,5%	19,6%	27,4%
Chinese Taipei	24,4%	22,9%	26,3%	13,6%	9,3%	8,7%	42,0%	49,9%	50,6%	35,2%	37,3%	48,3%
India	7,6%	10,4%	14,0%	5,9%	8,1%	8,3%	21,6%	23,7%	28,7%	10,4%	12,4%	18,5%
Indonesia	16,9%	23,3%	22,4%	12,4%	14,0%	13,9%	30,6%	35,5%	30,4%	15,1%	19,5%	18,1%
Israel	20,1%	30,2%	29,6%	6,2%	14,9%	15,5%	21,4%	38,3%	39,5%	16,6%	34,1%	37,9%
Russian Fed.	22,8%	24,7%	23,2%	10,6%	12,1%	12,2%	20,0%	25,7%	26,0%	10,6%	10,9%	9,1%
Singapore	45,9%	43,0%	46,7%	27,6%	35,0%	35,4%	58,2%	59,0%	64,0%	57,2%	58,4%	56,6%
South Africa	14,3%	18,4%	20,6%	5,5%	7,1%	8,7%	29,5%	37,4%	34,5%	9,7%	15,2%	14,6%
Hong Kong	12,0%	9,5%	7,0%	8,4%	9,7%	6,3%	14,0%	10,2%	5,9%	13,9%	14,1%	12,6%
Chile	23,4%	27,8%	31,7%	8,5%	8,2%	9,8%	39,4%	35,2%	37,6%	19,0%	19,0%	23,2%
Estonia	49,8%	40,0%	41,3%	25,1%	19,1%	18,5%	69,2%	58,8%	55,5%	47,5%	55,1%	50,8%
Slovenia	39,0%	36,2%	37,6%	19,6%	16,3%	15,7%	54,2%	54,7%	50,6%	36,9%	43,6%	45,6%
Malaysia	46,7%	41,8%	42,3%	24,4%	24,4%	25,2%	55,9%	64,1%	62,3%	38,8%	53,0%	50,4%
Philippines	25,1%	28,5%	32,1%	12,0%	11,8%	8,3%	41,2%	52,3%	53,1%	32,4%	46,0%	41,6%
Thailand	28,9%	31,7%	26,9%	8,2%	9,7%	10,5%	42,3%	52,5%	61,8%	33,5%	40,6%	38,1%
Romania	22,4%	24,1%	26,9%	19,0%	20,8%	17,8%	35,8%	47,9%	51,7%	26,0%	27,9%	29,0%
Viet Nam	16,3%	33,3%	36,9%	12,2%	26,3%	28,8%	40,5%	50,6%	54,3%	15,0%	27,5%	30,6%
Saudi Arabia	17,4%	30,5%	34,8%	12,7%	18,8%	14,2%	19,6%	48,4%	52,6%	1,3%	5,9%	2,0%

Source: OECD Input-Output Tables and authors' calculations.

Table 1.b: Induced import content of main GDP components

	Import content of private consumption			Import content of government consumption			Import content of total investment		
	1995	2000	2005	1995	2000	2005	1995	2000	2005
Australia	9,1%	9,1%	8,8%	9,0%	8,9%	8,7%	11,1%	11,1%	11,1%
Austria	11,0%	13,3%	13,8%	7,8%	9,1%	9,2%	16,2%	16,0%	18,1%
Belgium	17,4%	19,5%	18,9%	7,3%	9,5%	11,2%	21,6%	23,8%	21,0%
Canada	11,3%	10,6%	9,4%	10,3%	10,0%	9,8%	16,1%	15,3%	15,6%
Czech Republic	19,1%	20,6%	20,5%	14,2%	17,6%	14,4%	21,0%	23,9%	20,9%
Denmark	9,9%	11,7%	13,3%	6,4%	8,1%	9,3%	15,3%	17,5%	19,0%
Finland	10,7%	12,7%	13,3%	7,1%	9,8%	10,8%	12,3%	18,4%	18,4%
France	9,3%	11,0%	10,7%	6,5%	6,8%	6,8%	12,1%	13,5%	13,0%
Germany	9,0%	11,7%	12,0%	5,5%	7,0%	7,1%	11,7%	14,5%	15,4%
Greece	8,8%	11,3%	10,0%	10,6%	18,1%	10,2%	17,0%	14,0%	13,8%
Hungary	25,6%	23,7%	18,5%	19,5%	13,5%	11,4%	22,3%	20,8%	20,7%
Iceland	14,8%	9,2%	8,0%	13,7%	6,2%	5,5%	13,2%	5,4%	5,7%
Ireland	16,3%	16,1%	19,6%	13,1%	13,8%	14,4%	23,0%	21,7%	22,8%
Italy	11,8%	13,2%	13,1%	5,4%	6,2%	6,6%	14,7%	15,6%	14,8%
Japan	4,6%	5,1%	6,9%	3,0%	2,8%	6,0%	5,6%	6,4%	9,1%
Korea	14,8%	16,6%	16,0%	11,4%	10,2%	10,5%	15,4%	17,8%	17,8%
Luxembourg	15,4%	18,8%	22,1%	13,0%	15,8%	16,7%	19,3%	22,1%	30,8%
Mexico	18,0%	11,7%	11,2%	8,3%	5,0%	4,6%	26,8%	16,2%	14,4%
Netherlands	13,8%	14,5%	15,8%	9,2%	10,0%	10,3%	19,7%	19,0%	16,3%
New Zealand	11,5%	12,6%	11,0%	8,8%	10,4%	8,9%	14,4%	15,3%	13,5%
Norway	13,2%	12,8%	11,9%	10,0%	9,5%	9,3%	15,0%	14,2%	14,1%
Poland	12,2%	14,3%	14,8%	6,9%	6,0%	7,8%	15,0%	14,3%	15,9%
Portugal	14,6%	15,2%	14,7%	7,7%	8,3%	7,9%	16,0%	16,4%	17,0%
Slovak Republic	18,8%	20,7%	17,5%	17,7%	16,3%	12,7%	18,7%	21,9%	18,2%
Spain	10,7%	12,8%	12,2%	6,7%	8,8%	9,0%	12,7%	15,6%	14,0%
Sweden	12,6%	14,1%	14,7%	9,5%	10,0%	9,6%	15,7%	15,9%	17,2%
Switzerland	8,3%	11,0%	13,2%	5,8%	9,1%	9,2%	11,0%	17,5%	18,3%
Turkey	9,6%	11,6%	14,5%	6,0%	6,8%	10,7%	11,0%	13,0%	21,0%
United Kingdom	11,7%	10,4%	10,5%	11,2%	12,3%	12,5%	12,2%	11,7%	11,4%
United States	4,1%	4,6%	5,8%	3,7%	4,5%	6,2%	7,8%	7,8%	9,0%
Argentina	4,9%	4,5%	6,3%	2,2%	1,8%	2,8%	7,1%	7,1%	11,6%
Brazil	5,7%	7,2%	7,1%	3,3%	4,8%	3,7%	5,9%	7,7%	11,0%
China	9,6%	10,3%	14,0%	9,5%	10,6%	13,6%	11,5%	15,4%	20,5%
Chinese Taipei	12,9%	11,9%	15,4%	13,6%	9,3%	8,7%	18,9%	18,4%	21,0%
India	5,5%	6,4%	11,4%	4,2%	4,4%	8,3%	12,1%	13,3%	19,9%
Indonesia	9,7%	11,2%	12,2%	9,8%	12,0%	12,1%	18,1%	21,8%	19,8%
Israel	9,1%	14,8%	15,0%	6,2%	14,9%	15,5%	11,3%	19,3%	20,6%
Russian Fed.	8,9%	9,5%	9,3%	9,9%	11,7%	11,7%	10,8%	13,2%	13,5%
Singapore	17,4%	18,7%	20,3%	27,6%	35,0%	35,4%	20,5%	23,3%	25,4%
South Africa	7,6%	10,4%	11,0%	5,5%	7,1%	8,7%	10,0%	13,4%	16,1%
Hong Kong	7,0%	5,7%	4,5%	8,4%	9,7%	6,3%	7,3%	4,9%	2,3%
Chile	12,9%	15,7%	17,3%	8,5%	8,2%	9,8%	12,0%	12,3%	14,7%
Estonia	23,3%	19,6%	18,7%	16,7%	17,3%	16,2%	19,1%	21,5%	20,6%
Slovenia	14,7%	14,3%	13,9%	16,1%	12,4%	11,6%	18,7%	18,3%	19,7%
Malaysia	20,8%	21,9%	23,3%	13,1%	22,2%	22,4%	20,0%	21,8%	19,9%
Philippines	14,6%	15,2%	15,6%	12,0%	11,8%	8,3%	17,1%	16,9%	17,6%
Thailand	15,3%	17,3%	21,8%	5,8%	9,7%	10,1%	19,9%	20,1%	25,3%
Romania	12,2%	15,7%	17,2%	18,0%	20,8%	17,8%	18,4%	15,4%	14,0%
Viet Nam	12,3%	21,5%	23,9%	12,2%	26,3%	28,8%	27,6%	37,6%	41,4%
Saudi Arabia	3,7%	7,0%	8,3%	7,3%	11,9%	6,7%	2,4%	9,9%	11,9%

Source: OECD Input-Output Tables and authors' calculations.

Table 1.c: Direct import content of main GDP components

	Import content of private consumption			Import content of government consumption			Import content of total investment		
	1995	2000	2005	1995	2000	2005	1995	2000	2005
Australia	7,9%	9,5%	9,6%	0,0%	1,0%	1,2%	15,4%	15,5%	15%
Austria	13,2%	15,1%	14,9%	1,4%	1,9%	2,2%	20,5%	26,3%	25%
Belgium	14,8%	17,0%	14,8%	0,5%	1,1%	1,2%	22,0%	28,7%	29%
Canada	14,6%	13,2%	16,4%	0,0%	0,0%	0,0%	22,9%	26,8%	19%
Czech Republic	15,0%	19,0%	18,1%	4,6%	2,6%	5,4%	18,1%	29,4%	31%
Denmark	11,5%	18,6%	18,5%	0,7%	0,9%	1,1%	18,9%	22,9%	20%
Finland	9,9%	10,1%	13,6%	0,8%	1,0%	1,2%	30,1%	16,1%	14%
France	10,1%	11,0%	12,0%	1,7%	1,2%	1,9%	12,6%	13,7%	12%
Germany	9,3%	10,3%	10,5%	0,8%	1,0%	1,5%	11,0%	16,1%	16%
Greece	12,2%	13,1%	14,1%	1,0%	1,3%	-0,3%	18,0%	22,4%	22%
Hungary	21,5%	11,7%	17,0%	9,7%	3,0%	4,1%	37,7%	32,8%	28%
Iceland	15,9%	7,7%	6,8%	3,7%	0,0%	0,0%	28,5%	18,7%	19%
Ireland	30,0%	25,9%	17,6%	3,3%	0,0%	0,0%	28,5%	26,9%	19%
Italy	6,4%	7,5%	8,1%	0,3%	0,5%	0,6%	11,0%	14,0%	13%
Japan	4,5%	4,7%	4,8%	0,0%	0,0%	0,0%	2,6%	4,3%	6%
Korea	6,6%	7,2%	8,2%	0,0%	0,0%	0,0%	15,4%	17,7%	11%
Luxembourg	30,1%	33,0%	28,1%	2,6%	2,2%	1,7%	30,6%	32,7%	23%
Mexico	13,4%	6,9%	6,0%	0,1%	0,1%	0,0%	15,8%	15,8%	16%
Netherlands	12,3%	14,1%	14,6%	1,2%	1,2%	0,9%	21,9%	22,7%	23%
New Zealand	9,6%	11,2%	10,4%	1,3%	1,2%	0,9%	23,6%	25,9%	26%
Norway	15,8%	19,1%	20,1%	1,1%	1,5%	1,6%	27,1%	27,8%	22%
Poland	7,5%	12,0%	10,1%	1,0%	0,4%	1,7%	15,0%	31,5%	32%
Portugal	13,0%	17,3%	14,4%	0,9%	2,6%	1,6%	19,3%	21,9%	19%
Slovak Republic	19,4%	22,4%	27,2%	0,0%	0,0%	8,9%	34,9%	30,3%	39%
Spain	7,4%	10,3%	11,8%	0,6%	1,1%	2,4%	13,5%	19,0%	14%
Sweden	10,6%	12,4%	13,5%	1,0%	1,3%	1,6%	28,0%	31,9%	26%
Switzerland	8,0%	11,5%	11,2%	0,1%	0,1%	0,1%	15,6%	15,6%	16%
Turkey	8,5%	4,2%	8,4%	0,0%	3,4%	3,9%	25,8%	20,7%	21%
United Kingdom	9,4%	14,5%	16,7%	0,0%	0,4%	0,0%	25,2%	23,4%	14%
United States	4,5%	6,0%	6,0%	0,0%	1,5%	0,0%	10,6%	11,4%	8%
Argentina	3,3%	3,4%	6,1%	0,0%	0,0%	0,0%	15,5%	15,5%	15%
Brazil	3,9%	5,1%	3,3%	0,0%	0,0%	0,0%	7,2%	6,9%	10%
China	1,8%	3,1%	5,1%	0,4%	0,2%	0,2%	14,7%	5,4%	8%
Chinese Taipei	11,5%	11,0%	10,8%	0,0%	0,0%	0,0%	23,1%	31,5%	30%
India	2,1%	4,0%	2,6%	1,7%	3,7%	0,0%	9,5%	10,4%	9%
Indonesia	7,3%	12,1%	10,2%	2,6%	2,0%	1,8%	12,4%	13,7%	11%
Israel	11,0%	15,4%	14,6%	0,0%	0,0%	0,0%	10,1%	19,0%	19%
Russian Fed.	13,9%	15,2%	13,9%	0,7%	0,4%	0,4%	9,2%	12,5%	12%
Singapore	28,4%	24,3%	26,3%	0,0%	0,0%	0,0%	37,7%	35,8%	39%
South Africa	6,7%	8,0%	9,5%	0,0%	0,0%	0,0%	19,5%	24,1%	18%
Hong Kong	4,9%	3,8%	2,5%	0,0%	0,0%	0,0%	6,6%	5,3%	4%
Chile	10,5%	12,1%	14,4%	0,0%	0,0%	0,0%	27,4%	22,8%	23%
Estonia	26,4%	20,5%	22,6%	8,5%	1,9%	2,3%	50,1%	37,4%	35%
Slovenia	24,3%	21,9%	23,7%	3,5%	4,0%	4,1%	35,5%	36,3%	31%
Malaysia	25,9%	19,9%	19,0%	11,3%	2,2%	2,8%	35,9%	42,3%	42%
Philippines	10,5%	13,3%	16,5%	0,0%	0,0%	0,0%	24,0%	35,5%	35%
Thailand	13,5%	14,4%	5,1%	2,4%	0,0%	0,5%	22,4%	32,3%	36%
Romania	10,1%	8,5%	9,7%	0,9%	0,0%	0,0%	17,5%	32,5%	38%
Viet Nam	4,0%	11,8%	13,0%	0,0%	0,0%	0,0%	12,9%	12,9%	13%
Saudi Arabia	13,7%	23,5%	26,5%	5,4%	6,9%	7,4%	17,2%	38,6%	41%

Source: OECD Input-Output Tables and authors' calculations.

Table 2: Panel results

The table reports in-sample estimates of panel regressions of the form (15) performed on our set of 18 countries and on the G7 countries, respectively. The dependent variable is the quarterly growth rate of real imports of goods and services. Three models are compared in the table, according to the demand measure D used in each regression, where IAD stands for our new import intensity-adjusted measure of demand, GDP for real GDP, and DD for real domestic demand. P_M are relative import prices. To save space we do not report here the point estimates of the lagged values of the dependent variable and of P_M. R^2 is the in-sample coefficient of determination. Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The analysis uses quarterly data from 1985Q1 to 2010Q2.

	All countries					
	IAD model		*GDP* model		*DD* model	
	0 *lags*	1 *lag*	0 *lags*	1 *lag*	0 *lags*	1 *lag*
$\Delta\ln(D)_t$	1.18***	1.22***	1.34***	1.33***	1.48***	1.55***
	(0.0998)	(0.0706)	(0.2892)	(0.2436)	(0.1380)	(0.0841)
$\Delta\ln(D)_{t-1}$		0.50***		0.88***		0.58***
		(0.0568)		(0.1399)		(0.1380)
$\Delta\ln(P_M)_t$	-0.17***	-0.18***	-0.14*	-0.15**	-0.05	-0.07
	(0.0554)	(0.0491)	(0.0703)	(0.0598)	(0.0706)	(0.0603)
R-sq	0.40	0.46	0.19	0.26	0.26	0.30
#Observations	1836	1836	1836	1836	1836	1836

	G7					
	IAD model		*GDP* model		*DD* model	
	0 *lags*	1 *lag*	0 *lags*	1 *lag*	0 *lags*	1 *lag*
$\Delta\ln(D)_t$	1.35***	1.26***	1.60***	1.27***	1.62***	1.50***
	(0.0911)	(0.0851)	(0.1885)	(0.1133)	(0.2174)	(0.1523)
$\Delta\ln(D)_{t-1}$		0.47***		0.90***		0.63***
		(0.1109)		(0.1906)		(0.1557)
$\Delta\ln(P_M)_t$	-0.11**	-0.14***	-0.01	-0.04	0.09	0.03
	(0.0328)	(0.0302)	(0.0503)	(0.0362)	(0.0429)	(0.0445)
R-sq	0.51	0.54	0.25	0.32	0.27	0.32
#Observations	714	714	714	714	714	714

Table 3: Recessions vs. non-recession periods

The table reports the estimates of panel regressions of the form $\Delta \ln M_{c,t} = \delta_c + \beta_D \Delta \ln D_{c,t} + \beta_P \Delta \ln P_{M,c,t} + \rho_{c,t} + \varepsilon_{c,t}$ performed on our set of 18 OECD countries and on the G7 countries, respectively. D is the demand measure used in each regression, where IAD stands for our new import intensity-adjusted measure of demand, GDP for real GDP, and DD for real domestic demand. $\rho_{c,t}$ is a dummy variable equal to 1 if country i is in recession and equal to zero otherwise. R^2 is the in-sample coefficient of determination. Robust standard errors are reported in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The analysis uses quarterly data from 1985Q1 to 2010Q2.

	All countries					
	IAD model		GDP model		DD model	
	recession	*normal*	*recession*	*normal*	*recession*	*normal*
$\Delta \ln(D)_t$	1.66***	0.97***	2.85***	0.70**	2.20***	1.04***
	(0.2034)	(0.0957)	(0.3052)	(0.2818)	(0.2020)	(0.0947)
$\Delta \ln(P_M)_t$	-0.28**	-0.14**	-0.20**	-0.14*	0.04	-0.09
	(0.1176)	(0.0615)	(0.0788)	(0.0670)	(0.0980)	(0.0733)
R-sq	0.62	0.26	0.41	0.07	0.36	0.14
#Observations	190	1646	190	1646	190	1646
	G7					
	recession	*normal*	*recession*	*normal*	*recession*	*normal*
$\Delta \ln(D)_t$	1.71***	1.14***	3.20***	0.75**	2.53***	0.95***
	(0.1700)	(0.0966)	(0.4776)	(0.2608)	(0.4194)	(0.1170)
$\Delta \ln(P_M)_t$	-0.26**	-0.07**	-0.14	-0.02	0.10	0.03
	(0.0832)	(0.0348)	(0.0995)	(0.0442)	(0.0743)	(0.0378)
R-sq	0.73	0.31	0.45	0.09	0.32	0.13
#Observations	76	638	76	638	76	638

Table 4: Short-term and long-term demand import elasticities

The table reports estimated values of short-term and long-term import demand elasticities for our panel of 18 countries, as well as for individual G7 economies. Results for short-term elasticities, β_D, comes from panel regressions of the form (14) and from the same regression performed on individual G7 countries, where D is the alternative demand measure (IAD or GDP) used in the regression. Results for long-term elasticities come from two different models: VECM results for the G7 countries correspond to the demand coefficients, $\widetilde{\beta}_D$, of the cointegrating vector of a Vector Error Correction Model of the form $\Delta \ln M_t = \alpha(\ln M - \widetilde{\beta}_D \ln D - \widetilde{\beta}_P \ln P_M)_{t-1} + ... + \varepsilon_t$, estimated for each country, where 4 lags of the endogenous variables are included in the short-term dynamics. In the panel case, the coefficients denoted with a star are estimated as in Mann and Pluck (2005). OLS results, $\widehat{\beta}_D$, come from panel regressions of the form $\ln M_{c,t} = \delta_c + \widehat{\beta}_D \ln D_{c,t} + \widehat{\beta}_P \ln P_{M,c,t} + \varepsilon_{c,t}$ and from the same regression estimated on individual G7 countries. All coefficient are statistically significant at 1% level. Sample period: 1985Q1 to 2010Q2.

	IAD model			GDP model		
	$Short-term$	$Long-term$		$Short-term$	$Long-term$	
		$VECM$	OLS		$VECM$	OLS
$Panel-all\ countries$	1.18	1.32*	1.47	1.34	1.66*	1.89
$United\ States$	1.56	1.41	1.70	1.94	1.87	2.11
$United\ Kingdom$	1.20	1.45	1.56	1.86	1.92	2.00
$Japan$	1.38	1.12	1.86	1.14	4.75	2.64
$France$	1.39	1.10	1.73	2.54	1.74	2.71
$Germany$	0.84	2.25	1.97	1.08	4.57	3.37
$Italy$	1.45	1.58	1.70	1.85	2.92	2.71
$Canada$	1.56	2.00	1.58	1.82	2.74	1.96