**Global Value Chains and Business Cycles Shocks:**

Trade-income ratio in a vertically specialized scenario

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**Abstract**

International trade has changed drastically with the emergence of borderless production systems, commonly referred to as Global Value Chains (GVC), and so has the relationship between trade and income. In this paper, we examine the relationship between trade and income by developing an empirical model that takes into account cyclical and structural components, using the Brazilian economy as a country-case. Our approach emphasizes the structural component of the recent change in the trade-income ratio and analyzes in more detail the implications of GVC on trade elasticity to income. A decomposition analysis using an Error Correction Model (ECM) for the period of 2000-2013 suggests that short-term factors were dominant during economic crisis. Moreover, we find that the reshaping of the trade elasticity to income at the aggregated world level also can be observed for an individual country. Trade elasticity appears to have *decreased* in the 2000s, i.e. the Brazilian trade has become less sensitive to changes in income. We find that vertical specialization (VS) significantly affects trade by raising its trade elasticity to income on the aggregated sector level, i.e. trade elasticity is higher when VS variables are considered. However, we cannot find strong evidences for the assumption of greater vertical specialization, greater sensibility to external shocks on the disaggregated sector level.

**Keywords:** *Global Value Chains; Trade elasticity to income; Vertical Specialization.*

**Resumo**

O comércio internacional mudou drasticamente com o surgimento de sistemas de produção internacionais, comumente referidos como Cadeias Globais de Valor (CGV), transformando a relação entre comércio e renda. Neste artigo, analisamos a relação entre comércio e renda a partir de um modelo empírico que considera componentes cíclicos e estruturais, tendo a economia brasileira como estudo de caso. Nossa abordagem enfatiza o componente estrutural da recente mudança na relação comércio-renda e analisa as implicações das CGV na elasticidade-renda do comércio. A análise de decomposição usando um Modelo de Correção de Erros (MCE), para o período de 2000-2013, sugere que fatores de curto-prazo foram dominantes durante momentos de crise econômica. Além disso, verificamos que a reformulação da elasticidade-renda do comércio a nível global também pode ser observada para um país individual. A elasticidade do comércio parece ter diminuído ao longo da década de 2000, ou seja, o comércio do Brasil tornou-se menos sensível às mudanças na renda. Finalmente, verificamos que a especialização vertical afeta significativamente o comércio, aumentando sua elasticidade comércio-renda ao nível agregado dos setores. No entanto, quando analisamos os setores econômicos desagregadamente, não encontramos fortes evidências para a hipótese de que uma maior especialização vertical seria responsável por uma maior sensibilidade a choques externos.

**Palavras-chave:** *Cadeias Globais de Valor; Elasticidade comércio-renda; especialização vertical.*

**JEL:** F14; F15; C21.

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**1. Introduction**

International trade has changed drastically with the emergence of borderless production systems, commonly referred to as global value chains (GVC), and so has the relationship between trade and income. Not only trade as a share of global output is currently more than four times its level in the 1950s, but also the foreign content share in gross exports on average has almost doubled since 1970 (INTERNATIONAL MONETARY FUND, 2013). In recent years, the remarkable collapse in world trade that followed the Global Crisis of 2008-2009, whilst severe, sudden and synchronized, put GVC as one of the key aspects of the debate over the causes and consequences of the crisis. This crisis is a mark for several scholars because has been the first economic crisis felt globally since the globalization of production, i.e. the expanded use of GVC (MILBERG; WINKLER, 2010). In this sense, several studies have been questioning if the relationship between trade and income has undergone a structural or cyclical change. This issue has received renewed attention as scholars struggled to understand an unexpected global trade slowdown in the aftermath of the Global Crisis of 2008-2009. Global trade presented a 3.0 percent annual growth rate, between 2012 and 2015, well below the pre-crisis average growth of about 7 percent per annum for 1985-2007 (CONSTANTINESCU; MATTOO; RUTA, 2016)

In this paper, we examine the relationship between trade and income by developing a country-case empirical model that takes into account both and structural components, and we estimate the influence of vertical specialization on the change in trade elasticity at the sector level. Despite an extensive literature on the subject, there is no consensus to date whether the recent change in the trade-income relationship is due to cyclical or structural factors. This paper aims to contribute to this line of research and argues that a country’ integration into GVC has to be analyzed on a sector-level data to be consistent with the assumption that vertical specialization has effects on macroeconomic volatility. Our analysis thus proceeds by asking two questions: first, has the relationship between trade and income experienced a cyclical or structural change? Second, if structural factors are relevant, what is the importance of vertical specialization for the transmission of macroeconomic shocks at the sector level*?*

The research aims to assess if the reshaping of the trade elasticity to income at the aggregated world level also holds at the disaggregated level (here on sector-level data) and can be observed for an individual country[[4]](#footnote-4). Hence, the research attempts to identify the causative factors by examining the relationship between an asymmetric vertical integration pattern on sector-level and the vulnerability to macroeconomic shocks. This objective is based on the assumption that GVC have changed the role of trade in macroeconomics, forcing scholars to rethink the difference between supply and demand and their interaction with GDP. The intuition underlying this research is that an increased vertical integration can result in higher simultaneity of trade collapses across countries, once vertical specialization would provide an additional channel of transmission with the increasing trade of intermediate parts. Our approach emphasizes the structural component of the recent change in the trade-income ratio and analyzes in more detail the implications of GVC on trade elasticity.

From the current academic literature, the closest studies in spirit to ours are Escaith *et al.* (2010a; 2010b), Constantinescu, Mattoo and Ruta (2015), Cheung and Guichard (2009), Milberg and Winkler (2010), Al-Haschimi *et al.* (2015) and Gangnes, Ma and Assche (2012). Our work relates to a set of studies that estimates the long-term and short-term variations observed in the relationship between trade and income and a wide literature on the causes of the recent trade slowdown, especially those that emphasize the role of GVC in the transmission of business cycle shocks. Escaith *et al.* (2010a; 2010b) find evidences of an increase in world trade elasticity in the 1990s and a returning to a new steady state around 2004, relating this to the process of vertical specialization. Constantinescu, Mattoo and Ruta (2015) emphasize some of the structural factors that have contributed to the lower responsiveness of trade to income, finding that those are key to understanding the current slowdown (specially the changes in international vertical specialization), meanwhile cyclical factors are important for the recent trade collapse. Cheung and Guichard (2009) emphasizes that the trade finance mechanisms may explain the collapse in world trade, although part of the trade decline remains unexplained and perhaps reflects a breakdown in GVC. Similar to their work, we also use an Error Correction Model (ECM) to measure the short-run and long-run dynamics of trade elasticity. Dividing the world between emerging and advanced countries, Al-Haschimi *et al.* (2015) investigate the empirical importance of vertical specialization for the elasticity of global trade to income. Apparently, demand reacts more strongly when is followed by stronger GVC participation, which may have reached its peak recently, for both emerging and advanced countries; however, demand elasticity tends to be higher for the former. Differently from these studies, we analyzed an individual country on a sector-level data.

Our sector-level analysis benefits from Milberg and Winkler (2010) contributions, for whom economic globalization has resulted in a steady increase in the world trade elasticity to income, although this process is not homogeneous across sectors. Our emphasis on the tradable sector is in accordance with Bussière *et al.* (2013), which estimate trade elasticity from a demand composition perspective, finding that the most import-intensive categories of expenditure are responsible for the larger movements in trade dynamics, i.e. the high import intensity of exports, especially in the tradable sector, contribute to the simultaneity of the trade collapse across countries.

Our research also benefit from several works that investigate the channels through which a country’s integration into GVC may increase trade elasticity to income. Commonly illustrated in the literature by the collapse of trade in 2008-2009, two possible channels are considered: the *supply chain effect* and the *composition effect.* Gangnes, Ma and Assche (2012) use trade data (exports) from China to OECD countries. Alessandria *et al.* (2013) provide evidence of the role of inventory adjustment for import dynamics using US imports of autos from Japan to develop a general equilibrium model. Altomonte *et al.* (2012) findings applied to French firms are consistent with the research of Alessandria *et al.* (2013) for the United Sates case. Both researches highlighted the *adjustment in inventories*. Unlike their work, here we use an exploratory analysis based on input-output matrices focusing on the composition effect.

Our empirical strategy is to estimate the relationship between Brazilian imports and real GDP by using an Error Correction Model (ECM). Assuming that there is a stable trade elasticity to income in the long-run, we expect that the reshaping of the trade elasticity to income at the aggregated world level also holds at the disaggregated level and can be observed for an individual country. We work with annual data from National Input-Output tables over the period 2000-2013, estimated by Guilhoto e Sesso Filho (2005; 2010), in current prices, from IBGE National Accounts database, basing our analysis on sector-level data in order to have a consistent dataset with time-series. In order to remove the changes in relative price, we deflated all elements using a specific price deflator for each category – GDP, Agriculture, Services, Industry and Imports implicit deflators with 2000 as base year, extracted from Ipeadata.

The results are partially supportive of our priors. With regard to the first question of interest, whether the relationship between trade and income experienced a cyclical or structural change, we find strong evidence pointing to a special relevance of structural factors, specially in the recent years of trade decline. A decomposition analysis using ECM suggests that short-term factors were dominant during economic crisis. Moreover, we find that the reshaping of the trade elasticity to income at the aggregated world level also holds at the disaggregated level and can be observed for an individual country. As hypothesized, trade elasticity appears to have *decreased* in the 2000s, i.e. the Brazilian trade has become less sensitive to changes in income. In the last regression for the post-Crisis period (2008-2013), all variables are significant, and the lower long-run trade elasticity might reflect a possible change in the way trade reacts to macroeconomic shocks in the recent trade slowdown. With regard to our second question, we find that vertical specialization significantly affects trade by raising its trade elasticity to income on the aggregated sector level, i.e. trade elasticity is higher when VS variables are considered. However, we cannot find strong evidences for the assumption of greater vertical specialization, greater sensibility to external shocks on the disaggregated sector level.

The paper is structured in four sections, besides introduction and concluding remarks. In section 2, we review the related literature on the relationship between trade and income, paying particular attention to how GVC may have contributed to reshape trade elasticity. In section 3, we review the literature on the transmission mechanisms through which GVC may affect the international transmission of business cycles shocks. Commonly illustrated in the literature by the collapse of trade in 2009, two possible channels are revisited: the supply chain effect and the composition effect. In section 4, using the Brazilian economy as a country-case, we estimate the vulnerability to business cycle external shocks on sector-level data, given GVC contribution to reshape the elasticity of international trade. An exploratory analysis using Input-Output tables is used, not only to attempt to the problem of multiple counting, but also to address the real implications for macroeconomic transmissions in a world increasingly characterized by vertical specialization. The impact of asymmetric demand shocks on Brazilian trade pattern is estimated using an Error Correction Model (ECM) for the period of 2000-2013, with the National Accounts Database. Finally, the general purpose is to contribute with evidences to rethink trade integration as a policy strategy for pursuing long-term economic growth, considering the asymmetric structure of production and the relative autonomy of export as a component of aggregate demand in a vertically specialized scenario.

**2. The magnitude of trade fluctuations: Trade Elasticity and GVC**

There are evidences of transformations in the way macroeconomic shocks are transmitted across countries, and the magnitude, simultaneity and speed of the trade collapse that followed the Global Financial Crisis of 2008 corroborates with this assumption. Furthermore, world trade has grown persistently more slowly than the world GDP in the aftermath of the Global Crisis (CONSTANTINESCU; MATTOO; RUTA, 2016; GANGNES; MA; ASSCHE, 2015). While under the surface the literature attempts to answer to how occurred and which were the transmission mechanisms of the recent trade slowdown, the major question is whether this change in the trade-income relationship is cyclical of structural. In this sense, the amplified fluctuations of international trade given the impact of external business cycle shocks have been analyzed in terms of *trade elasticities.*

From the current academic literature, we identify two research branches. A first set of studies estimates the long-term and short-term variations observed in trade dynamics in terms of trade elasticity to income (*long-run elasticity of trade).* Another branch investigates the *causes* of what might be a structural change in trade patterns, highlighting the role of vertical specialization for changes in trade elasticity to income. This separation into two distinct research branches does not mean that there are no complementary questions, or even overlapped aspects. The Global Crisis is considered a mark for several authors from both strands of investigation. A wide literature on the trade collapse of 2008-2009 have been questioning why did trade volumes collapse so dramatically relative to GDP, and if the recent trade slowdown turned to be a new normal on global trade patterns.

International trade has traditionally been analyzed on price elasticities (HOUTHAKKER; MAGEE, 1969). Recently, several studies increasingly realize the importance of income elasticities[[5]](#footnote-5). *Elasticity of trade to income* measures the ratio of the percentage change in trade over the percentage change in income. Most of the literature on trade elasticity do not consider neither price effects nor substitutions effects explicitly, what means that trade elasticities reflect the pure effect[[6]](#footnote-6) of a change in domestic income (measured by GDP) to the quantity of imports (ESCAITH; LINDENBERG; MIROUDOT, 2010a).

**Box 1. Trade Elasticities**

Elasticities measure the responsiveness of quantity demanded or quantity supplied to changes in income, prices, or other variables, i.e. a percentage change in one variable resulting from a 1-percent change in another. Price elasticity and income elasticity of demand are two main representatives of elasticities. While the former is the ratio of relative change (best interpreted as the percentage change) in quantity demanded to relative change in price, the latter measures how much quantity demanded changes with respect to a change in income.

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with E = elasticity, Q = quantity demanded, P = price, and I = Income.

Therefore, the income elasticity of import demand (, for example, is given by:

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with E = elasticity, M = quantity imported, I = Income.

Structural changes may have played a key role in the recent slowdown in trade. Constantinescu, Mattoo and Ruta (2015) found that the responsiveness of trade to income – *the long-run income elasticity of trade* – already started to decline long before the Crisis of 2008-2009. They found that the long-term income elasticity of trade was 1.3 (1970-1985), rose to 2.2. in the 1990s (1986-2000), and reverted back to 1.3 in the 2000s. In the post-2008 (2008-2013), the long-run trade elasticity fell even lower (0.7). Moreover, they confirm the existence of significant structural breaks in the trade-income ratio in the 1990s relative to the other periods. Al-Haschimi *et al.* (2015) found evidences that the ratio of global import growth to GDP growth accelerated strongly from mid-1980s until late 1990s, when it started to fall strongly. The ratio was almost 2.0, on average, over the period 1981-2007, i.e., global imports grew almost twice as quickly as global GDP, and turned to 1.0 for the period 2011-2014. Although the Global Crisis is considered a mark for several authors, one can see that the rising trend gives place to decline some ten years before.

This discussion has developed to analyze how GVC may affect the trade-to-income ratio. Several studies have argued that GVC have contributed to reshape the elasticity of international trade to income (AHAMAD, 2013; ESCAITH; LINDENBERG; MIROUDOT, 2010a; GANGNES; MA; ASSCHE, 2014a; INTERNATIONAL MONETARY FUND, 2013). The IMF (INTERNATIONAL MONETARY FUND, 2013) report argues that the responsiveness of trade flows to changes in demand tend to increase during global slowdowns (FREUND, 2009) and, despite the fact that standard theories predicted an elasticity of one, trade flows have always been two or three times more volatile than GDP (HOUTHAKKER; MAGEE, 1960 *apud* IMF, 2013)[[7]](#footnote-7). Compared to previous economic downturns, the Great Trade Collapse of 2008-2009 was an unprecedentedly[[8]](#footnote-8) drop in trade that might reflect a previous increased sensibility of trade to income growth (GANGNES; MA; ASSCHE, 2015). A brief overview of the related literature on GVC and trade elasticity indicates a more severe, rapid, and persistent reaction of trade to the fall in GDP in 2008-2009 than any other trade collapse in the past (ESCAITH; LINDENBERG; MIROUDOT, 2010a). The magnitude of this reaction implies a high trade elasticity to income. In this sense, if the emergence of GVC helps to explain the rising ratio of global trade to GDP in the 1980s and 1990s, GVC may also help to explain the magnitude and the synchronization of the trade collapse after the Global Crisis and the recent trade slowdown (AL-HASCHIMI *et al.*, 2015).

Is important to say that is not the globalization of production *per se* what influences the rise in trade elasticities, but the rising sensitivity of trade to changes in GDP, i.e. the nature of GVC, not the rise in trade openness (MILBERG; WINKLER, 2010). In this sense, the faster trade growth compared to GDP may reflect the emergence of GVC. Al-Haschimi *et al.* (2015) investigate the empirical importance of vertical specialization for the elasticity of global trade to income. This trade dynamics was assessed using a standard import demand function enlarged by measures of GVC integration[[9]](#footnote-9) for 14 emerging and advanced countries. They found evidences that demand reacts more strongly when is followed by stronger GVC participation, both in emerging and advanced countries, however demand elasticity tend to be higher for the former. Further, they suggest that the process of GVC integration may have reached its peak recently, what has waned the positive impact of GVC integration on trade-to-income since mid-2000s. Vertical specialization has been neglected for too long, and may be exactly what can explain the unknown part of the trade-to-income ratio (HUMMELS; ISHII; YI, 2001).

Escaith *et al.* (2010a) investigates the role played by GVC in explaining the trade collapse that followed the Global Crisis of 2008-2009 and the long-term variations observed in trade elasticity. They first estimated income elasticity of trade at the aggregated world level by ordinary least squares (OLS) with a sample from 1980 to 2009, finding a trade elasticity of, on average, *2.28*. This result had its robustness checked[[10]](#footnote-10) and the estimated elasticity was also 2.28, however, not all constant over the years. From 1989 to 1998, there was a steady increase (from about 1.6 to 3.0), which was followed by a decrease in trade elasticity (about 2.3) between 2004 and 2008. Trade elasticity increased extensively during the 1990s, but reached a new steady state around 2004 with a higher level, what means that trade responsiveness to changes in GDP during 2004-2008 was greater than three decades ago. These estimates indicate that there might be a structural change in the way a global turmoil is transmitted across the world. Whilst the hypothesis of a structural change in world trade is supported by their results, there are no clear evidences on the causes of the observed change. They found no pattern for the observed change in elasticities, by exploring sub-groups of countries, when the participation into GVC of different countries is considered.

Other authors also consider the existence of structural factors, though GVC may not have such a strong role in the explanation of the Crisis-related decline in the trade-to-income ratio. Constantinescu, Matoo and Ruta (2015) found evidences of a changing pattern in trade-to-income ratio, which they attribute to a slowing pace of international vertical specialization. But is important to highlight the temporality of the events, since the authors suggest that the acute increase in the 1990s turned to a decline *earlier* in the 2000s. This indicates that trade is persistently growing slowly not only because of cyclical factors, such as a slow growth of GDP, but also because of a structural change in the trade-GDP relationship that include the evolving world production fragmented internationally into GVC during the 1990s and the deceleration of this process in the 2000s. Therefore, the next section investigates the causes of what may be a structural change in trade patterns, emphasizing the role that vertical specialization has in explaining the recent trade collapse and the channels through GVC can transmit macroeconomic shocks.

**3. GVC, Crisis and Macroeconomic Shocks**

The Global Crisis of 2008 has been followed by a remarkable collapse in world trade. While this crisis had its roots in the financial markets of a number of developed countries, the impacts were felt globally (WORLD TRADE ORGANIZATION, 2014b). A sudden, severe and synchronized collapse in global trade affected every single country that is part of the global trading system (YI, 2009). More than 90% of OECD countries have simultaneously declined their exports and imports exceeding 10%, however, a more severe retraction in trade was seen for emerging economies[[11]](#footnote-11) (ALTOMONTE *et al.*, 2012; BALDWIN; TAGLIONI, 2009). The post-crisis period is marked by an unexpected global trade slowdown, raising questions about whether there have been structural or cyclical changes in the trade-income relationship.

Several explanations were given for this potential new trade pattern - weak demand conditions, a rise in protectionism[[12]](#footnote-12), a drop in trade finance[[13]](#footnote-13), and a domino effect caused by GVC (BALDWIN, 2009). Cyclical factors may have played a key role in the recent trade slowdown, which may be partially explained by the composition of demand growth (GANGNES; MA; ASSCHE, 2015). The weaknesses in investment[[14]](#footnote-14) and private consumption, particularly in Europe, increased global imbalances with the collapse of exports and imports flows, resulting in considerable gaps between exports and imports (BALDWIN; TAGLIONI, 2009). The recent trade slowdown, however, does not reflect strictly a slowly growth of global GDP, but also a changing trade-income relationship with a less responsive trade to GDP (CONSTANTINESCU; MATTOO; RUTA, 2016)**.**

In additional to the cyclical weak dynamics in global trade flows, structural factors started to be considered as global trade drivers of the current trade slowdown. Most of the standard trade models have neglected the fundamental structural change that led to a globally integrated production structure and a rising trade in intermediates (AL-HASCHIMI *et al.*, 2015). Vertical specialization is one of the leading causes of the changing trade-income relationship (CONSTANTINESCU; MATTOO; RUTA, 2016)**.** Therefore, the importance of vertical specialization has to be considered, and the *magnitude* of the drop in trade relative to output and the acute *synchronized* transmission of macroeconomic shocks across countries, both aspects have shed light to the particular contribution of GVC.

There is nothing new in the fact that trade can act as a transmission mechanism for the international propagation of adverse external shocks across countries. Although, the economic crisis of 2008 showed that trade was a major transmission channel that turned the crisis global (LANE; MILESI-FERRETTI, 2010). In this sense, what would possibly make this drop in trade a unique episode among many drops of trade after a financial crisis? A number of transmission mechanisms have been proposed, and among those mechanisms several studies observed that the rising of GVC affected trade performance differently during what was named the “*Great Trade Collapse*” (ALTOMONTE *et al.*, 2012; BALDWIN; TAGLIONI, 2009; BEMS; JOHNSON; YI, 2009; FREUND, 2009; YI, 2009). This suggests that GVC play a different role as a transmission channel of macroeconomic shocks across countries, the so-called *trade spillovers* (INTERNATIONAL MONETARY FUND, 2011, 2012, 2013).

GVC have changed the role of trade in macroeconomics and have forced economists to rethink the difference between supply and demand, and their interaction with GDP. The simplistic world where my imports depend on my GDP and my exports depend upon your GDP gives place to a world with increasing imports of intermediate inputs into exports, where foreign demand determine both exports and imports of several nations (BALDWIN; TAGLIONI, 2009). In this sense, trade collapses have to be analyzed via international input-output tables, not only to attempt to a problem of multiple counting, which affects the magnitude of the trade collapse, but also to address its real implications for macroeconomic transmissions in a world characterized by vertical specialization. When the manufacturer exports the resulting output, considering a production process that at least one stage of production uses imported intermediate inputs, we say that the production process is vertically specialized.

Vertical specialization increased over time (BEMS; JOHNSON; YI, 2009; HUMMELS; ISHII; YI, 2001), and changed the standard international trade transmission mechanism. This means that the transmission of shocks is not a mainly macroeconomic phenomenon anymore, with vulnerability restrict to fluctuations in the level of their trading partner’s final demand (ESCAITH; LINDENBERG; MIROUDOT, 2010a). Comparing to the logic behind the standard international trade transmission mechanism, Yi (2009) pointed that initially the adjustments are the same – a large negative financial shock in the US, e.g., leads to a decline in its output, with households and firms suffering a decline in their incomes and reducing their spending on imports. The difference is that part of this reduction is on imported vertically specialized goods, and if US exporting firms are responsible for producing some of the parts and components, they will suffer an immediate reduction in their exports. Besides, there is an additional channel coming from reduced spending on domestically produced goods (“made in USA”) with imported parts made by US exporting firms. This means that there will be a direct production chain transmission mechanism from US imports to US exports. In a vertically specialized world, the result is a more synchronized international trade collapse.

In general terms, an increasing vertical specialization provides a real transmission mechanism that might help to understand the widespread decline in trade in at least three ways: i) the possibility of re-nationalisation of international production chains; ii) more cross-border transactions occur between separate stages of the production process (moreover, if the elasticity of substitution across stages is very low, the shocks to production in one country might be transmitted to other stages in other countries); iii) considering the case of demand shocks been concentrated on goods that are vertically specialized, trade would be highly sensitive to changes in demand (BEMS; JOHNSON; YI, 2009, 2010; YI, 2009). While seems to have a tighter connection between imported intermediate linkages and vertical specialization, Bems, Johnson and Yi (2009) argue that a country’s exports and imports tend to move in the same direction in response to changes in both domestic and foreign demand. Therefore, a key question is whether and through which channels GVC affected the international transmission of business cycle shocks. Is it possible that the acute and amplified responsiveness of trade to changes in demand would be trigger by characteristics inherent to GVC (*supply chain effect*)? Or is it only that international vertical specialization is concentrated in sectors that have higher income elasticities (*composition effect*)?

Both aspects find support in the literature. Some authors argue that GVC may increase the elasticity of trade to income, and so has amplified trade fluctuations to external business cycle shocks (commonly illustrated in the literature by the collapse of trade in 2009) by two possible channels: the *supply chain effect* and the *composition effect.* However, it remains unclear through which channels GVC affect the extent of trade spillovers.

***i) Supply Chain Effect***

The *supply chain effect* addresses that characteristics inherent to the structure of global value chains, such as higher inventory holdings, turned income elasticities in GVC trade to be higher than regular recorded trade (ALESSANDRIA; KABOSKI; MIDRIGAN, 2013; GANGNES; MA; ASSCHE, 2014b). The general idea is that the magnitude and timing of international transmission of macroeconomic shocks along the supply chain may differ from traditional demand shocks on final goods (ESCAITH; LINDENBERG; MIROUDOT, 2010b).

The assumption of a different role performed by GVC has been tested from different perspectives. Considering the performance of trade in intermediates and the hierarchies of firms belonging to the same multinational groups, Altomonte *et al* (2012) have found evidences of a different performance of trade in intermediates, which has been shown to be the main determinant of the magnitude of the Great Trade Collapse. They also showed a specific dynamic in intra-group trade with initially a faster reaction to negative demand shocks followed by a faster recovering if compared with arm’s length trade. Part of the explanation given for those findings applied to French firms are consistent with the research of Alessandria *et al.* (2013) for the United Sates case. Both researches highlighted the *adjustment in inventories*.

There are empirical and theoretical reasons for considering the inventory management decisions as a key determinant of amplified cyclical fluctuations of trade to GDP, and in the transmission of business cycles across countries. This has been called “*bullwhip effect*”[[15]](#footnote-15) and refers to how small changes in final demand can cause a relevant change in the demand for intermediate goods along the value chain (LEE; PADMANABHAN; WHANG, 1997; WORLD TRADE ORGANIZATION, 2014b). The traditional macro-economic effect on inventories was amplified on the microeconomic side by structural changes in world production, and the increasing international vertical integration (ESCAITH; LINDENBERG; MIROUDOT, 2010b). At the same time large players keep their inventories at a minimum level (buffer stocks) given the usual risks of international transportation, the “just-in-time” management of internationally fragmented value chains makes them pressure their suppliers to maintain large stocks in order to quickly respond upon request. The result is significant levels of inventories in importing firms that operates within GVC. In a economic downturn, the purchases of new imported inputs are reduced and the production process has to continue by drawing down these large inventories that firms used to hold, what would pressure upstream exporters within global value chains and result in an increased sensitivity of trade to foreign income shocks (AL-HASCHIMI *et al.*, 2015; GANGNES; MA; ASSCHE, 2014b). Therefore, upstream firms are forced to keep greater levels of stock to face the greater demand volatility. In other words, would be an extension of an initial demand shock along the GVC due to an adjustment of production and stocks to new expectations (ALTOMONTE *et al.*, 2012).

Is not easy to decompose these effects, given the difficult to obtain data able to distinguish between GVC trade and regular trade. In this context, using a dataset covering China’s trade by custom regime, Gangnes *et al* (2014b) evaluate the existence of both effects in Chinese exports and found out no evidences of a supply chain effect. They suggest that this may be the case only under certain circumstances, e.g. as suggested by Chen and Lee (2009 *apud* GANGNES; MA; VAN ASSCHE, 2014) the size of bullwhip effects would be affected by the degree of demand uncertainty.

***ii) Composition Effect***

The second channel, *the composition effect*, suggests that GVC trade is concentrated especially in durable goods industries, which are more sensitive to external income fluctuations, i.e. have higher income elasticities. Durables and capital goods are more sensitive to income shocks, what means that households and companies disproportionately delay new purchases of those goods during economic downturns. Therefore, GVC alter the composition of trade and turn aggregate trade more sensitive to foreign income shocks (BEMS; JOHNSON; YI, 2010; EATON *et al.*, 2011; GANGNES; MA; ASSCHE, 2014b).

Eaton *et al* (2011) showed that less spending on durable goods during 2008-2009 intensified the downturn. Gangnes *et al* (2014) evaluate how the rising integration of China in GVC has affected the income elasticity of its exports and found out that durable goods exports are much more sensitive to foreign income shocks than non-durables (nearly four times)[[16]](#footnote-16), finding a composition effect especially in three industries: machinery, textiles, and non-manufactures. As noted by several authors, the Great Trade Collapse illustrates the income-trade relationship beyond the traditional macroeconomic effects (AHAMAD, 2013; ESCAITH; LINDENBERG; MIROUDOT, 2010b; GANGNES; MA; ASSCHE, 2014b, 2015; INTERNATIONAL MONETARY FUND, 2013). Part of the peculiarity of this synchronization of business cycles across regions is connected to the fact that the demand shock was large but highly concentrated in a narrow category of goods (machinery, electronic and telecommunications equipment, automotive products) and intermediate products (WORLD TRADE ORGANIZATION, 2014a). Not by chance, several studies have documented the role of composition of trade, notably that of durable goods, in the volatility of trade.

There are evidences suggesting that the collapse in merchandise trade has been particularly acute in manufacturing. According to Yi (2009), this suggests that the vertically specialized nature of manufacturing, in general more vertically specialized than agriculture and commodities, could be a relevant determinant of the larger collapse in manufacturing production and trade.

In the next section, we use the Brazilian economy as a country-case to estimate the vulnerability to business cycle external shocks on sector-level data, given GVC contribution to reshape the elasticity of international trade. The impact of asymmetric demand shocks on Brazilian trade pattern is estimated using an Error Correction Model (ECM).

**4. An estimation with the Error Correction Model: Brazilian trade-income relationship**

In this section, we estimate the relationship between Brazilian imports and real GDP by using an Error Correction Model (ECM). Assuming that there is a stable trade elasticity to income in the long-run, we expect that the reshaping of the trade elasticity to income at the aggregated world level also holds at the disaggregated level and can be observed for an individual country. As described previously, offshoring and outsourcing have contributed to increase trade elasticity during the 1990s, but having reached a new steady state afterwards, trade elasticity started to decrease. The ECM allows capturing both structural factors (or trend) and cyclical developments, i.e. to estimate both the long-run and the short-run trade elasticity to income. This model also allows estimating the speed of convergence back to the long-run steady state relationship.

We work with annual data from National Input-Output tables over the period 2000-2013, estimated by Guilhoto e Sesso Filho (2005; 2010), in current prices, from IBGE National Accounts database, basing our analysis first on the entire aggregate sectors[[17]](#footnote-17) in order to have a consistent dataset with time-series, and further on 32 selected sectors to assess the variation across sectors. In order to remove the changes in relative price, we deflated all elements using a specific price deflator for each category – GDP, Agriculture, Services, Industry and Imports implicit[[18]](#footnote-18) deflators with 2000 as base year, extracted from Ipeadata.

The analysis[[19]](#footnote-19) initiates with a simple relationship between trade and GDP:, where and are Brazilian imports and GDP, respectively, and Q the share of imports in GDP. This equation, in natural log-form, is: . Adding the lagged values of trade ( and GDP (, and stochastic fluctuations (, where *t* subscript denotes time, we obtain the following expression:

(3.1)

Assuming a long-run equilibrium relationship between M and Y and considering and their values at a steady-state equilibrium, where equal to zero, we have the following equation:

(3.2)

Where is the long-run trade elasticity, and equals to *one* at the long-run equilibrium. To model short-run deviations from equilibrium in the presence of stochastic shocks, we take the differences of , adding and subtracting and from the right hand side, indicating the error correction model below:

(3.3)

Where and indicate the short-run of a change in GDP on imports; ) represents the speed of adjustment of trade to discrepancies between trade and GDP in the previous period. In the reduced form:

(3.4)

Where captures the lagged adjustment, i.e. the speed at which imports adjust to trade; , captures the short-term trade elasticity, and . The long-run trade elasticity is estimated from .

We checked the degree of integration running Phillips-Perron unit root tests, finding that *m* and *y* have unit roots, though we reject the hypothesis that and contain unit roots. In order to justify the use of this model specification, the next test is a Johansen test, showing that the rank of cointegration of m and y is one. Also, to verify the suitability of the model, we tested for the normality distribution of the residuals (Jarque-Bera statistic), for serial correlation and for autoregressive conditional heteroskedasticity (ARCH) effects in the residuals. The results of the estimation should be interpreted with caution, once the model does not capture the structural complexity of the trade-GDP nexus and treats GDP as exogenous to trade outcomes (WORLD BANK, 2015).

The results from the model estimation are presented in Table 1. First, the regression is run on aggregate data for the Brazilian input-output[[20]](#footnote-20) over the period 2000-2013. All variables of the model are significant and of special relevance to our analysis, explaining 74% of the variance in the data. We find that the speed at which Brazilian trade adjusts to the variance between trade and GDP in the previous period is significant, and, furthermore, Brazilian imports converge to their equilibrium value more quickly when compared to Escaith *et al.* (2010a) and Constantinescu *et al.* (2015) estimations for OECD countries and the world, respectively. This result is in line with the general idea already discussed that GVC trade may differ from regular trade not only in the magnitude, but in the speed with which adjustments take place.

The long-run trade elasticity for the entire sample is *2,64*. In this sense, we can say that the reshaping of the trade elasticity to income at the aggregated world level can also be observed for an individual country. Another important feature is that, when compared to both world trade elasticity estimated by Escaith *et al.* (2010a)[[21]](#footnote-21) and by Constantinescu *et al.* (2015)[[22]](#footnote-22), *1,90* and *1,31,* respectively, this result (*2,62*) is considerably higher, what suggests that the Brazilian trade is more vulnerable to macroeconomic shocks. As hypothesized, trade elasticity appears to have *decreased* in the 2000s, i.e. the Brazilian trade has become less sensitive to changes in income. In the last regression for the post-Crisis period (2008-2013), all variables are significant, and a lower long-run trade elasticity (*2,35*) might reflect a possible change in the way trade reacts to macroeconomic shocks in the recent trade slowdown. However, the computed values for the pre-Crisis period are not significant, what indicates that some caution should be taken when interpreting the results. In addition, the derived speed of trade adjustment increased considerably. This brings our analysis to check more precisely how both short-run and long-run factors have contributed to the Brazilian trade growth. The Figure 1 below presents the results from the ECM.

**Table 1. Estimation of the Error Correction Model and Brazilian long-run trade elasticity, 2000-2013**

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*Source: Author’s calculations.*

**Figure 1. Contributions to Brazilian trade growth, 2000-2013**

*Source: Author’s calculations.*

A decomposition analysis using ECM suggests that short-term factors were dominant during economic crisis. As we can see, the years of 2001 and 2002, marked by a great economic uncertainty in Brazil derived from both an energy crisis and a political change filled with promises of economic changes (Lula’s first successful election after three electoral defeats was feared by international investors to be a first step of a partial Brazilian default), and the Global Economic Crisis of 2008-2009, were critical moments when short-term factors had a key contribution, though their contribution has subsided in recent years. This means that short-term factors, e.g. a weak demand, unlikely explains alone the recent trade slowdown. These results suggest that the possible reasons behind the changing relationship between trade and income might be closely related to structural factors. In this sense, further our approach emphasizes the structural component of the recent change in the trade-income ratio and analyzes in more detail the implications of GVC on trade elasticity, estimating the influence of vertical specialization.

**The role of Vertical Specialization**

In order to estimate the influence of GVC in the change in trade elasticity to income, we introduced a vertical specialization variable in the cointegrating equation[[23]](#footnote-23), as we can see below:

, (3.5)

where VS is the sector vertical specialization share, constructed from Input-Output data, based on an extension of the methodology of Hummels *et al.* (2001), as measured in Cheung and Guichard (2009), and identifies vertical specialization as the use of imported inputs in producing goods that are exported. An alternative equation is also tested assuming the impact of vertical specialization independently of changes in Brazilian income[[24]](#footnote-24):

(3.6)

Compared to the equation (3.6), the estimations of the equation (3.5) produced more significant coefficients for all variables and this equation (3.5) is further used to analyze the variation across sectors. Whilst the isolated effect of VS is considered, the long-run trade elasticity estimated using the equation (3.6) suggests a less responsive trade to changes in income.

In addition, the equation (3.5) is tested and suggests that VS, and the impact of VS relate to changes in Brazilian income in the previous period (, has significantly affected the long-run relationship between trade and income. All variables of the model are significant with a level of 1%, explaining 96% of the variance in the data. Our findings for the Brazilian economy are close in spirit to Cheung and Guichard (2009), suggesting that vertical specialization significantly affects trade by raising its trade elasticity to income. The long-run trade elasticity significantly changed to *3,55,* and the trade adjustments occurs in a faster pace, meanwhile the short-term elasticity decreased (from *3,18* (model without vertical specialization) to *1,52* (model with vertical specialization)), supporting our assumption that long-term factors are in the basis of the recent change in the relationship between trade and income. Our model estimations for the time-period of 2000-2007 and 2008-2013 produced not significant evidences and are thus not reported. The results for 2000-2013 are in the Table 2 below.

**Table 2. Estimation of the Error Correction Model (with VS and VS\*GDP) and Brazilian long-run trade elasticity, 2000-2013**



*Source: Author’s calculations.*

**Variations across sectors: the role of Vertical Specialization**

The results of similar regressions at the sector level are presented in Table **1a (in the Annex)**, relating vertical specialization and the vulnerability to external shocks across sectors. The addition of vertical specialization variables considerably increase the goodness-of-fit of the model for all the 32 sectors considered in the analysis, specially for sectors from manufacturing, as would be already expected since the fragmentation of production is more evident among those sectors, and surprisingly also for services, but the results are not always significant. In accordance with our previously analysis, the speed of trade adjustment shows an increasing trend for almost all sectors. Therefore, this brings our analysis to the following question: greater trade elasticity comes with higher vertical specialization levels? Or, in other words, have sectors with higher vertical specialization share experienced greater sensibility to macroeconomic shocks in Brazil?

**Table 3. Vertical specialization index and long-run trade elasticity at a sectorial level, 2000-2013**



*Source: Author’s calculations.*

The results are presented in Table 3 above. When we analyze the VS index for the entire aggregate Brazilian sectors, a decreasing trend is computed over the 2000-2005 period, and an upward trend during the 2006-2013 period, with 2009 as an exceptional year. Among the sectors[[25]](#footnote-25) that persistently have showed a VS level above the VSTotal, only three individual sectors[[26]](#footnote-26) exhibit higher trade elasticity to income when compared to the (3,55) long-term trade elasticity estimated for the entire aggregate sectors. In addition, the paper also advances by monitoring the sector-level vulnerability to external shocks, giving the importance of the composition effect. When we consider those sectors where the isolated (without changes in Brazilian income) impact of VS on trade is significant and shows large proportions, the same amount of sectors, only three[[27]](#footnote-27), exhibit high trade elasticity.

We can not say that the assumption of a negative shock suffered by a single sector with high reliance on imported input initially might be translated into a higher change in trade than in total GDP, leading to higher trade elasticity, is the general case for the Brazilian economy. To sum up, although on the aggregated sector level trade elasticity is higher when VS variables are considered, on the disaggregated analysis we cannot find strong evidences for the assumption of greater vertical specialization, greater sector sensibility to external shocks.

**5. Concluding Remarks**

This paper investigates the relationship between trade and income by developing a statistical ECM model that considers both cyclical and structural components of the recent trade slowdown. Using the Brazilian economy as a country-case, our preliminary evidence suggests that the reshaping of the trade elasticity to income at the aggregated world level also can be observed for an individual country. Moreover, aggregated results obtained tend to support that trade elasticity decreased in the 2000s, supporting the hypothesis that Brazilian trade has become less sensitive to changes in income. The last regression for the post-Crisis period finds lower long-run trade elasticity, reflecting a possible structural change in the way trade reacts to macroeconomic shocks in the recent trade slowdown. When we analyze this process in detail, we find that short-term factors were dominant during periods of economic crisis, though their contribution has subsided in recent years. In other words, short-term factors unlikely explain alone the recent trade slowdown experienced by the Brazilian imports.

These findings conducted our work to emphasize the structural component of the recent change in the trade-income ratio and analyze in more detail the implications of GVS on trade elasticity, estimating the influence of vertical specialization. We find evidences suggesting that vertical specialization has significantly affected the long-run relationship between trade and income, raising trade elasticity to income. Whilst trade adjustments appears to occur in a faster pace, the short-term trade elasticity decreased in the comparison between both models (with and with no vertical specialization variables), corroborating our assumption that long-term factors are in the basis of the recent Brazilian trade slowdown. We also use a sector level analysis to relate the lower long-run trade elasticity to different levels of vertical specialization across sectors. Apparently, trade elasticity to income is higher when VS variables are considered on the aggregated sector level, meanwhile, on the disaggregated analysis we cannot find strong evidences for the assumption of greater vertical specialization, greater sector sensibility to external shocks. In this sense, as the general case for the Brazilian economy, there are no strong evidences that a negative shock suffered by a single sector with high reliance on imported inputs will be translated into a higher change in trade than in total GDP, leading to higher trade elasticity.

Overall, these findings contribute with evidences to further debate a country deeper vertical specialization share as a policy strategy for pursuing long-term economic growth. The apparent structural change in the responsiveness of trade to variances in income should be further analyzed and a fruitful research agenda appears to estimate trade elasticity from a demand composition perspective, assessing trade dynamics across countries and considering the asymmetric structure of production and relative autonomy of export as a component of aggregate demand in a vertically specialized scenario.

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***Annex***

**Table 1a. Estimation of the Error Correction Model (with VS variables and with no VS variables) and long-run trade elasticity at a sectorial level, 2000-2013**



*Source: Author’s calculations.*

1. Doutoranda em Economia (IE/UNICAMP e CEPN/PARIS 13) e pesquisadora colaboradora do Núcleo de Economia Industrial e da Tecnologia (NEIT-IE-UNICAMP). [↑](#footnote-ref-1)
2. Professor associado (IE/UNICAMP) e pesquisador do Núcleo de Economia Industrial e da Tecnologia (NEIT-IE-UNICAMP) e da Rede Mercosul. [↑](#footnote-ref-2)
3. Doutoranda em Economia (IE/UNICAMP e CEPN/PARIS 13) e pesquisadora colaboradora do CERI/UNICAMP. [↑](#footnote-ref-3)
4. According to Escaith *et al.* (2010b), this is, so far, an unanswered question. [↑](#footnote-ref-4)
5. The first studies about income elasticities of trade highlighted the importance of this measure in a growing economy, justifying their contribution in a different economic context compared to nowadays. See Houthakker and Magee (1969). [↑](#footnote-ref-5)
6. According to Escaith *et al.* (2010a), considering that GDP, on the demand side, is equal to the sum of consumption, investment, and the net balance between exports minus imports (X-M), any variation in the relative price of exports or imports is *implicitly* taken into the domestic product. [↑](#footnote-ref-6)
7. Value-added exports as a percentage of world output fell in 2009, and this happened at the same time that trade fell relatively more than demand (INTERNATIONAL MONETARY FUND, 2013). [↑](#footnote-ref-7)
8. Even if compared with the Great Depression in 1929 (EICHENGREEN; O’ROURKE, 2010). [↑](#footnote-ref-8)
9. Their measure of GVC participation is based on the decomposition of trade flows proposed in Koopman *et al.* (2014). Instead using the bilateral version of the index, they aggregate all partner countries using a year-specific trade-weighted average to minimize a potential endogeneity bias in the estimation. [↑](#footnote-ref-9)
10. The authors estimated a state space object containing GDP and imports, and applied a Kalman filter. For details, see Escaith *et al.* (2010a). [↑](#footnote-ref-10)
11. The contraction was also felt in industrial production, with the world industrial production falling 13% between April 2008 and March 2009. A more severe retraction in trade was seen for emerging economies (-28% for goods exports; -9% for industrial production) if compared with industrialized countries (-24% for goods exports; -17% for industrial production). Although, we must highlight the asymmetric contribution of emerging countries for the composition of the industrial production rate, with China pointing to only -2% of industrial production contraction, while Brazil (-20%), Taiwan (-36%), Mexico (-14%) and Korea (-22%) (data from BALDWIN; TAGLIONI, 2009). [↑](#footnote-ref-11)
12. Despite the developments after the recent economic crisis, according to World Trade Report (2014), the world did not experience a large-scale outbreak of trade protectionism, what can be explained in part due a set of multilateral trade rules and the growing relevance of GVC, linking countries and creating a common interest in preventing the spread of protectionism. [↑](#footnote-ref-12)
13. With the collapse in trade credit, tighter lending conditions worldwide have constrained global spending (YI, 2009). Furthermore, Milberg and Winkler (2010) pointed that a trade credit crunch has a more severe impact on international trade when trade is based on GVC. [↑](#footnote-ref-13)
14. According to Bussière *et al.* (2013), there would be no “puzzle” in the magnitude of the trade drop observed during the recent financial crisis. The authors construct an empirical model of international trade flows based on an import intensity-adjusted measure of aggregate demand, finding evidences that the most import-intensive categories of expenditure are responsible for the larger movements in trade dynamics. The most procyclical components of demand, especially *investment,* but also *exports*, showed a relevant import content, and during recessions a decline in those components usually exceeds considerable that of GDP. Is important to highlight that their results are also consistent with other periods, including those of expansion. Moreover, in a scenario of increased internationalization of production, they consider that the high import intensity of exports, especially in the tradable sector, contribute to the simultaneity of the trade collapse across countries. [↑](#footnote-ref-14)
15. The “bullwhip effect” is also referred to as the “whiplash” or “whipsaw” effect (WTO, 2014). [↑](#footnote-ref-15)
16. According to Gangnes *et al.* (2014), there are no evidences that durable goods exports have a different price elasticity than non-durables. [↑](#footnote-ref-16)
17. The 1995-1999 Input-Output tables are aggregate in 42 sectors; 2000 to 2009, 42 and 56 sectors, and from 2010-2013, 68 sectors. [↑](#footnote-ref-17)
18. The price average variation in the period compared to the average price of the period (IPEADATA). [↑](#footnote-ref-18)
19. This model is similar to Escaith *et al.* (2010a) and Constantinescu *et al.* (2015). [↑](#footnote-ref-19)
20. The aggregate data considers 56 sectors in total. When the variation across sectors is estimated, we restrict to 32 sectors. [↑](#footnote-ref-20)
21. The long-run trade elasticity estimated is *1,90,* considering 24 OECD countries in the 2000s. [↑](#footnote-ref-21)
22. World long-run trade elasticity of *1,21* with a significance level of 1% using quarterly data over the period of 2001-2013; and *1,31* with significance level of 1% using yearly data, 2001-2013. [↑](#footnote-ref-22)
23. This model is similar to Escaith *et al.* (2010a), although adapted to sector level analysis. [↑](#footnote-ref-23)
24. A similar equation was estimated by Cheung and Guichard (2009). [↑](#footnote-ref-24)
25. We consider only the 10 sectors for which coefficients are significant for the model with VS variables. [↑](#footnote-ref-25)
26. 28. Transport, storage and postal services; 30. Financial intermediation and insurance; 31. Business services. [↑](#footnote-ref-26)
27. 8. Leather goods and footwear; 30. Financial intermediation and insurance; 32. Household services. [↑](#footnote-ref-27)