



GEP 2019–14

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November 2019

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# Measuring Fifty Years of Trade Globalization

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**Abstract:** Although trade globalization is a multi-faceted phenomenon, researchers often capture its magnitude by trade volume alone. In order to gain a deeper understanding of the phenomenon we propose measures that also account for the interconnectedness of countries, for geographical distance, and for the role of individual sectors in bilateral trade. We also improve upon existing indices by moving from a country-level analysis (internationalization) to a truly global perspective (globalization). We measure trade globalization using data from CHELEM (CEPII) over a period of 50 years, covering 72 countries for the sub-period 1967–1990 and 84 countries for 1994–2016. The results show substantial increases in all dimensions of globalization, despite substantial differences between the measures, highlighting the need to analyze globalization with a comprehensive set of indicators. Regarding the number of positive bilateral trade flows, globalization was almost completed by 2016. The importance of distance also diminished throughout the period analyzed, but neighboring countries still share stronger trade relations. Results indicate that trade globalization for high-tech sectors varies significantly from the evolution seen in other sectors, especially large, low-tech sectors. The latter tend to show the highest level of trade globalization over the whole period, but the former group could catch up considerably.

**Key words:** globalization, trade interdependencies, multidimensional, measures, distance, sectors.

**JEL Codes:** F10, F14.

**Acknowledgements:** The authors are grateful for financial support from: (i) the Oesterreichische Nationalbank, Anniversary Fund, Project No. 15482, (ii) the Styrian Government for the Project “(Un)Divided; and (iii) Fundação para a Ciência e a Tecnologia under Grant UID/GES/00315/2019.

## 1. Introduction

Globalization is one of the most prominent topics in economics among academics and policy makers, and in the broader public debate. The first to introduce the term “globalization” into the economic literature were Naisbitt (1982) and Levitt (1983), who describe the evolution from nationally acting firms to global market players and highlight the important role of technological change in facilitating global trade. In this respect, OECD (2005) refers to globalization as a complex, multidimensional integration process in which the increase in the mobility of production factors reduce the importance of distance (and space).

In this paper we restrict the analysis to one of the most important economic aspects of globalization – trade globalization – ignoring, therefore, other aspects of the phenomenon, such as its cultural, ecological, legal, political, and social dimensions. The distinction between internationalization and globalization is noteworthy: whereas in the context of internationalization the nation state remains the central point of investigation (Scholte, 2008), globalization emphasizes the interdependencies of countries that result in deeper trade relations. This integration process is yet far from being completed as digitalization is projected to further reduce trade costs, thereby increasing world trade by 2% annually until 2030 (WTO, 2018).

Over the last decades considerable effort has been undertaken to advance the measurement of globalization and to create a deeper understanding of its components. Multidimensional measures of globalization – such as the widely applied KOF Globalisation Index (Dreher, 2006; for an update see Gygli, Haelg, Potrafke, and Sturm, 2019) – aim to measure the variety of influential economic, social, and political factors. However, these approaches still follow a country-level perspective. They can therefore provide a magnitude of indicators at the national level but neglect the single most important factor that distinguishes globalization from internationalization: interconnectedness. As affirmed by De Lombaerde and Iapadre (2008, pp. 174-175), “*the most important unsettled issue is that of defining and correctly representing the geographic space of the process. The available indicators still rely on a misleading identification of globalization with a country’s openness to the rest of the world, seen as a unique partner, without paying due attention to the geographic diversification and reach of its international relationships*”. Aiming to overcome this gap in the literature, we propose a set of indicators to measure the different facets of trade globalization.

We contribute to the literature at four main levels. First, as mentioned above, by proposing new measures of trade globalization that account for its several relevant dimensions, namely the number of bilateral flows, geographic distance, volume, and the number of sectors involved in trade. Second, we adopt a real global approach instead of conducting, as customary in this area, a country-level analysis, thereby shifting the focus from the concept of internationalization to the true concept we aim to evaluate: globalization. Third, we make the distinction between bounded and unbounded dimensions of trade globalization, allowing us to capture, in the first case, how far we are from the maximum level of trade globalization. Fourth, at the empirical level, we conduct a detailed quantification of trade globalization over a period of 50 years (1967-2016).

The paper is structured as follows. The literature review, in Section 2, discusses meaningful definitions of globalization and provides an overview of existing globalization measures. In Section 3 we propose new trade globalization measures that can incorporate the interconnectedness of countries, distance, and a sectoral component. In section 4 we present the data used in our empirical analysis. In Section 5 we evaluate the evolution of trade globalization during the period 1967-2016. In Section 6 we complement this evidence with results at the sectoral level. In Section 7 we present some final remarks.

## **2. Defining and Measuring (Trade) Globalization**

### **2.1. Defining Globalization**

We can identify two major strands of definitions in the literature highlighting different aspects of economic globalization. The first strand focuses on the connection effect that globalization exerts on countries. Globalization thus “*reflect[s] increased economic interdependence of countries. Such phenomena include flows of goods and services across borders, reductions in policy and transport barriers to trade, international capital flows, multinational activity, foreign direct investment, outsourcing, increased exposure to exchange rate volatility, and immigration*” (Goldberg & Pavcnik, 2007, p. 41). McGrew (1992, p. 15) stresses the fact that globalization involves “*the widening, deepening and speeding up of worldwide interconnectedness*”. Norris (2000, p. 155) completes this view by characterizing the phenomenon at hand as “*a process that erodes national boundaries, integrates national*

*economies, cultures, technologies and governance, and produces complex relations of mutual interdependence.”*

The second strand of literature focuses on globalization as a synonym for the decline in trade costs and the positive effect on global trade flows. In this vein, Harvey (1989) uses the expression “*time-space compression*” to express the idea that technological innovation in the areas of communication and transport have helped to overcome distance more easily. Along the same lines, Friedman’s famous book “*The World Is Flat*” (Friedman, 2005) describes factors leading to the “*death of distance*” (Cairncross, 1997) that have fostered the establishment of global value chains. Keohane, Nye, and Joseph (2000, p. 106) emphasize that “*for a network of relationships to be considered ‘global’, it must include multicontinental distances*”. Nevertheless, the discussion of the extent to which distance still matters and whether “*the world is not flat*” after all (Christopherson, Garretsen, & Martin, 2008) is still ongoing.

To sum up, globalization reflects not only the increase of economic interdependencies between countries, but also the widening and deepening of these economic interconnections. With the special focus of this paper on trade globalization, these interdependencies also manifest in outsourcing processes and the establishment of global value chains, implying that globalization affects not only the number of countries and the volume of trade but also the number of sectors involved in trade.

## **2.2. (Trade) Globalization Measures**

As (trade) globalization and the understanding of its development have become central topics in economics, the proper measurement of trade globalization has become crucial to advancing our knowledge about them. Global trade volume and openness to trade have long been the most straightforward indicators of globalization. One reason for this is the availability of rich data in terms of number of countries and time span, allowing researchers to describe the evolution of globalization since the 19<sup>th</sup> century (Federico & Tena-Junguito, 2017). Nevertheless, these indicators do not allow for drawing conclusions regarding the structure and causes of the development of (trade) globalization. Starting in the early 2000s, researchers have therefore proposed multidimensional indices to capture globalization in its multifaceted nature, including economic, political, social, and environmental aspects. Trade is identified as a key component

of economic globalization. Still, the interdependencies between trading partners cannot be studied using these types of indicator.

One of the first composite indices of globalization is the Foreign Policy/A.T. Kearney Index (A.T. Kearney, 2001, 2007). This index aims to measure the degree to which countries are connected with other countries and the degree to which the countries are affected by globalization. However, the A.T. Kearney Index has been criticized on various grounds. Whereas Scholte (2002) disapproved of the limited theoretical foundation and relevance of the index, Lockwood (2004) highlighted its limited robustness due to the fact that the weights for the variables under study were chosen arbitrarily, and because of problems associated with measuring the openness to trade without considering the impact of differences in country sizes. Lockwood (2004) and Heshmati (2006) propose several adjustments to the index to overcome these various limitations.

Given the weaknesses of the A.T. Kearney Index, researchers proposed multidimensional indices that are more elaborate and methodologically robust, following guidelines summarized in the OECD Handbook on Constructing Composite Indicators (2008). Two well-known indices belong to this category. The first is the Maastricht Globalization Index (Martens & Zywiets, 2006; Martens & Raza 2009; for an updated version see Figge & Martens, 2014) which builds on the World Development Indicators and widens the perspective of globalization to the environmental dimension as well as to the globalization in the trade of military arms as a share of the military budget. Moreover, the authors aim to control for exogenous factors to counteract the naturally higher degree of openness of smaller countries compared to larger countries. The second index is the most widely used globalization measure – the KOF Globalisation Index, introduced by Dreher (2006).<sup>1</sup> Dreher, Gaston, Martens, and Van Boxem (2010) claim that the advantage of the KOF index when compared to the Maastricht Globalization Index resides in the fact that the latter is no more than a simple additive composite index, whereas the KOF Index uses statistical analysis to more robustly assign weights to the variables. The update of the Maastricht Globalization Index by Figge and Martens (2014) addresses this weakness, introducing more robust weighting schemes. It is also important to mention the New Globalization Index proposed by Vujakovic (2010), as it is the only multidimensional index that considers the distance between the countries under study.

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<sup>1</sup> For an overview see Potrafke (2015) and Gygli et al. (2019).

Nevertheless, it does not account for the number of countries involved in trade and cannot shed light on the inherent trade structure.

Table 1 presents a systematic overview of the common characteristics of multidimensional indices. The number of indicators, the time span, and the number of countries studied by the indices varies widely, with the KOF Index outperforming the other multidimensional indices in all three categories in terms of coverage.

[Insert Table 1 here]

Trade globalization is a central element of economic globalization in all of these indices. Vujakovic (2010) uses nine indicators to measure economic globalization, two of them directly addressing trade globalization. In the KOF Index, trade as a percentage of GDP accounts for only 11% of economic globalization. The CSGR Index measures economic globalization using four indicators. One of them is trade, which receives 83.29% of the total weight. Thus, while all multidimensional indices use trade as a proxy for economic globalization, the weight assigned to this dimension varies widely. Moreover, most indices use the openness to trade indicator as the single proxy for trade globalization, considering neither the absolute level of trade volume nor the bilateral interdependencies between countries involved in trade. Therefore, regarding the measurement of trade globalization, these indices should be considered rather unidimensional and simple indicators as they relate each country's exports to GDP and report values for every single country separately. There is a long tradition of using a country's exports as a proxy for trade globalization. Several authors also use exports plus imports in relation to GDP to account for the differences in country sizes and to avoid problematic interpretations due to the higher probability of small countries being more open to trade than larger countries (for an overview see Squalli & Wilson, 2011). However, these indicators do not capture the interdependencies between countries or the distances between them.

As Figge and Martens (2014) point out, the abovementioned indices are constructed at the national level and their aim is to provide a ranking of countries and information about a country's international competitiveness in a globalized world. Thus, these indices make no distinction between globalization and internationalization, as the former is argued to be the consequence of the latter. Most indices do not even propose an aggregated metric to measure globalization at the global level (one exception being the KOF index). For this, it would be necessary to leave behind the single country perspective, as is done in network analysis.

Researchers use network analysis in many fields. When applied to trade globalization this approach can be advantageous, as countries are treated as being “*embedded in the whole web of trade relationships*” (De Lombaerde, Iapadre, McCranie, and Tajoli, 2019, p. 497). Thus, more attention can be given to the relationship between countries through the structure of trade flows (De Benedictis and Tajoli, 2011). Moreover, De Benedictis, Nenci, Santoni, Tajoli, and Vicarelli (2014) highlight that trade relations between two countries should not be viewed in isolation from the development in other countries, since all countries are interconnected through the network. Ignoring this web of interdependencies underestimates the complexity of globalization. Kali and Reyes (2007) use network analysis to highlight differences in the strength of trade linkages by distinguishing between global and regional trade networks for the period 1992 to 1998. Barigozzi, Fagiolo, and Mangioni (2011), using data from the 1990s and early 2000s, identify clusters of countries that form trade sub-networks due to their strong interlinkages with one another, while trade with other countries remains significantly lower. The work of Arribas, Pérez, and Tortosa-Ausina (2009) is noteworthy in this regard. These authors assume that the process of globalization is completed when trade is equally distributed among countries. Consequently, they propose to measure the gap between actual globalization and perfect international integration. While this approach is obviously interesting, it does not take trade volume into account, thereby not distinguishing between a world with small volume of trade flows and a world with large trade volume.

Squartini, Fagiolo, and Garlaschelli (2011) and Barigozzi et al. (2011) have also used network analysis to study commodity-specific globalization trends for 97 product groups from 1992 to 2002/2003. They perform their analysis at the sectoral level and investigate a trade web for each sector in order to highlight the geographical differences between the trading patterns of goods such as coffee and steel. However, due to the vast amount of data, such analyses can only be performed for a small number of selected sectors. Studying the number of sectors involved in every single bilateral trade relation in this manner is impossible. Network analysis thus sheds light on the interconnectedness of countries and on the structure of bilateral trade relationships. At the same time, the approach ignores other important characteristics of globalization, such as trade volume.

### **2.3. Research Gaps**



The discussion so far reveals two critical research gaps in the literature. First, existing measures are unable to capture all relevant dimensions of trade globalization (Scholte, 2008; Martens, Caselli, De Lombaerde, Figge, and Scholte, 2015). For example, several of the most commonly used multidimensional indices do not account for the interconnectedness among countries. The one approach that does – network analysis – neglects trade volume (and often distance). Second, most trade globalization measures adopt a country-level perspective, capturing the degree of openness and internationalization of countries rather than globalization proper. As criticized by De Lombaerde and Iapadre (2008) and more recently by Martens et al. (2015), this leads to a neglect of the geographical distribution and diversification of trade as well as to an underestimation of countries' integration. The existing indices thus fail to distinguish trade relations between neighboring countries from trade relations between geographically dispersed countries, since they treat all countries other than the one being examined as “rest of the world”.

The main objective of the present paper is to overcome these research gaps. More specifically, our approach adds to the existing literature at four main levels. First, we introduce a set of measures that allows the user to capture a more comprehensive concept of trade globalization, taking into account not only the number of countries' bilateral trade relationships, but also the distances between the countries and the number of sectors involved in these relations. Our approach also creates a deeper understanding and quantification of the evolution of trade globalization according to sectoral characteristics. Second, we avoid the country-level perspective, following instead a real global approach to evaluate the level of world trade globalization proper. Third, we distinguish – at both the conceptual and empirical levels – bounded and unbounded dimensions of trade globalization. Concerning the bounded dimensions of the phenomenon, this allows us to quantify the gap *vis-à-vis* the maximum levels that can be reached in each dimension. Finally, at the empirical level we provide a detailed quantification of trade globalization over a long period of time, namely from 1967 to 2016.

### **3. Measures of Trade Globalization**

As defined in the literature discussed in the previous section, trade globalization is a complex and multifaceted phenomenon. We pay heed to this definition by proposing a set of trade globalization measures that incorporate interdependencies and distance between countries as well as sectoral components of international trade:

Trade Globalization = f (Volume of trade, Number of bilateral relations, Distance, Number of sectors) (1)

While the first dimension of trade globalization – the volume of trade – does not have an upper bound, the other dimensions are bounded. This gives us a benchmark to which their current levels can be compared. In the present study we aim to capture both the bounded and unbounded dimensions of trade globalization, thereby providing a more comprehensive evaluation of the phenomenon.

We take the matrices of bilateral trade as the starting point of our analysis. A generic element of the matrix,  $x_{iht}$ , represents the exports from country  $i$  to  $h$ , in period  $t$ .  $I$  denotes the number of exporting countries and  $H$  the number of importing countries. Since no country trades with itself, the number of relevant elements of each matrix is  $I(H - 1)$ .

The first and most commonly considered dimension of trade globalization is trade volume. In order to capture this dimension, we obtain:

$$R_t = \frac{\sum_{i=1}^I \sum_{h=1}^H x_{iht}}{\sum_{i=1}^I \sum_{h=1}^H x_{iht-1}}. \quad (2)$$

Then, we calculate:

$$R'_t = R'_{t-1} R_t \quad (3)$$

with  $R'_{1967} = 1$ .

As mentioned above, this corresponds to the unbounded dimension of trade globalization, as it compares the actual volume of trade with the corresponding value at the beginning of the period under scrutiny.

Concerning the bounded dimensions of trade globalization, the maximum value is obtained when all sectors are traded in all bilateral relations. We introduce three measures of trade

globalization, all of them ranging from 0 (minimum level of trade globalization) to 1 (maximum level of trade globalization).

Our first (and simplest) index captures the percentage of bilateral relations with positive trade in the total number of country pairs at the world level in year  $t$ :

$$G1_t = \frac{\sum_{i=1}^I \sum_{h=1}^H v_{iht}}{I(H-1)} \quad (4)$$

where  $v_{iht}$  distinguishes positive from non-positive bilateral trade flows:

$$v_{iht} = \begin{cases} 1 & \text{if } x_{iht} > 0 \\ 0 & \text{if } x_{iht} = 0 \end{cases} \quad (5)$$

Aiming to capture the distance travelled by trade, we consider a new measure –  $G2_t$  – capturing the proportion of the total distance among all the countries in which positive trade exists:

$$G2_t = \frac{\sum_{i=1}^I \sum_{h=1}^H Dist_{iht} v_{iht}}{\sum_{i=1}^I \sum_{h=1}^H Dist_{iht}} \quad (6)$$

where  $Dist_{iht}$  is the distance between  $i$  and  $h$ .  $G1_t$  and  $G2_t$  range between 0 (no trade between any country pair) and 1 (trade in all bilateral relations).

A final and important aspect of our framework concerns the sectoral dimension of trade globalization. We argue that trade globalization is higher when more sectors ( $s = 1, 2, \dots, S$ ) are involved in trade. Therefore, we calculate a new measure incorporating this dimension. We first obtain  $Z_t$  which represents the average number of sectors involved in bilateral trade:

$$Z_t = \frac{\sum_{i=1}^I \sum_{h=1}^H c_{iht}}{I(H-1)} \quad (7)$$

where:

$$c_{iht} = \sum_{s=1}^S b_{ihst} \quad (8)$$

and

$$b_{ihst} = \begin{cases} 1 & \text{if } x_{ihst} > 0 \\ 0 & \text{if } x_{ihst} = 0 \end{cases} . \quad (9)$$

Calculating the ratio between  $Z_t$  and  $S$  (total number of sectors), we get the percentage of sectors with trade, allowing us to obtain  $G3_t$ :

$$G3_t = G2_t \frac{Z_t}{S}. \quad (10)$$

The maximum level of trade globalization regarding its bounded dimensions occurs when  $G3_t = 1$ , meaning, as mentioned above, that all sectors are traded in all bilateral relations.

#### 4. Data

We apply the measures introduced in the previous section to characterize the evolution of trade globalization in the period 1967-2016. Our data come from CHELEM (CEPII) using ISIC, 4 digit-level (147 sectors). We obtain bilateral distances and deflators from CEPII. Taking into consideration the important political changes in the first half of the 1990s, namely the disintegration of the USSR, Yugoslavia, and Czechoslovakia, we are forced to consider two different series: (i) 1967-1990 (72 countries, including the three just named); (ii) 1994-2016 (84 countries).<sup>2</sup> The countries included in the samples represent around 96% of world GDP, allowing us to rely on the robustness of our results. For each year of the sub-period 1967-1990, we have: (i) a matrix of bilateral trade flows, in overall terms, including 5,112 elements; (ii)

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<sup>2</sup> Therefore, comparisons between the two periods should be approached with caution.

similar matrices for the 147 sectors. This information corresponds to more than 18 million bilateral trade flows. For the sub-period 1994-2016, we consider 6,972 elements in the matrix, adding up to almost 25 million bilateral trade flows. Altogether, we consider around 43 million bilateral trade flows. Figure 1 summarizes the empirical approach followed in this study.

[Insert Figure 1 here]

Our analysis is restricted to the manufacturing sector, since data for the service sector are not available for our sample and time span. Yet even though trade in services has increased over the last decade and is projected to continue to do so in the future, trade in services accounts for only 21% of total trade in 2017 and is projected to increase to 25% in 2030, implying that our data capture the major part of international trade (WTO, 2018).

## 5. Overall Evidence

The exponential growth of world trade during the second half of the 20<sup>th</sup> century is well-established empirically. The role of falling trade costs (due to greater efficiency in transportation infrastructures, falling communication costs, and lower tariffs) as well as the collapse of communism help to explain this trend, especially since the 1990s (Rodrigue, 2017). Yet there are also periods of decline and stagnation in world trade, as shown in Figure 2. The most prominent of these periods can be explained by the two oil price shocks in the 1970s, the bursting of the dot-com bubble, and the largest worldwide recession since World War II in 2009 (WTO, 2018).

[Insert Figure 2 here]

### 5.1 Bilateral Relations and Distance in Trade Globalization

As discussed in Section 2, the current understanding of the role of distance in bilateral trade linkages and the extent to which sectors are involved in trade globalization is very limited. Given this shortcoming in the literature, we assume these aspects as central in our analysis. Together with the number of positive trade flows, they represent the bounded dimensions of trade globalization. The literature suggests that distance plays an important role in bilateral trade relations: Chortareas and Pelagidis (2004) stress that increases in trade volume tend to be regional rather than global; Baldwin (2006) refers to the *spaghetti bowl phenomenon*.

Additionally, De Lombaerde et al. (2019) show that trade globalization strengthens the ties between countries that have long-established trade relations and that distance still matters even though new countries have become part of the international trade network since the 1960s.

Figure 3 presents evidence regarding the bounded dimensions of trade globalization.

[Insert Figure 3 here]

We begin our analysis with the number of bilateral trade relations and the importance of distance. In Figure 3 we show evidence that  $G1_t$  and  $G2_t$  were already high in the 1960s and close to their upper bounds in 2016 (Figure 3, Panel (3a)). Results for  $G1_t$  indicate that 83.53% of all possible bilateral trade relations were already in place in 1968. This percentage grew to 99.02% in 2016. The percentage of positive bilateral trade relations increased almost monotonically. However, the size of the increases varies over time. On average,  $G1_t$  increased by 0.53% annually in the first sub-period and by 0.29% annually in the second sub-period. This slower increase can be interpreted as an indication that trade globalization regarding the number of countries involved in international trade had reached almost its full potential. There is practically no room for further increases in the degree of integration. In only four years do we find small decreases in the level of  $G1_t$ : 1971, 1983, 1985, and 2012. Three of these years fall into the first part of the period studied (1971, 1983, and 1985). Nevertheless, these small negative changes are negligible when compared to the increases over the full period.

Examining our data in greater detail, we find that in 1968, only four countries in the sample were exporting to all other countries – the United States, Japan, Sweden, and Finland. Fewer than half of all 72 countries were exporting to Bangladesh and Brunei, and Albania also was not well integrated into the global trade network. Brunei was the country with the fewest trading partners over the full period of investigation. This country traded with only 12 of the 71 other countries in 1968, and with 69 of the 83 other countries in 2016. At the same time, the “average country” had 59 trading partners in 1968 and 82 in 2016. By 1980, the number of countries having established positive trade relationships with all other countries had tripled relative to 1968. This increase was driven mainly by the better integration of the most remote countries (for instance, Bolivia increased the number of its trading partners from 31 to 45 while Bangladesh went from 40 to 64).

During the 1980s globalization accelerated even more. The number of countries having established trade linkages with all other countries doubled during this decade, and the average

number of trade linkages reached 93.74%. Again, the development was driven by the most remote countries – Brunei for example increased its number of trading partners from 20 in 1980 to 38 in 1990; Cameroon went from 43 to 60; and Gabon (and Vietnam), which had traded with 40 (41) countries in 1980, traded with 56 in 1990. Interestingly, the number of countries trading with at least 80% of all other countries increased only slightly.

With the enlarged dataset starting in 1994, the absolute number of bilateral trade relations increased enormously. At the same time, in 1994 there was also a greater number of countries that were less connected with the world. Taking the average number of trade relations as our yardstick we find that this holds especially for newly established countries like Bosnia and Herzegovina, Kazakhstan, Kyrgyzstan, and Macedonia, as well as – to a certain extent – for the Baltic countries. Altogether, the percentage of positive trade relations was slightly lower in 1994 than in 1990.

In 2016, 66 of the 84 countries evaluated had positive export trade relations with all other countries in the sample, whereas in 1994 only 25 had exported to all other countries (17 of them were European countries). However, at the end of our observation period, we see hardly any further trade integration at the lower bound of the sample. The least integrated countries do not, or only slightly, increase the number of countries they trade with.

Turning to the importance of distance in understanding the development of trade relations, the analysis of the gap between  $G1_t$  and  $G2_t$  provides useful insights. The gap was largest in 1968 and has fallen since then. This convergence process suggests that bilateral trade is first established between spatially closer countries and then spreads to more distant places. Aiming to complement the analysis of the influence of distance on the level of trade globalization, we calculate two very simple additional metrics: (i) the percentage of total trade occurring between countries with a common border; and (ii) the percentage of total trade occurring between countries with a maximum distance of 3,000 km. Considering the most recent sub-period of our analysis (1994-2016; 84 countries), the percentage of trade between countries sharing a common border fell from 27.71% in 1994 to 24.13% in 2016. In the same period, the second measure evolves from 53.65% to 47.93%. In conclusion, the evidence supports the idea that declining trade costs as well as better access to international transportation systems facilitated the integration of peripheral and less developed countries into the global trade network, making distance a less relevant barrier to trade.

## 5.2 Sectors Involved in Bilateral Trade Relations

In this section we complement the above analysis by considering the number of sectors involved in each individual trade relationship. The evidence presented in Panel (3b) of Figure 3 shows a different picture than does Panel (3a). In contrast to the results of  $G1_t$  and  $G2_t$ , the sectoral dimension of trade globalization is far from complete. The results show that in 1968 an average of only 21.82% of the sectors were involved in each bilateral trade (i.e., on average, 32.08 of 147 sectors were traded in bilateral relationships). The steady increase in  $Z_t$  over time is, however, remarkable: in the first sub-period, the average number of sectors traded increased to 45.02 in 1980, and to 52.75 in 1990. This growth suggests that countries diversify as trade relations intensify. The establishment of new countries had a decreasing effect on the average number of sectors involved in trade. Therefore, the second sub-period started with an average of 50.51 sectors in 1994, growing to 65.74 in 2005, and 74.80 in 2016 (50.88% of the total number of sectors). Nevertheless, while the average number of sectors involved in trade increases steadily, the boundary of 147 sectors is unlikely to be reached any time soon. Moreover, there is notable variation between country pairs. The more industrialized countries are more diversified than developing countries. Still, the latter have caught up substantially over time.

Figure 4 shows that 47.40% of all bilateral relations involved fewer than 10 sectors in 1968. This share went down to 10.10% in 2016. It is noteworthy that the first cases of bilateral relations involving more than 140 sectors were between neighboring countries, namely between France and Italy, and between Belgium and France in 1970. We need to wait until 1990 to observe trade relations involving all sectors (in the country pairings USA-Canada, Germany-Switzerland, and in the exports of the former USSR to seven other countries, mainly from Eastern Europe). Thus, trade barriers and distance still seem to play a significant role when it comes to intensifying trade relations. Altogether,  $G3_t$  shows a clear positive trend as it grows from  $G3_{1968} = 0.172$  to  $G3_{2016} = 0.502$ , with an average annual growth rate of 3.02% in the first sub-period and 2.16% since 1994.

[Insert Figure 4 here]

## 5.3 Bounded and Unbounded Dimensions of Trade Globalization

In Figure 5 we show the relationship between changes in  $R'_t$  and changes in  $G3_t$  in order to highlight the commonalities and differences in the evolution of bounded and unbounded



dimensions of trade globalization. The growth trend of  $R'_t$  is remarkable, with an average annual growth rate of 5.68% in the first sub-period and 5.05% since the 1990s. The growth of the bounded dimensions, captured through  $G3_t$ , was considerably lower, as mentioned in Section 5.2. Generally, the change in trade volume was much more affected by cyclical fluctuations than in  $G3_t$ : whereas there were six years of contractions in trade volume<sup>3</sup>, there were only two years in which  $G3_t$  fell (1982 and 1983). In fact  $G3_t$  grew even during the Great Recession of 2009, emphasizing the need to study trade globalization not only with the help of trade volume but rather with a more comprehensive set of indicators.

[Insert Figure 5 here]

## 6. Sectoral Characteristics and Their Relevance in Globalization

Seeking to provide a more disaggregated analysis of trade globalization, in this section we explore evidence at the sectoral level. To that end, we replicate the overall analysis for each of the 147 ISIC 4-digit sectors. Three dimensions of trade globalization can be considered: number of flows, distance, and trade volume. Using the sectoral matrices,  $R'_{st}$ ,  $G1_{st}$ , and  $G2_{st}$  are obtained, with the obvious adjustments, as in equations (3), (4), and (6).

### 6.1 Evidence at the Individual Sectoral Level

When we analyze the development of sectoral trade globalization in greater detail it is crucial to account for the significant differences in sector sizes.<sup>4</sup> Figure 6 therefore shows the levels of both  $G2_{st}$  and  $R'_{st}$  relative to the respective sectoral weights for six representative points in time. The figure documents: (i) low levels of trade globalization in the 1960s; (ii) tremendous increases over time; (iii) significant differences between the sectors; and (iv) significant differences between the bounded and unbounded dimensions.

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<sup>3</sup>  $R'_t < 1$  occurred in 1975, 1982, 1986, 2001, 2009, and 2015. The strongest decrease in trade volume was reported in 2009 ( $R'_{2009} = 0.823$ ).

<sup>4</sup> Throughout the whole investigation period, the sectors in our sample were very heterogeneous in size: we observe a small number of large sectors and many small sectors. The size of the individual sectors did not remain constant over time; yet the initial size of the sector influences the sectoral growth potential. It is therefore important to put the growth rates in trade globalization into perspective: high growth rates in small sectors need to be interpreted differently from the same growth rates in large sectors. By accounting for sector size, we are also able to highlight the structural change that takes place over time.

Concerning trade volume, we find that  $R'_{st}$  was below 1.30 in 1968 for every single sector. Its growth remained modest in the 1970s and 1980s, with only 29 sectors reaching a level of  $R'_{st}$  higher than 5. From the 1990s on, however, sectoral trade volume growth increased significantly, with 32 sectors reaching levels higher than 10 in 1996. By 2016,  $R'_{st}$  is greater than 10 in 84 sectors, and 16 sectors had values even greater than 50.<sup>5</sup> As already described, the size of the sectors is critical for interpreting the level of  $R'_{st}$ : whereas most sectors with very high growth rates were very small, the electronic equipment as well as the TV & radio sectors were characterized not only by very high increases in  $R'_{st}$  but also by significant increases in sector weight, highlighting the important role that these sectors played in the overall development.

The trend toward greater trade globalization is also evident from the evolution of the average level of  $G2_{st}$ . While 1968 saw an average of only 0.161 (with the upper bound being 1), the average was 0.255 in 1986. Nevertheless, the development in the bounded dimensions was far less pronounced than in the unbounded dimension. In 2016 the average level of  $G2_{st}$  is 0.450, thus still leaving manifold possibilities for sectoral trade globalization to increase in the future. Looking even more closely, we find that the number of sectors with  $G2_{st} < 0.2$  fell from 97 in 1968 to 40 in 1996, and to 20 in 2016. Meanwhile, the number of sectors with  $G2_{st}$  between 0.6 and 0.8 was zero until 1996, but increased to 41 of 147 sectors in 2016. Until 1986, fabrics & textile fibers and basic chemicals were the two sectors with the highest levels of trade integration in  $G2_{st}$ . Since then, the plastics sector has gained more and more importance, such that it became the most globalized sector in 2016, with  $G2_{st} = 0.812$ . In comparison to  $G2_{st}$ , the results for  $G1_{st}$  suggest an even higher level of sectoral trade globalization, implying that distance is important at the sectoral level as well. In fact, the average value of  $G1_{st}$  was 0.218 in 1968 and reached 0.509 in 2016.

[Insert Figure 6 here]

## 6.2 Sectoral Trade Globalization according to R&D Levels

Given the differences between sectors, we wish to shed more light on the process of trade globalization. We complement our analysis up to this point by analyzing sectors' R&D intensity. We distinguish between high-technology (HT), medium-high-technology (MHT),

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<sup>5</sup> Some sectors experienced extraordinary high growth rates due to their very small sizes. These sectors, such as TV, could not be displayed in the figures, as otherwise the growth rates of the majority of sectors would not be visible.

medium-low-technology (MLT), and low-technology (LT) sectors (according to the OECD classification). Before we turn our analysis to the various dimensions of trade globalization, we first focus on the importance of the share of the respective technology classes for trade in general. We observe a clear shift in exports since the 1960s, from lower-tech sectors to high-tech sectors. The latter increase their share from 10.51% in 1968 to 27.25% in 2016. At the same time, the low-tech and medium-low-tech sectors suffered the greatest declines in importance, leaving the medium-high-tech sectors as the largest group over the whole investigation period (with a share of 34.56% in 1968 and 31.22% in 2016, respectively). In terms of growth in trade volume, the evolution of the high-tech sectors is remarkable, above all since the 1990s.

Concerning the bounded dimensions of trade globalization, Figure 7 shows that the level of the phenomenon negatively depends on the level of R&D-intensity. Specifically, the high-tech sectors were characterized by the lowest level of trade globalization in 1968 (with  $G1_{HT,1968} = 0.525$ ) and continued to be so in 2016 (with  $G1_{HT,2016} = 0.921$ ). The low-tech sectors, conversely, were always the most globalized ones, advancing from an initial level of  $G1_{LT,1968} = 0.737$  to  $G1_{LT,2016} = 0.961$ . The catch-up of the medium-low and medium-high tech sectors toward full integration is also noteworthy. We can conclude therefore that the number of positive bilateral trade relations increased significantly over time for all R&D categories. While the differences between the results for  $G1_t$  and  $G2_t$  were very small in the overall picture, the very low levels of  $G2_{HT,t}$  show the importance of distance for these sectors when they set out to establish trade relations at the beginning of our observation period. Studying Figure 7, panels (7a) and (7b) together reveal that globalization first involves sectors with low R&D requirements, which can be adopted by developing countries and industrialized countries alike. The export of high-tech sectors, conversely, involves greater investments in labor and capital, and evolve much more slowly. The lower degree of trade integration in  $G1_{HT,t}$  and  $G2_{HT,t}$  can also be explained by the fact that some of these sectors were almost insignificantly small in the 1960s. As these sectors grew in importance, namely due to innovations in the information and communication sectors (WTO, Institute of Developing Economies, OECD, World Bank, and China Development Research Foundation, 2019), so did trade.

[Insert Figure 7 here]

In a last step we combine the study of the joint evolution of the bounded and unbounded dimensions of trade globalization with the consideration of sectors' R&D-intensity (Figure 8).

So far we have seen that bounded and unbounded dimensions can vary widely in their growth rates, but that all dimensions of trade globalization increase over time, albeit at different paces. Turning to the four groups of sectors differentiated by R&D-intensity, we find that the annual change in  $R'$  is very low in the first sub-period for all groups. This change is much more pronounced in the second sub-period, and while this holds for all groups of sectors, the effect is much more pronounced in the high-tech sectors. This development is partially driven by a sector-size effect because high-tech sectors were smaller on average than other sectors. The higher annual growth rates in the high-tech and medium-high-tech sectors' bounded dimensions ( $G2$ ) show the catch-up toward the already more globalized low-tech and medium-low-tech sectors, supporting our interpretation of the evidence presented in Figure 7. We furthermore find a very strong positive correlation between the absolute number of bilateral trade relations and the volume of trade for all technology classes (above 0.95 for all four technology categories and for both sub-periods). Interestingly, changes in  $R'$  do not necessarily coincide with changes in  $G2$ , implying that while bounded and unbounded dimensions move in the same direction, the pace can be quite different. This once again highlights the need to study a wide variety of indicators to successfully map trade globalization.

[Insert Figure 8 here]

## 7. Conclusion

This paper adds to the literature by: (i) considering over a long time span the interdependencies between countries, rather than treating countries as isolated entities; (ii) proposing a set of bounded and unbounded dimensions in order to gain a deeper understanding of the underlying forces; and (iii) analyzing the sectoral evolution of trade globalization, at the individual level and with the help of R&D categories, to establish a more in-depth understanding of the phenomenon.

From an empirical point of view, we present evidence that trade globalization increased significantly in all dimensions under study over the course of time. Our approach innovates insofar as it allows us to highlight differences between the individual dimensions. We can provide evidence that both the initial levels and the evolution over time varied considerably and deserve more detailed investigation.

With respect to the number of bilateral relations and the distances involved, we were able to show that trade globalization was already advanced in the late 1960s, but expanded further to approach almost its upper bounds in 2016. Altogether, our results point to the existence of a gradual “*death of distance*”: even those countries that were not well-integrated into the world trade network in the 1960s significantly increased the number of their trading partners, regardless of distance, by 2016.

A closer look at sectoral trade globalization, however, reveals the great potential for further integration: the average share of sectors involved in bilateral trade linkages increased from one fifth in 1968 to one half in 2016, with stronger trade linkages between neighboring countries. Again, we found a disaggregated analysis of individual sectors and their R&D characteristics to be beneficial, as it highlighted the existence of strong heterogeneity at the sectoral level. We find the low-tech sectors to be the most globalized, and to remain so despite the catch-up of other sectors. We found the development of some medium-high-tech and high-tech sectors particularly noteworthy. These were small in sectoral size and in trade volume at the beginning of the observation period but experienced very high growth rates.

Thus, we were able to show that trade globalization should be understood not only as a multidimensional phenomenon, but that these different dimensions evolve at different paces, allowing us to draw finely differentiated conclusions regarding the level of trade integration already achieved. In terms of the number of countries, trade integration has almost reached its upper bound; however, protectionist policies could have a detrimental effect in the future. We find full trade integration regarding the number of sectors to be far from complete, implying that potential advantages of international trade have not yet been seized.

In future research we aim to: (i) discuss in more detail the reasons behind evidence at the sectoral level for some specific sectors; and (ii) to quantify the contribution of each country (both as exporter and importer) to the trends we identify (which is different from evaluating globalization at the country-level) in order to gain even more insight into the drivers of trade globalization.

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Table 1: Multidimensional indicators of globalization

Index	Authors	Number of indicators (economic dimension)	Other dimensions	Distance	Time frame	Number of countries
A.T. Kearney / Foreign Policy Globalisation Index	A.T. Kearney (2001), Lockwood (2004)	11-14 (2-4)	Political, cultural, environmental, personal contacts	No	1998-2009	62 72 (from 2007 on)
CSGR Globalization Index	Lookwood and Rodeano (2005)	16 (4)	Social, political	No	1982-2004	26 in 1982; 103 in 2004
KOF Index	Dreher (2006), Gygli et al. (2019)	23 (8)	Political, social, cultural	No	1970-2017	208
Maastricht Globalisation Index	Martens and Zywietz (2006), Figge and Martens (2014)	11 (3)	Political, social & cultural, technological, environmental	No	2000 -2008, 2012	117
New Globalization Index	Vujakovic (2010)	21 (9)	Political (environmental), social	Yes	1995-2005	70

Figure 1: Empirical approach

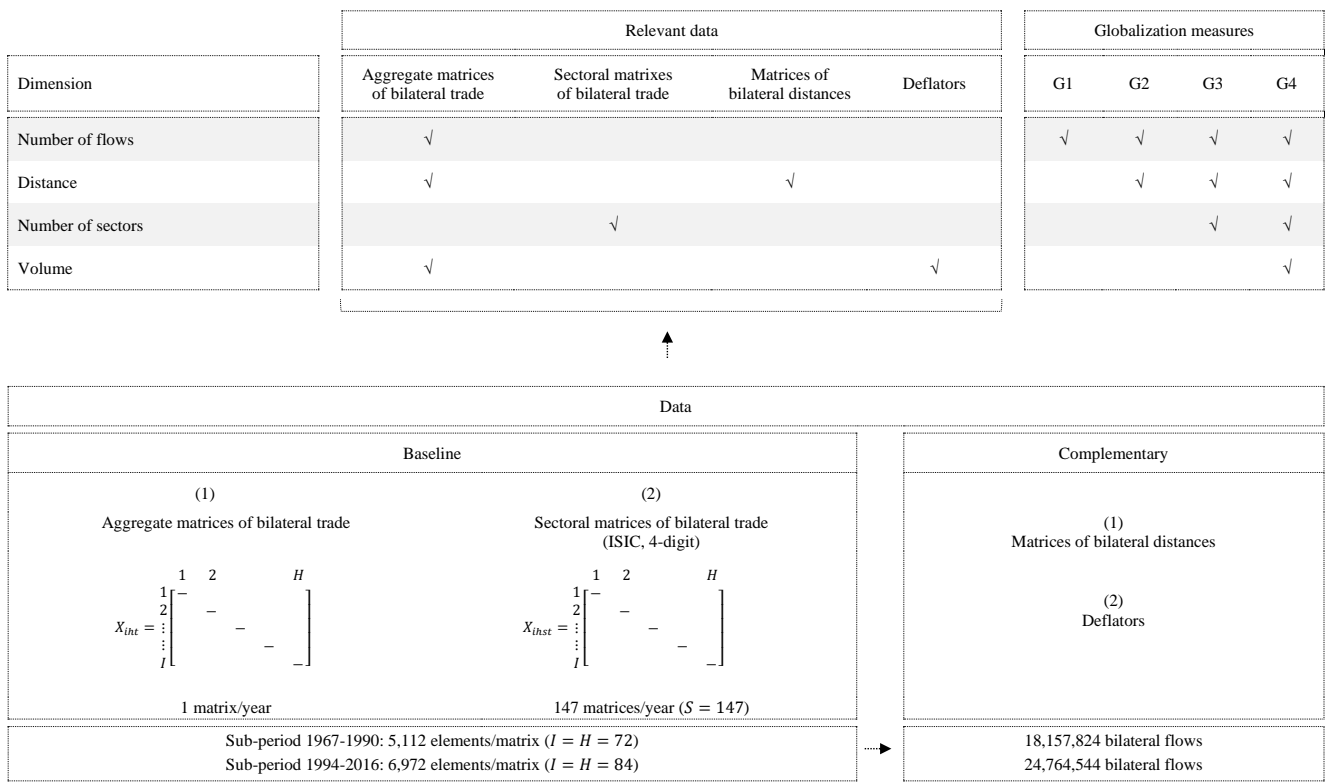
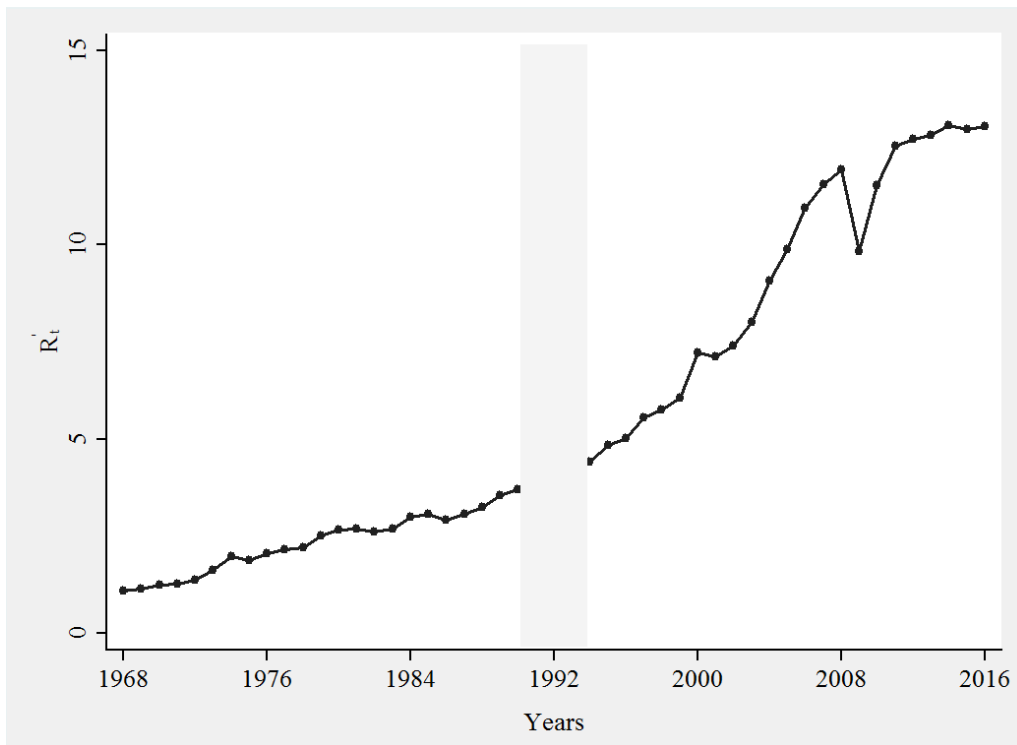
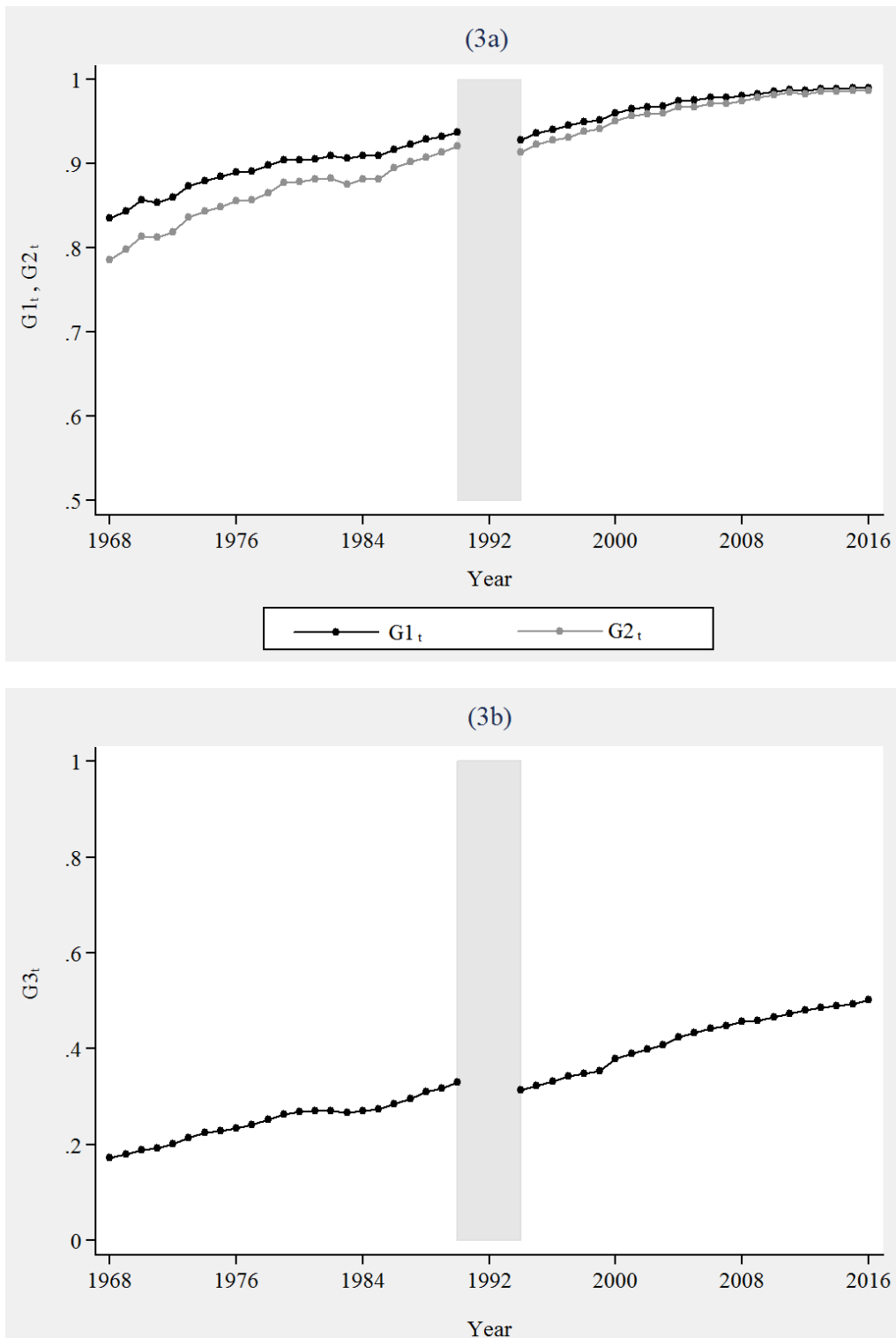


Figure 2: Evolution of trade volume



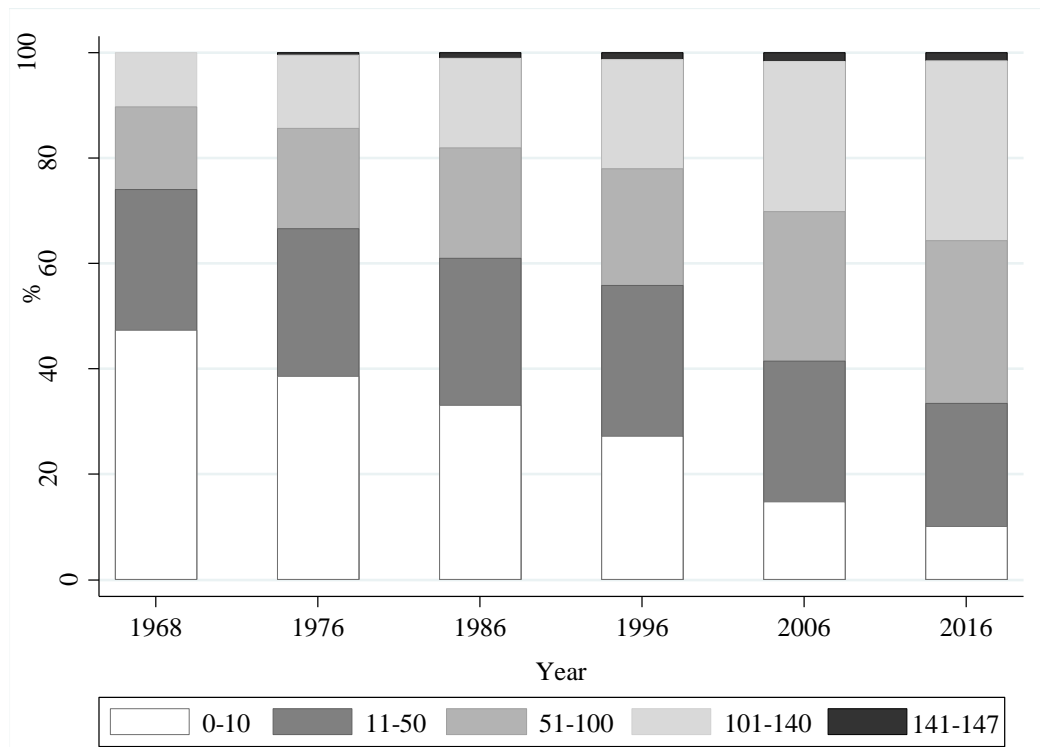
Note:  $R_t'$  captures the unbounded dimension of trade globalization, corresponding to a comparison between the actual volume of trade and the corresponding value at the beginning of the period under scrutiny.

Figure 3: Bounded dimensions of trade globalization



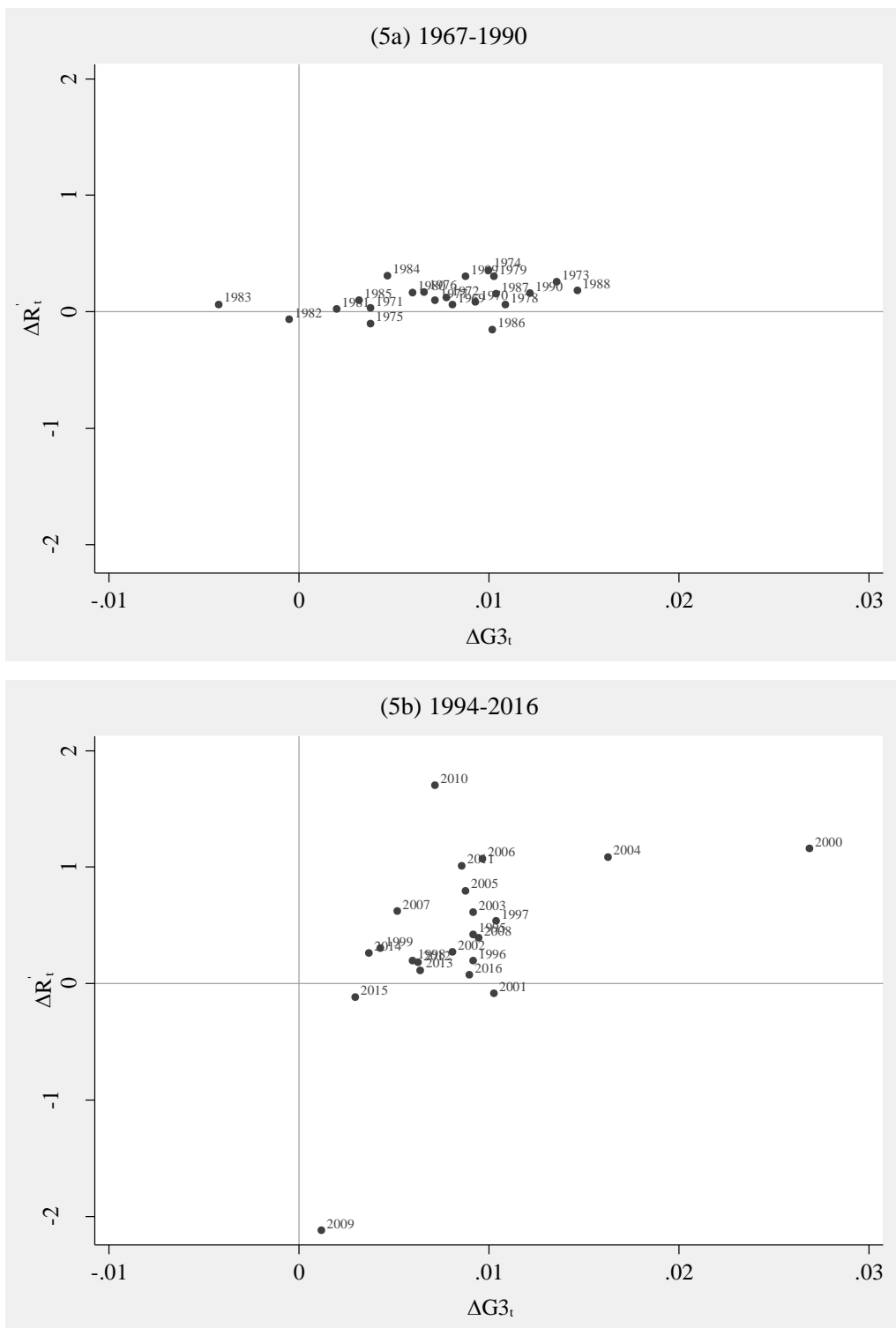
Note: In panel (3a),  $G1_t$  represents the percentage of bilateral relations with positive trade in the total number of country pairs at the world level and  $G2_t$  incorporates the distance travelled by trade, capturing the proportion of the total distance among all the countries in which positive trade exists. In panel (3b),  $G3_t$  is built from  $G2_t$  by adding the sectoral dimension of trade globalization.  $G3_t = 1$  when all sectors are traded in all bilateral relations.

Figure 4: Number of sectors per bilateral trade flow



Note: For each of the years considered, the number of sectors involved in each bilateral trade relation was calculated. For the first sub-period, this corresponds to obtaining the number of sectors traded in each of the 5,112 flows; while for the second sub-period, 6,972 flows were analyzed. Thereafter the flows were classified into five categories: 0-10 sectors per flow; 11-50; 51-100; 101-140; and 141-147.

Figure 5: Bounded and unbounded dimensions of trade globalization



Note: this figure displays the relationship between changes in  $R'_t$  (capturing the unbounded dimension of trade globalization) and changes in  $G3_t$  (bounded dimensions of trade globalization).

Figure 6: Trade globalization - an analysis per sector

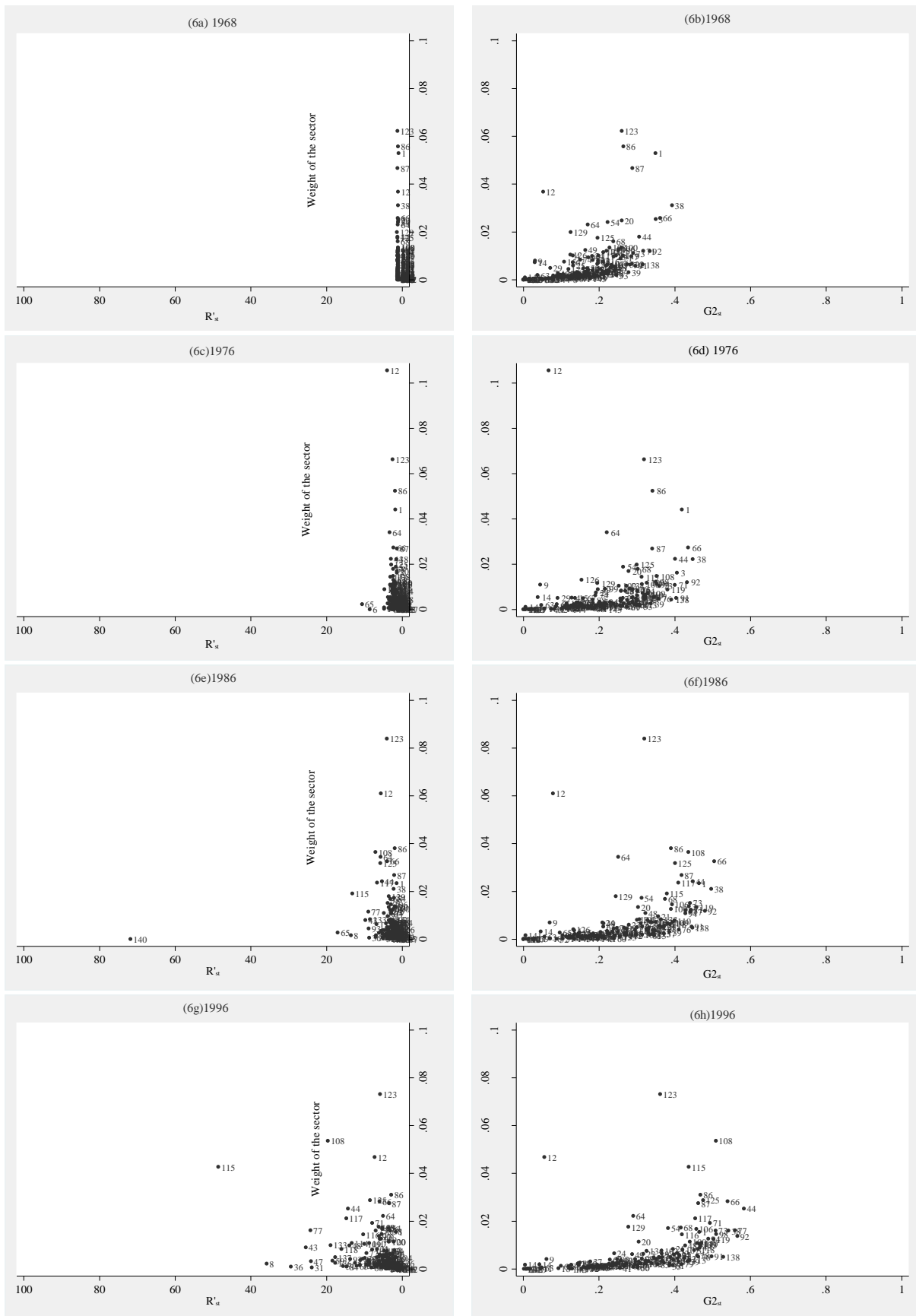
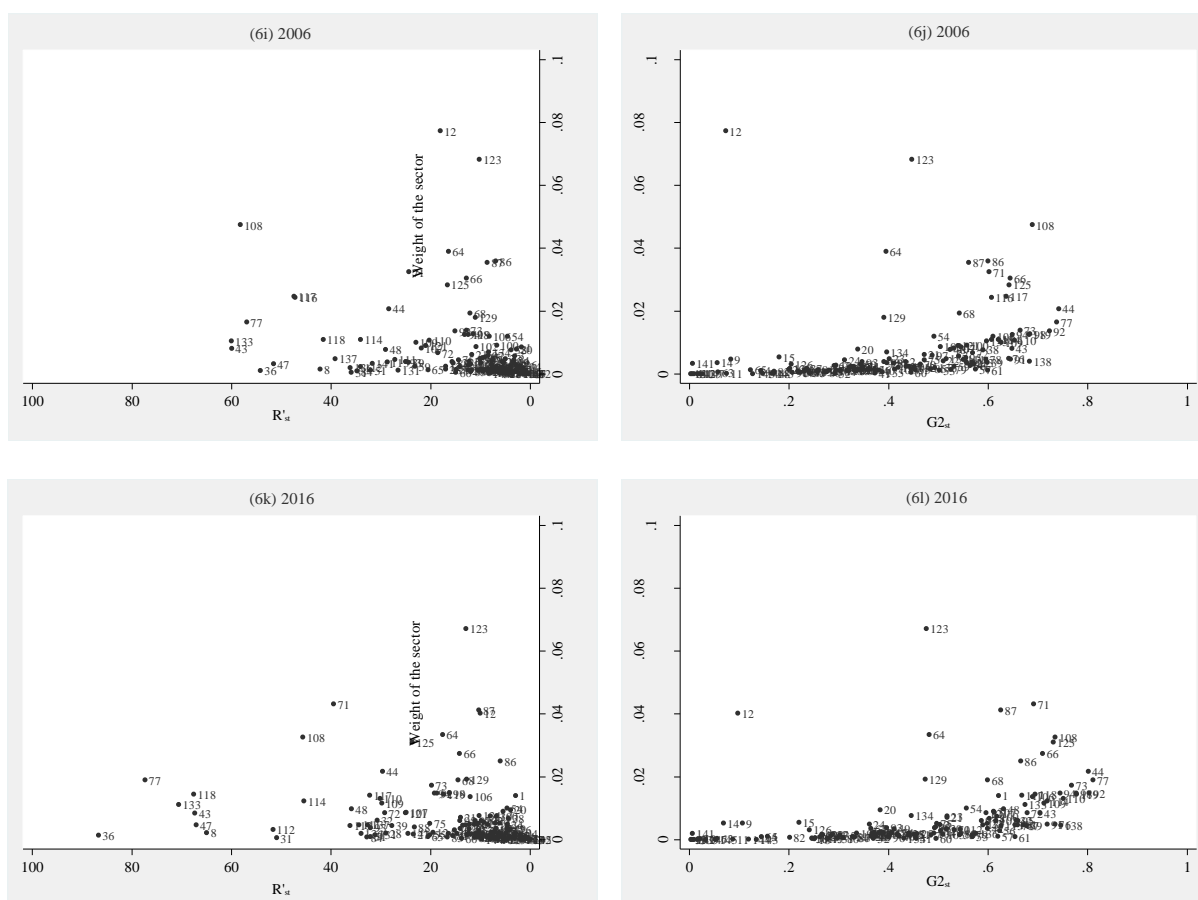


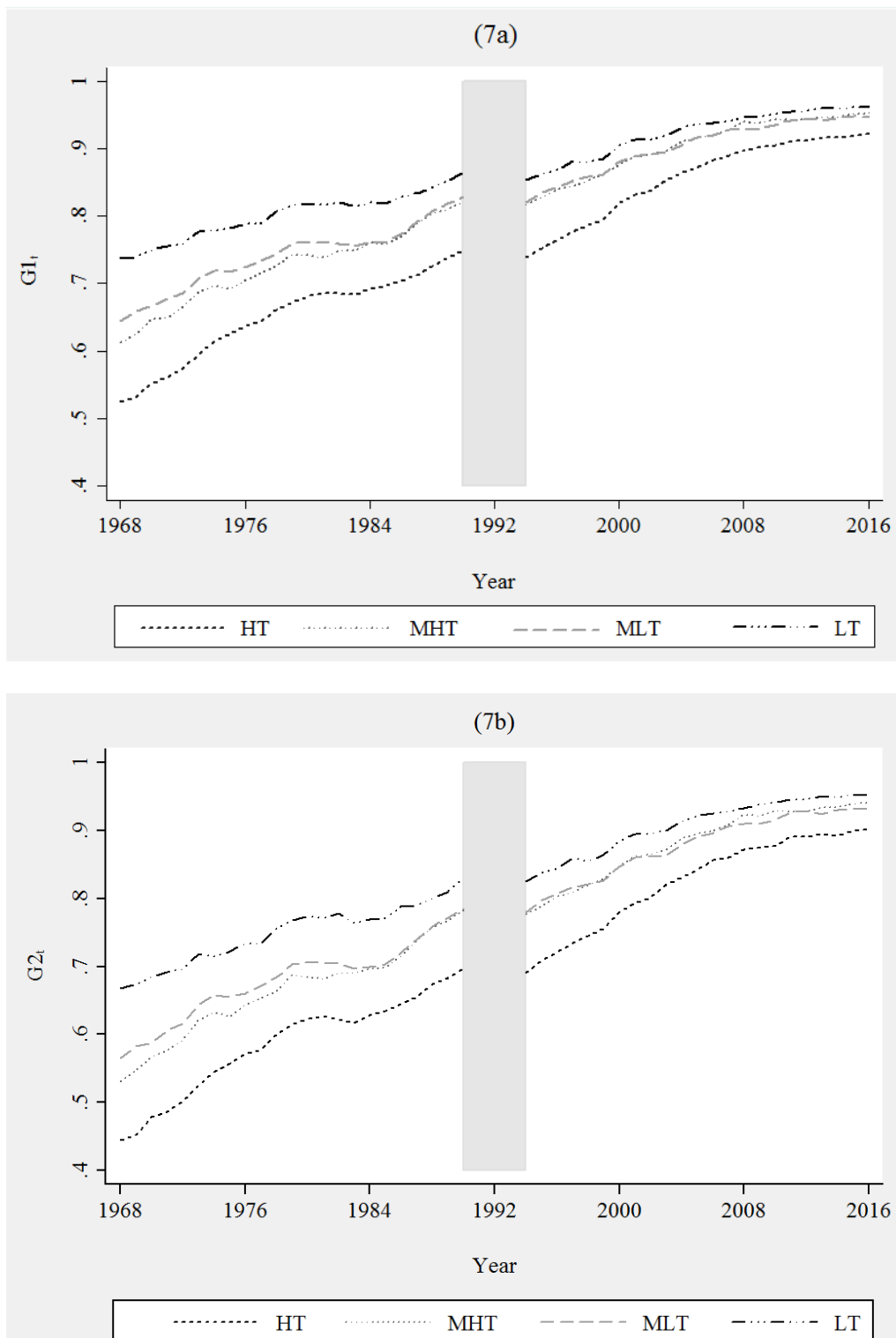


Figure 6: Trade globalization - an analysis per sector (cont.)



Note: These panels show evidence concerning the levels of both  $G2_{st}$  and  $R'_{st}$  relative to the respective sectoral weights for six selected years. In each year, sectors with  $R' > 100$  are excluded from the graphs. The number of sectors excluded by this criterion is: 0 sectors in 1968; 4 sectors in 1976 (0.02% of the total in terms of volume of trade); 4 sectors in 1986 (0.10% of the total); 5 sectors in 1996 (0.18% of the total); 6 sectors in 2006 (4.23% of the total); and 7 sectors in 2016 (7.83% of the total).

Figure 7: Sectoral trade globalization according to R&D intensity – bounded dimensions



Note: In this figure sectors are grouped into 4 categories: high-technology (HT); medium-high-technology (MHT); medium-low-technology (MLT); and low-technology (LT) sectors (according to the OECD classification). Panel (7a) shows for each of the categories the evolution of  $G1_t$  while in panel (7b) a similar analysis concerns the evolution of  $G2_t$ .



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