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The Volatility of International Trade Flows in the 21st Century

Whose Fault Is It Anyway?

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Abstract

After investment, exports and imports are the most volatile components of aggregate demand within countries. Moreover, the volatility of growth and the volatility of trade flows tend to move together; they declined from the 1990s until 2009, followed by an increase since 2009. This paper explores the drivers of such movements in trade-flow volatility. The analysis decomposes trade growth into six components to study their contribution to the overall volatility of trade flows, and presents three findings. First, trade volatility is mostly explained by a factor common to all countries, country-specific factors, and changes in the gravity-related characteristics of a country's trading partners. Product composition and the identity of trading partners appear to be less important in explaining volatility. Second, the pre-2009 decline in volatility and the post-2009 increase in volatility appear to be driven by different factors. The former is mostly explained by a steady decline in the variance of country-specific factors. In contrast, the latter appears to be driven mainly by an increase in the volatility of factors common to all countries. Third, trade diversification is a likely force behind the steady decline in trade volatility driven by country-specific factors, especially in developing countries.

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The Volatility of International Trade Flows in the 21st Century: Whose Fault Is It Anyway?

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1 Introduction

Volatility is regarded as an important determinant of many economic outcomes. A variety of studies identify a link between volatility and variables such as economic growth (Ramey and Ramey, 1995 and Hnatkovska and Loayza, 2004), poverty and inequality (Gavin and Hausmann, 1998; Laursen and Mahajan, 2005), and welfare (see Loayza et al, 2005, and references therein). Moreover, economic volatility, which was previously thought of as a malady of developing economies (Loayza et al, 2005 and Koren and Tenreyro, 2007), now affects rich and poor economies alike. This has brought renewed attention to the study of volatility and its determinants.

One potential cause of volatility is international trade, with three empirical regularities backing this claim.[2] First, exports and imports rank among the most volatile components of GDP, falling second only to investment. Second, trade volatility follows closely the behavior of GDP volatility over the past 20 years—a slight downward trend from the mid-1990s until 2008, followed by a sharp increase after the global financial crisis of 2008-2009. Finally, there is evidence of a positive correlation between trade openness and volatility (di Giovanni and Levchenko, 2009).[3]

Moreover, the rapid expansion of trade over the last 25 years relative to GDP has translated into stronger and broader trade linkages across the board (de la Torre et al., 2015). A consequence of this denser global trade network is a higher degree of business cycle synchronization around the world (Calderón, Chong and Stein, 2007).

The above discussion suggests that understanding the factors affecting the volatility of international trade flows is of paramount importance for understanding GDP volatility, both within countries and globally. With this objective in mind, this paper provides a decomposition of trade growth volatility into various elements. More specifically, it follows the methodology in Koren and Tenreyro (2007), which allows us to decompose trade volatility into six factors which have received attention in the literature—a common term, a country-specific term, a partner term, a sectoral term, a resistance term and an error term.[4]

[2] In addition to affecting volatility directly, international trade has also been found to affect the relationship between volatility and growth (see Kose, Prasad, and Terrones, 2005).

[3] To be sure, Caselli et al., 2015, revisit the relation between trade openness and GDP volatility through a model of international trade and find that countries that suffer from big country-specific shocks can experience reductions in volatility when opening to international trade, as trade becomes a source of diversification.

[4] The partner term refers to the volatility that can be attributed to shocks that stem from trading partners. The sectoral term refers to the volatility that can be attributed to shocks that stem from sectors that are present in a country's trade basket. The resistance term refers to the volatility that can be attributed to changes in the geography and economic characteristics of trading partners and changes in the elasticity of trade to these attributes. Finally, the error term is the volatility that can't be attributed to the aforementioned elements.

The results of the empirical exercise presented in this paper are threefold. First, a decomposition of trade volatility over the past 20 years points to two main drivers of trade growth volatility over that period. The largest contribution to trade growth volatility can be attributed to the volatility of the common factor and the resistance term. When the two are taken together (that is, when their correlation is taken into account), they account for close to 70 percent and 60 percent of the overall volatility of exports and imports, respectively. The second largest contribution comes from the country-specific and the error terms, which taken together account for close to 30 percent and 40 percent of the overall volatility of exports and imports, respectively. In contrast, the product and partner effects do not appear to add significantly to trade volatility, beyond the effect captured by the common factor.

Second, the volatility decomposition presented in this paper provides a useful methodology to understand the evolution over time of the six components of volatility. In particular, the paper performs additional decompositions using 10-year rolling windows to study changes over time of the elements of interest. The results of this exercise highlight two important trends among the factors contributing to trade volatility. On the one hand, the common effect and the product effect experienced a sharp increase in volatility since 2009, after years of relatively flat volatility profiles. In contrast, the country-specific and the error terms show a steady downward trend throughout the period of analysis, especially until 2008. Hence, the results suggest that the decline in trade volatility observed prior to 2009 was mainly driven by a gradual decline in country-specific risk. Moreover, the lower incidence of the country-specific effect and the error was not reversed after the global financial crisis, suggesting that on average countries were able to maintain lower variances of the country-specific term relative to the early periods even as total trade volatility increased since 2008. In contrast, the post-2009 spike in trade volatility appears to be driven mainly by a sudden rise in the volatility of common factors, and to a lesser extent, in sectoral volatility.

Finally, the paper explores one potential force driving the decline in the volatility of the country-specific term described above—trade diversification. We do so by pursuing three alternative exercises. First, the paper shows that the variance of the country-specific term is negatively correlated with the initial number of product-partner pairs of a country. Moreover, we show that this negative correlation is not driven by other variables that are linked to both diversification and volatility, such GDP per capita or population. Second, we use a fixed effects approach to highlight that as countries become more diversified they experience a significant reduction in the variance of the country-specific term. Lastly, we study the effect of trade diversification on country-specific trade volatility by exploiting differences in the timing of trade liberalization. Kose, Prasad and Terrones (2005) and Cadot, Carrère and Strauss-Khan (2011) provide evidence of an increase in the degree of diversification following periods of trade liberalization. This implies that countries that liberalized trade more recently should have had bigger gains in terms of

diversification compared to those that liberalized earlier, and, as a result, experienced greater reductions in the volatility of the country-specific term. We test this hypothesis by analyzing the evolution of the volatility of the country-specific term in two groups of countries: i) countries that liberalized trade prior to 1985 (early liberalizers) and ii) countries that liberalized trade between 1985 and 1998 (recent liberalizers). The results show significant differences between the two sets of countries. Regarding the initial levels of volatility, countries with recently liberalized trade regimes have higher levels of volatility in the country-specific term compared to countries with more established liberalized trade regimes. However, the difference in volatility between the two groups has fallen significantly over time as the former experienced more marked reductions in country-specific variance over time relative to the latter.

This paper is related to a large literature studying volatility and its determinants. From a methodological standpoint, this paper is closely related to Koren and Tenreyro (2007) who decomposed the volatility of GDP growth into country-specific, sectoral and idiosyncratic terms. In this sense, the use of trade data allows us to analyze additional dimensions and questions that could not be studied in Koren and Tenreyro (2007). This paper is also related to di Giovanni and Levchenko (2009) who study the relation between trade openness and volatility. Relative to both these studies, this paper contributes to the debate by studying changes over time in the factors affecting volatility as well as emphasizing the effect of trade liberalization on volatility.

Similar to this paper, Di Giovanni and Levchenko (2012) study the risk content of exports across countries, with an interest in the contribution of export products. In particular, the authors compute a trade weighted measure of volatility associated with the sectoral composition of trade by using the sectoral volatilities calculated by Koren and Tenreyro (2007). Jansen, Lennon, and Piermartini (2016) apply a portfolio theory approach to assess the contribution of trading partners GDP volatility on a country's GDP volatility. In contrast to both these papers the methodology used here allows us to study factors that go beyond the individual contributions on a country's volatility profile of the sectoral composition of trade or trading partners.

This paper is also related to a number of studies looking at the role of globalization and trade linkages in affecting business cycle synchronization, and potentially volatility, across countries. For instance, Calderón, Chong and Stein (2007) find that countries with stronger trade linkages have greater business cycle synchronization. Yet, Kose, Prasad and Terrones (2003) find limited evidence of a link between broad-based globalization and business cycle synchronization. In contrast, our results show a significant role of a common effect in explaining trade volatility. Part of the differences in the findings of Kose, Prasad and Terrones (2003) and the ones presented in this paper may be due to the time period studied. In effect,

and as was discussed earlier, the results in this paper highlight the sharp increase in the common effect after 2009, an event that occurs outside of the timeframe studied in Kose, Prasad and Terrones (2003).

The rest of this paper is organized as follows. Section 2 characterizes three broad trends in international trade over the past 20 years and highlights three questions emerging from them which are at the heart of this paper. Section 3 presents the methodology used to address the main questions of this paper. Section 4 presents the main results of the paper and relates these with the question motivating it. Section 5 presents a number of robustness checks. Section 6 concludes.

2 Trade patterns around the 21st century: Trends in growth, volatility and openness

After two decades of stubbornly high GDP growth volatility in the 1970s and 1980s, the 1990-2008 period saw a marked reduction in volatility in the average country in the world. This period of relative stability, which has been labeled as "the great moderation", ended abruptly as the global financial crisis of 2008-2009 erupted and hit the global economy across the board.

The great moderation and the following period of volatility also saw important, and likely inter-related, developments on the side of international trade. Indeed, a cursory look at the data shows three broad trends in international trade flows: i) a steady reduction in the volatility of trade growth, especially in the mid-2000s, followed by a sharp increase since 2008, ii) a gradual deceleration of trade growth in the years from 1990 until 2008, followed by a more marked deceleration of trade growth after 2008, and iii) a sustained increase in the relative weight of trade flows on GDP. [5]

These three broad trends are depicted in Figure 1. The figure presents the average growth rate and the standard deviation of the growth rate of both export and import flows, as well as the average ratio of trade over GDP, all calculated over 10-year rolling windows. In addition to plotting the evolution of these statistics for the average country, Figure 1 also presents the evolution for the median, the 25th percentile

[5] To be sure, arguably the deceleration in trade flows, which has become particularly acute in the aftermath of the 2008 global financial crisis, has causes that go beyond the sluggish growth of GDP worldwide, especially when looking at the pre-crisis trends. For instance, Constantinescu, Mattoo, and Ruta (2015) use an error correction model to study the responsiveness of trade to GDP growth for a long time horizon and find that the decline in the former is of structural nature and goes beyond the recent slowdown on the latter. Yet, as mentioned in Baldwin (2009) and Levchenko, Logan and Tesar (2010), changes in GDP growth between 2008 and 2010 did affect trade growth over that period. Regardless of the causes behind the dynamics of trade, this papers highlights that, in broad terms, trade and GDP appear to follow similar dynamics over the 1990-2011 period.

and 75th percentile of each the distributions of these variables.[6] The evidence in the graph shows that the three trends described above are not specific to the average country—they are also evident in countries located at the 25th, 50th, and 75th percentiles of the distribution of each variable. In this sense, the trends characterized in Figure 1 cut across a broad set of countries of different levels of income and openness.

Alongside these three trends, there have been two additional, and possibly inter-connected, changes in the global trade landscape since the 1990s. The first is the rapid increase in the share of countries adopting liberalized trade regimes since the 1990s, going from approximately 30 percent of the countries in the world in the late 1980s to close to 75 percent by the early 2000s (Wacziarg and Welch , 2008). The second change is a steady and widespread process of trade diversification observed since the 1990s (see Lederman, Pienknagura, and Rojas, 2015, and references therein).

The discussion above puts three questions on the table that are at the heart of the discussion of this paper:

1) What factors drove trade volatility over the past 20 years: global factors, country-specific factors, the composition of trading partners, the composition of export products or other factors?
2) How has the influence of each of these factors over volatility evolved over time?
3) What role has the process of trade liberalization and diversification played in explaining the influence of the factors affecting trade volatility?

In order to answer these questions, the paper follows the methodology proposed by Koren and Tenreyro (2007) and decomposes trade volatility into different sources. The next section describes in detail the methodology used to decompose the volatility of trade flows. Then, Section 4 presents the results of the decomposition and addresses the three questions posed above.

3 Methodology and Data

Broadly speaking, the discussion over trade and, more generally, GDP volatility has focused around four potential forces. First, there is a conventional wisdom view that emphasizes the role of growing trade and financial globalization as a cause of volatility and business cycle synchronization. To be sure, the evidence prior to the global financial crisis of 2008-2009 provided limited support to the idea that globalization leads to business cycle synchronization (Kose, Prasad and Terrones, 2005). Yet, the great degree of co-movement observed since the global financial crisis brought the attention back to globalization as a potential source

[6] Figure 1 presents results for a set of countries from high-income and emerging economies reporting trade data for all years since 1979.

of volatility. Underlying this conventional view is the idea that there are shocks that are common across countries and sectors of the economy.

A second source of volatility identified in the literature is related to country-specific shocks. For instance, Koren and Tenreyro (2007) argue that country-specific risks, which they interpret as domestic policy risks, explain a large share of GDP volatility. Relatedly, Raddatz (2007) shows through a VAR exercise that internal factors (as opposed to external factors like commodity prices) are the main source of fluctuations in low income countries. In these papers, country-specific shocks cut across all sectors in the economy.

A third source of volatility is related to trade connections and the identity of trading partners of a given economy. More specifically, the literature has stressed the role of trade linkages as a channel through which shocks are propagated (Frankel and Rose, 1998, Calderón, Chong and Stein, 2007, and Jansen, Lennon, and Piermartini, 2016). This suggests that deeper trade linkages increase a country's exposure to shocks emanating from their partners. However, the extent to which trade linkages are an important driver of volatility is related to the magnitude of these shocks. Hence, the intensity of a country's trade linkages and the identity of the partners with whom these linkages are established may be important drivers of volatility.

Finally, the literature has emphasized the role of product composition as a factor affecting volatility. In particular, Imbs and Wacziarg (2003) and Klinger and Lederman (2004, 2006) find that poorer countries, which tend to display higher GDP and export volatility, have more concentrated production and export baskets. In addition, Koren and Tenreyro (2007) find that poorer countries are concentrated in sectors that are more volatile.

Product composition may also affect trade volatility, and ultimately GDP volatility, through an additional channel. Berthelon and Freund (2008) find that 25 percent of trade goods have experienced an increase in their elasticity with respect to distance, and that differentiated goods have a lower distance elasticity than homogeneous goods. This suggests that changes in search and transportation costs driven from technological change may favor some products more than others. As a result, countries with export baskets concentrated in goods experiencing more drastic changes in their distance elasticities are more prone to experience volatility stemming from this channel.

3.1 Methodology

The emphasis put by the literature in these sources of volatility motivates the empirical exercise pursued in these paper. In particular, we break down a country's export (import) growth into the sum of the growth rates of each destination (origin)-product pair, each of which can have different intrinsic volatilities.

Formally, the growth of exports (imports) in country *i* (g_{it}) can be written as the weighted sum of the trade weighted growth rates of each exporter-importer-product triad:

$$g_{it} = \sum_{j \in J_{it}} \sum_{k \in K_{ijt}} a_{ijkt-1} \times g_{ijkt} \quad (1)$$

where a_{ijkt-1} is the weight in year *t*-1 that the exports (imports) of products in sector *k* from (to) country *i* to (from) country *j* carry in country *i*'s total exports (imports), and g_{ijkt} is the growth rate of exports of goods in sector *k* from (to) country *i* to (from) country *j* in year *t.* The objective of this paper is to understand the factors affecting the volatility of g_{ijkt}, and the role they play in explaining the volatility of g_{it}.

To separate the incidence of each of the forces discussed above in explaining trade volatility, we proceed by breaking further each of the exporter-importer-sector growth rates as follows. First, for each year we estimate the following gravity equation:[7] [8]

$$\ln(X_{ijkt}) = \alpha_t + \gamma_{it} + \lambda_{jt} + \eta_{kt} + \xi_{ijt} + \epsilon_{ijkt} \quad (2)$$

where $\ln(X_{ijkt})$ is the logarithm of sectorial bilateral real export flows[9] of goods in sector k (in the set of industries traded from i to j denoted as K_{ijt}) from country $i, (i \in I)$ to importer j (in the set of i's trade partners J_{it}) in year t. Focusing on country i's exports, the first component in (2), α_t, is a global effect, common to all exporters, importers and sectors for a given year. This captures shocks to trade flows that affects all sectors and countries in the same magnitude. The second component (γ_{it}) is a country-specific component that captures shocks to country i's exports that impact all destinations and sectors equally. This, for example, captures economy-wide macroeconomic policies. Analogously, λ_{jt} is an importer-specific effect that captures shocks common to all origins and sectors. This, for instance, captures changes in the

[7] The estimation results of equation (2) are presented in Appendix B.

[8] The trade literature has proposed several specifications and estimation techniques to estimate the gravity equation. The early gravity papers used a specification and methodology similar to the one used here. A more recently strand of the literature has highlighted the limitations of estimating the log of trade flows in datasets with a large presence of zero flows (see Santos Silva and Tenreyro, 2006). While the latter is a more robust estimation method, we choose the former for two reasons. First, we restrict our sample in such a way to minimize the presence of zeroes. In fact, this restriction is necessary for the right interpretation of the methodology pursued in this paper (see Koren and Tenreyro, 2007). Second, estimating the log of trade flows is more appropriate as its first difference is easily interpretable as a growth rate and, consequently, so are each of the elements in equations (2).

[9] In the description of (2) we focus on exports for illustrative purposes. In the next section, where the main results of the paper are presented, we discuss results for exports and imports.

income level of the importer that affects the demand of all goods from all origins. The fourth component (η_{kt}) is the sectorial effect and captures shocks to trade in sector *k* common to all origins and destinations. Importantly, the exporter, importer, and sectoral effects are normalized such that the sum of all these effects across origins, destinations and sectors, respectively, sum to zero each period.[10] In this sense, the exporter, importer and product effects capture movements along these dimensions that are not captured by the common effect (that is, that do not cut across origins, destinations, and products). The fifth component (ξ_{ijt}) represents the sum of the bilateral resistance effect common in the gravity trade literature. This term explains the fraction of trade from exporter i and importer j that is explained by distance, a shared border, a common legal system, colonial ties, a common language and the presence of free trade agreements between the pair at time t. The remaining term (ϵ_{ijkt}), referred to as the error effect, is the part of exports that is unexplained by the previous components.

Having estimated (2), one can easily approximate aggregate trade growth for country i in period t as[11]:

$$\ln(\widehat{X_{it}}) = \ln(X_{it}) - \ln(X_{it-1}) \cong \sum_{\mathrm{j}\in \mathrm{J_{it}}} \sum_{k\in K_{ijt}} a_{ijkt-1} \times \left(\ln(X_{ijkt}) - \ln(X_{ijkt-1}) \right) \qquad (3)$$

Replacing (2) into (1) leads to:

$$\begin{aligned} \ln(\widehat{X_{it}}) \cong \widehat{\alpha_t} + \widehat{\gamma_{it}} + \sum_{\mathrm{j}\in \mathrm{J_{it}}} a_{ijt-1} \times \widehat{\lambda_{jt}} + \sum_{\mathrm{j}\in \mathrm{J_{it}}} \sum_{\mathrm{k}\in \mathrm{K_{ijt}}} a_{ijst-1} \times \widehat{\eta_{kt}} + \sum_{\mathrm{j}\in \mathrm{J_{it}}} a_{ijt-1} \times \widehat{\xi_{ijt}} \\ + \sum_{\mathrm{j}\in \mathrm{J_{it}}} \sum_{\mathrm{k}\in \mathrm{K_{ijt}}} a_{ijkt-1} \times \widehat{\epsilon_{ijkt}} \end{aligned} \qquad (4)$$

where a_{ijt} and a_{ikt} are the trade shares of partner *j* and sector *k* over i's total exports respectively. Equation (4) states that country i's aggregate trade growth can be approximated as the sum of the growth of a global effect, country i's exporter effect and the trade-weighted sum of the partners' effects, sector effects, resistance effects and idiosyncratic effects.[12]

[10] The restrictions imposed to each set of fixed effects is arbitrary. For example, Koren and Tenreyro (2007) perform a similar empirical exercise as the one presented but impose a zero sum restriction on the country-specific effect. The restrictions chosen in the empirical exercise in this paper are more fitted for the questions which are at the heart of it.

[11] This stems from the identity $g_{it} = \sum_{j=1}^{J} \sum_{k=1}^{K} a_{ijkt} \times g_{ijkt}$ and the approximations $g_{it} \cong \ln(X_{it}) - \ln(X_{it-1})$ and $g_{ijkt} \cong \ln(X_{ijkt}) - \ln(X_{ijkt-1})$

[12] For more details of the exact calculation of each of these effects see Appendix A.

There are two important things to mention with regards to equation (4). First, all of the elements in (4) can be potentially correlated between each other. This is true statistically, but is also economically plausible. For instance, macroeconomic policies, which affect country-specific shocks, can respond to shocks in sectors that are economically relevant in the country. Also, equation (4) is an accounting identity since the error term captures everything that is not explained by the other effects and because we do not place any restrictions on the covariances across elements. As such, while being a convenient way to partition the data, the elements in (4) cannot be matched directly to a specific theory.

From equation (4) it is straightforward to decompose trade growth volatility. In particular, trade growth volatility can be written as:

$$\begin{aligned}\mathrm{Var}(g_{it}) \cong \mathrm{Var}(\widehat{\alpha_t}) + \mathrm{Var}(\widehat{\gamma_{it}}) + \mathrm{Var}\left(\sum_{\mathrm{j}\in \mathrm{J_{it}}} a_{ijt} \times \widehat{\lambda_{jt}}\right) + \mathrm{Var}\left(\sum_{\mathrm{j}\in \mathrm{J_{it}}} \sum_{\mathrm{k}\in \mathrm{K_{ijt}}} a_{ijkt} \times \widehat{\eta_{kt}}\right) \\ + \mathrm{Var}\left(\sum_{\mathrm{j}\in \mathrm{J_{it}}} a_{ijt} \times \widehat{\xi_{\iota jt}}\right) + \mathrm{Var}\left(\sum_{\mathrm{j}\in \mathrm{J_{it}}} \sum_{\mathrm{k}\in \mathrm{K_{ijt}}} a_{ijkt} \times \widehat{\epsilon_{\iota jkt}}\right) + COV\end{aligned} \tag{5}$$

where Var(.) is the variance operator and *COV* is (twice) the sum of all the covariances of the element in (4). The variances and covariances are calculated across the T years in the sample. In particular, for each pair of variables *x* and *y* we calculate variances and covariances as

$$\mathrm{Var}(x) = \left(\frac{1}{T}\sum_{t=t0}^{T}(x_t - \bar{x})^2\right), \qquad \mathrm{Cov}(x,y) = \left(\frac{1}{T}\sum_{t=t0}^{T}(x_t - \bar{x})(y_t - \bar{y})\right)$$

Notice that the measure of volatility used in this paper is by construction capturing deviations around the simple average over the period. This measure is a good proxy of fluctuations derived from short-term shocks to the extent that trade flows grow at a relatively constant growth rate over the period of study. However, for period of trade accelerations, such as the ones observed in periods of liberalization (see Kose, Prasad, and Terrones, 2005), the variance may confound acceleration with volatility. For this reason, we also perform a volatility exercise where we modify the variance and covariance calculations in the following way:

$$\mathrm{Var}(x) = \left(\frac{1}{T}\sum_{t=t0}^{T}(x_t - \bar{x_t})^2\right), \qquad \mathrm{Cov}(x,y) = \left(\frac{1}{T}\sum_{t=t0}^{T}(x_t - \bar{x_t})(y_t - \bar{y_t})\right)$$

$$\text{with } \bar{x}_t = \left(\frac{1}{9}\sum_{\tau=t-t1}^{t+t2} x_t\right)$$

This alternative formulation allows to capture deviations around a local (moving) average around an arbitrary window ($t1$, $t2$), which can be appropriate in periods of trade growth accelerations.[13]

The variance decomposition presented above is a useful partition of the data that allows us to answer the three questions brought forward in Section 2. Each of these questions will be addressed in turn in the next section. But first we briefly describe the data used to perform the empirical exercise described above.

3.2 Data

Annual 4-digit SITC Rev. 2 data on bilateral trade flows—drawn upon from NBER-UN and described in Feenstra et al. (2005)—were used both in the bilateral trade flows estimations, as well as in the estimation using sectoral disaggregation. This dataset is merged with UN COMTRADE 4-digit SITC Rev. 2 data to add more recent years.

Parts of the paper group countries based on whether they have liberalized trade regimes using the classification proposed by Sachs and Warner (1995) and updated by Wacziarg and Welch (2008). While all data sources named above cover a wide set of countries and years, this paper uses a more limited set of these. In particular the sample consists of a core set of countries that reports positive bilateral trade flows with each country in the set for all years from 2001 onwards. The decomposition exercise is performed for the period ranging from 1990 to 2011. This sample captures most of world trade and for each country they capture a large percentage of the country's exports and imports (the minimum share is 67 percent for exports and 64 percent for imports). The algorithm used to select the countries in the sample is described in Appendix C. Section 5 studies the robustness of the results to the inclusion of a broader set of countries by using aggregated sector level trade flows.[14]

The choice of this limited set of countries is convenient for two reasons. First, it allows us to estimate the gravity equation in logs used to obtain the fixed effects without worrying about the zeros in the data.[15] As mentioned earlier, the log estimation used here provides a straightforward interpretation of the first differences of the fixed effects as growth rates. Second, the choice of years is suited to minimize miss-reporting of data. As argued in Berthelon and Freund (2008) the quality of trade data prior to 1980 is very

[13] The exercise was performed for t1=4 and t2=4. As will be discussed in the next section the main conclusions of the decomposition are not affected by this alternative decomposition.
[14] An additional, more restrictive sample was constructed using only countries that report bilateral trade flows for all year from 1990 until 2011. The results that are presented in Section 4 are unaffected by the use of this alternative sample.
[15] The number of zeroes, even when using the sector data, is less than 10 percent of the observations in each year.

poor, with only a handful of countries reporting in the 1970s. In contrast, data coverage expands dramatically in the mid-1980s. Having changes in coverage is particularly problematic in the context of this paper, where the ultimate objective is decomposing growth volatility, since zeroes impede the calculation of growth rates.

The presence of zeroes also constrains the definition of sectors used in this paper. Ideally one would like to identify the set of economically meaningful sectors for the set of countries analyzed in the paper. However, the problem of zeroes discussed above becomes more salient as we move to more disaggregated sector-level data. For this reason we restrict our analysis to four broad sectoral categories using Leamer's (1995) industry clusters.[16] In particular, the paper groups Leamer's industry clusters into four broad sectors: primary agricultural goods, non-agricultural primary sectors, labor intensive manufacturing and capital intensive manufacturing. Primary agricultural sectors include Leamer's Forrest Products, Tropical Agriculture, Animal Products and Cereals clusters. Non-agricultural primary sectors correspond to Leamer's chemical, petroleum and raw materials clusters. Labor intensive manufacturing sectors include Leamer's labor intensive cluster, and Capital intensive sectors correspond to Leamer's capital intensive and machinery clusters.

4 Results

Thus far this paper has presented two ideas that motivate the exercises that follow:

1) There was a systematic decline in trade volatility since the 1990s until 2008, followed by an increase in volatility after the global financial crisis.

2) There are five factors to which the literature has attributed these shifts in volatility.

In what follows, the paper explores (1) the interplay between these factors, (2) their changes over time and how they relate to the overall trends in trade growth volatility, and (3) their potential correlates. The rest of this section is organized around three subsections, each corresponding to the points above.[17] In each subsection we present results for exports and imports.

[16] Leamer (1995) proposes a set of 10 industrial clusters. The distinguishing feature of each of these clusters is that the products included in each of them tend to be exported by countries that are similar in terms of their endowments of labor, land and natural resources. The ten broad clusters are: petroleum; raw materials; forest products; tropical agriculture; animal products; cereals; labor intensive goods; capital intensive goods; machinery; and chemicals.

[17] Results with the alternative sample describe in footnote 15 are qualitatively similar to the ones presented here and are available upon request.

4.1 Growth volatility decomposition: 1990-2011

Figure 2 presents the results of the volatility decomposition for the period 1990-2011, for both exports and imports. The figure presents the mean and the median value of 8 of the 21 components (6 variances and 2 covariances) of the decomposition. The other 13 covariances are relatively small in magnitude (individually and as a sum) and are excluded from the analysis that follows.[18]

The results of the decomposition exercise highlight the dominant role played by common factors in explaining export and import growth volatility. The volatility of the common component ($\widehat{\alpha_t}$ in equation (4)) contributed more to overall variance than any other component. Moreover, the magnitude of its contribution is more than two times as large in absolute value as all but one component in the case of exports, and all but two components in the case of imports. The overall contribution of the common effect, however, is mitigated by a strong negative correlation with the bilateral resistance component. The contribution of the bilateral resistance term through its variance is also an important component in explaining aggregate volatility, ranking third in the case of exports and fourth in the case of imports. Taken together (that is, including their variances and their covariance) changes in the global component and the bilateral resistance component explain more than 70 percent of aggregate export variance and close to 60 percent of aggregate import variance in the average and median countries.

The other two components of equation (4) that appear to have a significant effect in overall export and import growth variance are the country-specific effects and the residual term. Both terms have variances that are similar in magnitude and they are negatively correlated between each other. Taken together, these two effects explain close to 30 percent of exports growth variance and close to 40 percent of import growth variance.

To be sure, the negative correlation between both the global effect and the resistance effect and the country-specific term and the error term are expected from an economic and statistical point of view. From a statistical point of view, these negative correlations capture the fact that when the elements of the growth decomposition that have a more aggregate nature (be it the global component or the country-specific) vary along its mean, the variables that are specific to the trade relation (country pair-product) will tend to move in the opposite direction. From an economic point of view, periods of rapid growth of the global component will typically result in more trade with distant countries, hence reducing the elasticity of trade with respect to distance. This mechanism would yield a negative correlation between the two components. Similarly,

[18] Moreover, both individually and as a sum, the 12 covariances are smaller in absolute value than 7 of the other 9 components in which the paper focuses. The 2 elements that are smaller in absolute value than the excluded elements are two variance terms. Yet, these two elements of the decomposition are of interest in themselves.

periods of rapid growth of a country's exports or imports across the board, will reduce the importance of relationship specific shocks captured in the error term.

The other two elements of equation (4) that are studied in the next subsections are the variances of the partners and products terms. While these two components are small in magnitude relative to the others, once we control for common effects, studying them is of interest given the discussion highlighted in the previous section. We will return to their analysis in the next two subsections.

Importantly, the balance across the factors driving volatility does not appear to be driven by the use of simple variances. As was highlighted in Section 2, one limitation of using simple variances as a proxy of volatility is the fact that in periods of growth accelerations they may confound these accelerations with volatility. To tackle this concern, the decomposition proposed in Section 2 was performed calculating deviations around moving averages instead of simple averages.[19] The results in Figure 3 suggest that the way we approximate volatility does not affect the balance of each of the factors affecting it.

4.2 How has the balance across elements changed over time?

So far this paper has explored the relative contribution to trade volatility over the past two decades of different factors highlighted in the literature. However, one might expect the relative balance across these elements to change over time. Factors like the wave of liberalization of the 1990s, which by the 2000s had already settled[20], or the ascent of China in world trade[21], may have changed the relative contribution to trade volatility of the different factors analyzed in this paper. Hence, this subsection explores in further detail the relevance of the factors contributing to trade volatility by studying changes in their relative contribution to volatility over time.

To study the changes over time of the factors analyzed in this paper, the decomposition of trade growth volatility is run over 10 year rolling windows. This gives a total of 11 overlapping periods that cover the liberalization wave of the 1990s, the period of rapid GDP growth in emerging economies of the early 2000s, and the global financial crisis and its aftermath. Similar to Figure 1, Figure 4 plots the evolution of both the mean and median value of each of the eight variances and covariances with the greatest contribution to total trade growth volatility.

The results in Figure 4 highlight an important shift in the relative contribution of each of the factors analyzed here. In particular, there are three patterns that can be detected when looking at the variance of each of the

[19] See Section 2 for a discussion of the two moving averages used in this robustness check.
[20] For instance, Wacziarg and Welch (2008) show that the number of countries with open trade regimes increased from 40 percent of their sample in 1990 to almost 80 percent in 2000.
[21] See de la Torre et al (2015).

elements in equation (4). The first pattern that emerges from the exercise presented in Figure 4 is the steady decline in the variance of the country-specific and the partner effect both for exports and imports. There is also a decline in the variance of the error term, especially in the case of imports. Clearly, the decline in the variance of the partner effect of one flow is related to the decline in the country-specific effect of the other flow. After all, the partner effect of each flow is the trade weighted sum of the country-specific effects calculated for the other flow. The second pattern that emerges is the relatively flat profile over time of the variance of the resistance effect.

Finally, the third pattern that emerges is the sharp increase in the variance of the common and the sectoral effects since 2009. To be sure, there are some differences in the evolution of the volatility of these two components before and after the global financial crisis. The common effect was relatively constant prior to 2009 and experimented a one-time increase after this year. In contrast, in the case of exports, the variance of the sectoral effect was increasing smoothly prior to 2009, jumps in 2009, and then declines after 2009. In the case of imports, there was a downward trend prior to 2009, a jump in 2009, and then a decline after 2009.

Hence, a simple look at the variances of the factors behind trade growth already provides important information about the forces behind trade volatility depicted in Section 2. The results in Figure 4 suggest that the decline in trade volatility observed prior to 2009 was mainly driven by a gradual decline in country-specific risk. Moreover, the reduction in the variance of this component has not been reversed after the global financial crisis, suggesting that countries have been able to maintain the improvements in their country-specific trade risk profile even as total trade volatility has increased. In contrast, the post-2009 spike in trade volatility appears to be driven mainly by a sudden rise in the volatility of common factors, and to a lesser extent, in sectoral volatility.

To be sure, the overall effect of each of the factors affecting the variance depends also on how they correlate with other terms. As was discussed earlier, once correlations are taken into account the common effect and the resistance effect explain close to 70 percent of the variance of exports and 60 percent of imports, while the country-specific and the error term account for about 30 and 40 percent of the variance of exports and imports, respectively. One can reassess the relative contribution of these two broader components through the rolling-window exercise presented in this sub-section. A simple calculation shows that, once covariances are taken into account, the relative contribution of the common effect and resistance term on export variance increases from close to 70 percent of total variance in the 10 years from 1992 to 2001, to close to 90 percent of the total variance in the period from 2001 to 2011. A more noticeable change is observed in the case of imports— the relative contribution of the common effect and resistance term increases from close to 35 percent of total variance in the 10 years from 1992 to 2001, to close to 80 percent

of the total variance in the period from 2001 to 2011. The rise in the relative weight of the common effect and the resistance on total trade variance is matched by an equivalent decline in the relative weight of the broad effect of the country-specific and error terms, which by 2011 account for approximately 15 percent of export growth variance and 26 percent of import growth variance.[22]

A superficial interpretation of the results analyzed in this section may suggest that understanding the determinants of country-specific factors becomes less important as common effects gain prominence in explaining total variance. However, there are three important reasons for which this might not be the case. First, by construction part of the common effect is capturing country-specific factors—the country-specific effect identified in the exercise presented in this paper should be interpreted as an idiosyncratic, country-specific, deviation from the shocks observed in other countries. In addition, the evidence observed for the pre-2009 period suggests that these country-specific deviations from the common effect played an important role in the steady reduction in trade volatility observed over that period. Finally, as opposed to the common factor, the partner and the product effects, or the resistance term, the country-specific effect is arguably the term in the variance decomposition that is affected the most by domestic policies, which means that it is the term that policy makers have a larger control of. Hence, understanding the factors potentially affecting the country-specific variance term can provide guidance of the mechanisms that can help countries reduce their trade volatility profile.

The next subsection turns its attention to the response of the country-specific effect to one specific policy: trade liberalization. As will be shown, countries that liberalized their trade regimes in the 1990s saw sharp reductions in their country-specific variance term. In particular, these countries converged to the country-specific volatility levels observed in countries that displayed liberalized trade regimes prior to 1985. The analysis then shows one potential channel through which trade liberalization may have induced a reduction in country-specific volatility, namely trade diversification.

4.3 Country-specific volatility, trade liberalization and diversification

The literature has highlighted a number of variables that could affect cross country volatility differences. First, a strand of the literature has emphasized the positive correlation observed between volatility and GDP per capita. Koren and Tenreyro (2007), for instance, show that poorer countries display more volatile growth profiles than richer countries. Moreover, the portion of overall GDP volatility that is explained by country-specific factors is typically larger in poorer countries than in richer ones. A strand of the literature

[22] These contributions do not necessarily sum to the total variance since the product and the partner also carry some weight in explaining total trade growth variance.

has also found a positive correlation between trade openness and volatility (see di Giovanni and Levchenko (2009)).[23]

A mechanism through which both GDP per capita and openness may affect volatility is the extent to which these two variables affect a country's degree of diversification. In effect, Acemoglu and Zilibotti (1997) present a model where underdevelopment, captured in lower levels of GDP per capita, affects a country's ability to diversify its production set, which ends up affecting its ability to cope with sector specific shocks. The positive correlation between diversification and GDP per capita has also been documented by Imbs and Wacziarg (2003) and Klinger and Lederman (2004, 2006). More recently, Haddad et al. (2013) and Lederman, Pienknagura and Rojas (2015) find that the statistical significance of openness and GDP per capita in explaining volatility is substantially reduced once diversification is taken into account. Finally, Caselli et al, 2015 argue that when country-wide shocks are important, openness to international trade can lower GDP volatility by reducing exposure to domestic shocks and allowing countries to diversify the sources of demand and supply across countries. Hence, the discussion above suggests that, regardless of the variables shaping it, trade diversification may be an important force behind the noticeable reduction in country-specific volatility observed since the 1990s.

The rest of this subsection studies the link between trade diversification and the country-specific component of trade volatility. Analyzing the correlation between diversification and volatility is especially important given the timeframe analyzed in this paper. In particular, as was documented in section 2, the bulk of the years included in our analysis (1990-2008) were marked by a steady decline in trade volatility across the board together with a marked increase in trade diversification in developing countries (see Lederman, Pienknagura, and Rojas, 2015 for a discussion). Related to the above mentioned phenomena, is the rapid increase in the share of countries liberalizing their trade regimes since the 1990s (see Wacziarg and Welch, 2008). Kose, Prasad and Terrones (2005) and Cadot, Carrère and Strauss-Khan (2011) provide evidence of an increase in the degree of diversification following periods of trade liberalization. This implies that recently liberalized countries may have witnessed more significant reductions in trade volatility over the period of time studied in this paper.

In light of the previous discussion, the rest of this section explores in greater detail the link between the fraction of trade volatility attributable to country-specific forces and the timing of trade liberalization and diversification. In particular, the analysis starts by linking the evolution of the country-specific component of trade growth volatility to differences in the process of diversification observed among countries that had

[23] This result is challenged by Caselli et al. 2015 who argue that when country-wide shocks are important, openness to international trade can lower GDP volatility by reducing exposure to domestic shocks and allowing countries to diversify the sources of demand and supply across countries.

established liberalized trade regimes prior to 1990 and those that embarked in trade liberalization post-1990. As was highlighted earlier, one of the important outcomes of the process of liberalization was a larger degree of trade diversification among countries experiencing changes in their trade regime. Thus, the rest of the subsection explore the link between trade diversification and country-specific volatility.

To be sure, the literature stresses that trade liberalization and diversification may be linked to variables such as GDP per capita and openness that could directly affect trade volatility. This makes it hard to credibly establish a causal link between the trade liberalization and diversification and volatility. For this reason, the evidence presented above should be interpreted as correlations. This limitation notwithstanding, the evidence presented in what follows can still shed some light in understanding the forces behind the patterns of trade volatility observed over the past two decades.

We start the discussion of the correlates of volatility by studying differences in volatility across countries with different timing of liberalization. In particular we start by emphasizing differences in volatility profiles between countries with established liberalized trade regimes and countries with recent liberalized trade regimes. To do so, we break the sample of countries studies in the paper into two groups—countries that liberalized their trade prior to 1985 according to Wacziarg and Welch (2008) are classified as countries with established liberalized trade regimes, the rest are classified as countries with recent liberalized trade regimes. The former group includes mainly high income countries while the latter is comprised by developing countries.

Figure 5 already points at differences in the behavior of the different elements of trade volatility for the two groups of countries both in terms of the initial levels of volatility as well as the evolution over time. With regards to the initial levels of volatility, Figure 5 shows that countries with recently liberalized trade regimes have higher levels of volatility in the country-specific term compared to countries with more established liberalized trade regimes.

Interestingly, Figure 5 also points to important differences among these two groups of countries with regards to the evolution over time of the variance of the elements of volatility. In particular, a cursory look at Figure 5 suggests that countries with more recent liberalized trade regimes have benefitted from a more marked reduction in country-specific variance compared to those with more established liberalized trade regimes, especially on the side of exports.

The conclusions stemming from the cursory analysis of Figure 5 are confirmed by two econometric exercises, the results of which are presented in Table 1. In particular, we run a regression of the log of the country-specific term variance against a time trend, a country fixed effect, and the interaction between time and a dummy taking value one if the Wacziarg-Welch trade liberalization year stands between 1985 and

1998 and zero if it is before 1985.[24] The inclusion of the country fixed effect captures all country-specific characteristics beyond the date of liberalization such as the initial level of development, size, or initial level of openness.

First, the results in Table 1 confirm what was highlighted in Figures 4A and 4B—there has been a downward, statistically significant, trend in the country-specific portion of trade volatility for the average country in our sample. Moreover, as shown in Figure 5, in the case of exports, the interaction term in column (1) of Table 1 is negative and significant, suggesting that the reduction over time in the variance of trade attributable to the country-specific term is more marked for recently liberalized countries (i.e., those that saw their trade regimes liberalized after 1985). In the case of imports (column (2)), the interaction term is negative but it is not statistically significant which suggests that from a statistical point one cannot reject the hypothesis of parallel trends between the two groups of countries.

The results shown for the variance of the country-specific effect are also evident when considering the broader definition country-specific term (i.e., one that also includes the error term). There is a negative and statistically significant trend in the (log) variance of the broad country-specific term for exports, albeit less significant than in the exercise that considers the variance of the country-specific term alone (Table 1, column (3)). In the case of imports, the interaction term is positive but is not significantly different from zero from a statistical point of view (Table 1, column (4)).

The results presented in Figure 5 and Table 1 suggest that countries that liberalized their trade regimes more recently experienced more marked declines in the part of their trade volatility attributable to country-specific factors relative to countries with established liberalized trade regimes, especially for exports. A question that emerges in light of this result is—what factors explain differences in the levels and the evolution of trade volatility attributable to country-specific factors between the two groups of countries described above? The rest of this section explores a potential answer to this question. In particular it highlights the marked process of diversification experienced by recently liberalized countries since the 1990s, which in turn, we argue, contributed to the reduction in country-specific volatility.

The evidence presented above seems, at first glance, inconsistent with the strand of the literature that has found a positive association between openness and GDP volatility. After all, the period of trade liberalization of the 1990s was accompanied by a rise in the incidence of trade over GDP for the average country in the world (which arguably was led by countries experimenting the reform). Yet, the two results can be easily reconciled once one takes into account the process of diversification that was triggered by trade liberalization. In other words, the common wisdom result that trade openness increases volatility is

[24] In our sample there are no countries with a liberalization date after 1998.

true if one abstracts from the potential link between openness and diversification. In fact, Haddad et al. (2013) show that trade openness reduces volatility to the extent that countries are well diversified. And, as documented by Kose, Prasad and Terrones (2005) and Cadot, Carrère and Strauss-Khan (2011), there is evidence that the trade liberalization induces trade diversification.

The link between trade liberalization and trade diversification can be further explored with two exercises. First, Table 2A and 2B presents the results of a regression of two measures of trade diversification (log of the number of products traded in a year and log of the number of partners in a year) against a dummy taking value one for the years after the Wacziarg and Welch (2008) trade liberalization date, for both imports and exports. The exercise is performed for a wide sample including all countries with trade data in every year. Hence, this regression captures changes in the degree of trade diversification after periods of trade liberalization.

The results in column (1) and (2) of Tables 2A and 2B show that, on average, the (log) number of products and partners increases in the years following an episode of trade liberalization. Interestingly, the results suggest that, for both measures of diversification and both samples, trade liberalization has a bigger impact on exports than it does on imports. This observation, together with the link between diversification and volatility that will be discussed in what follows, can explain why the trend in the variance of the country-specific term is significantly steeper for recently liberalized countries relative to countries that liberalized earlier in the case of exports, while in the case of imports there is a parallel trend.

One possible explanation for the results on Tables 2A and 2B is that technological change has led countries to diversify regardless of their trade regime. For instance, reductions in trade costs or the penetration of IT technologies worldwide may allow countries to expand the number of products and partners with which they trade. Another explanation is that countries with intrinsically higher levels of diversification, due for example to large size or high income level, may be driving the results described earlier. To address these concerns, columns (3) to (8) present the results for three alternative specifications of the regression described above: one which includes country fixed effects, one with year fixed effects, and one with both year and country fixed effects.

The results from the specifications that include fixed effects suggest that part of the positive effect of liberalization on diversification documented in columns (1) and (2) are indeed partly explained by country-specific characteristics and differences in the timing of liberalization of different countries, since the magnitudes of the coefficients presented in columns (1) and (2) are larger than those in (3) to (8). However, all the coefficients remain highly significant throughout the different specifications, samples, trade flows

and measures of diversification. All this is indicative that trade liberalization allows countries to expand their degree of trade diversification.

Given the results presented in Tables 2A and 2B, it is plausible to expect that countries that liberalized trade more recently (after 1985) experienced a more marked process of diversification compared to those that liberalized earlier (before 1985). Figure 6 confirms this—there has been a noticeable process of convergence in terms of the number of partners and products traded in recently liberalized. In 1985 countries that liberalized prior to that year exported on average to approximately 50 percent more destinations and close to 50 percent more products than countries that liberalized after 1985. By 2010 the destination gap was almost non-existent and the product gap was only 10 percent. A similar result is observed in the case of imports.

While the effect of trade liberalization on imports may be expected a priori given the reduction in import tariffs, the observed effect of liberalization on export diversification could be unexpected for some. After all, under certain conditions, trade openness is predicted to foster specialization, which in turn would translate into less diversification. One explanation for the result of trade liberalization on exports is Lerner's symmetry—de facto, restrictive import policies act as a tax on exports. In this sense, closed trade regimes introduce an anti-export bias in the economy. Tokarick (2007) quantifies the extent to which import tariffs introduce a de facto tax on exports and finds substantial anti-export biases introduced by import tariffs in many developing countries. [25] Hence, liberalization, by reducing import tariffs, appears to be reducing the anti-export bias in previously closed economies and, as a result, fostering export diversification.

What does trade liberalization and the resulting process of diversification imply for the volatility of the country-specific term in our exercise? There are a number of channels highlighted in the literature through which diversification can dampen supply (demand) volatility, which in our exercise is associated with the country-specific term when looking at the problem of the exporter (importer). First, trade liberalization can help domestic producers, including exporters, gain access to a more stable supply of inputs. This would be the case, for example, if the supply of intermediate goods by domestic producers is more volatile than that of foreign suppliers. In this case, trade liberalization can dampen (and in the extreme eliminate) the transmission of volatility from domestic producers of intermediate inputs to exporters. Moreover, the evidence above suggests that trade liberalization not only allows exporters to hedge against volatility stemming from domestic producers of intermediates through access to international producers, but also across international sources, since liberalization is associated with an expansion in the set of origins. All this would translate into a reduction in supply volatility in the country that liberalizes.

[25] Kehoe (1995) also provides evidence of an anti-export bias in Mexico prior to the liberalization of the 1980s.

A second channel is sheer volatility reduction from diversification. As highlighted in Acemoglu and Zilibotti (1997), the incidence on aggregate supply of idiosyncratic shocks to firms becomes smaller as countries become more diversified. A similar logic should apply for exports and imports. As the number of exporters, which can be roughly approximated by the number of product-destinations, increases, the incidence of idiosyncratic shocks to individual exporters on total exporters is expected to decline, resulting in more stable aggregate exports. Similarly, the incidence of idiosyncratic shocks to the demand for imports of a specific product or destination on total demand for imported goods is smaller as the import basket becomes well diversified.

The two channels highlighted above imply that the volatility of exports and imports attributable to the country-specific term should decrease with diversification. As a first pass in testing this hypothesis, we regress the log of the variance of the country-specific term of exports and imports against the number of product-partner pairs in logs that each country has in 1990. Figure 7, Panel A (B) confirm the hypothesis—countries that start the 1990-2011 period with a more diversified export (import) basket experience lower country-specific variance of exports (imports).[26] [27] Clearly, the results in Panels A and B can be confounding other factors that affect the variance of trade and that are also correlated with our measure of diversification. For instance, GDP per capita can affect both volatility (Acemoglu and Zilibotti, 1997) and diversification (Klinger and Lederman, 2004 and 2006). For this reason, Panels C and D of Figure 7 show the results of a regression similar to the one described above but including also the log level of GDP per capita in 1990 and the log of the size of the population in 1990. As shown there, the partial correlation between country-specific volatility and diversification remains significant even after controlling other variables potentially affecting the degree of trade diversification of these economies. All this suggests that differences in country-specific variance do appear to be related to diversification as suggested by the two channels discussed above.

An implication of the channels discussed above and the results in Figure 7, Panels A-D, is that as countries become more diversified, for example because of liberalizing trade, they should experience reductions in their country-specific variance. This is already hinted in Figure 5, since countries that liberalized after 1985 should have experienced a more marked process of diversification. To further test this prediction, we use the results of the rolling-window exercise to run a regression of the year by year country-specific variance against the level of diversification in a country in year t (captured by the log of the number of product-partner pairs in that year) and a country fixed effect. Hence, the coefficient of the regression captures the

[26] Similar results are obtained if diversification is measured through the Herfindahl index.

[27] The number of products is taken over the SITC rev 2 four digit classification. This gives a total of approximately one thousand products. The number of partners is taken from the total set of countries reporting positive export values for all years from 1990 until 2011.

elasticity of the country-specific variance to changes in diversification around the country mean. The results presented in Figure 7, Panels E and F, reaffirm the role played by diversification in explaining the reduction in the country-specific variance over the period 1990-2011—countries that experienced larger increases in diversification saw larger reductions in country specific variance.

5 Extensions

The results presented in previous sections centered the analysis on a sample that includes approximately forty countries. That sample, which excludes small and low income countries, is used for reasons that are discussed above. However, the exclusion of these countries may taint the conclusions presented so far for a number of reasons.

First, as argued in Koren and Tenreyro (2007), an analysis of GDP volatility shows that poorer countries typically have higher country-specific volatility compared to higher-income countries. Second, Koren and Tenreyro (2007) also find an association between a country's income level and its pattern of specialization, whereby poorer countries typically specialize in goods with a higher variance. Also, poorer countries may have a bias to trade among themselves due to geographic clustering (i.e. gravity forces at play) or similarity of preferences (i.e. Linder's hypothesis), among other potential explanations. All this implies that the inclusion a broader set of countries may result in changes in the relative incidence of the variance attributable to each of the factors included in our decomposition.

To tackle this concern this section presents the results of a variant of the exercise presented earlier in the paper. For simplicity we focus exclusively on exports. In particular, we run the following regression:

$$\ln(X_{ikt}) = a_t + d_{it} + \beta_k TWGDP_{it} + +p_{kt} + e_{ikt} \quad (6)$$

where $\ln(X_{ijkt})$ is the logarithm of sectorial real exports from country $i, (i \in I)$ in a given year t, in sector k (in the set of industries traded from i to j denoted as K_{ijt}). The first component in (6), α_t, is a global effect, common to all exporters and sectors for a given year. This captures shocks to trade flows that affect all sectors and countries in the same magnitude. The second component (d_{it}) is a country-specific component and captures shocks to country i's exports that impact all destinations and sectors equally. This, for example, captures economy-wide macroeconomic policies, and is interpreted as a supply (demand shock). Clearly, the use of aggregate trade flows (as opposed to bilateral flows) limits the ability of the exercise to disentangle between supply and demand effects. To mitigate this problem, we include the trade

weighted GDP of all destinations with which country *i* trades in year *t*. This allows to partially disentangle between supply and demand forces. However, the omission of geography related variables could mean that our proxy of demand shocks is also capturing changes in shocks associated with the resistance term (ξ_{ijt}. in equation (4)). The fourth component (p_{kt}) is the sectorial effect and captures shocks to trade in sector k common to all origins and destinations. The final term (e_{ijkt}), referred to as the error effect, is the residual unexplained trade by the previous components. After estimating equation (6), we follow the same steps as above to arrive at a variance decomposition similar to the one in (4).

The use of aggregate trade data allows us to double the sample of countries used in the exercise, most of which are middle-income and low income countries. We added countries that have non-zero trade flows for all years from 1990 until 2011 in all of the sectors considered in the exercise. We use two sectoral classifications—a broader classification that uses the same four sectors described above and narrower classification that uses the ten sectoral clusters defined in Leamer (1995).

Figure 8, Panel A, presents the results of this modified version of the variance decomposition exercise for the full 1990-2011 period. Contrary to the baseline results (Figure 2), the balance between the different terms in the variance decomposition is now tilted towards the country-specific term. This is especially evident when looking at the average country—the variance of the country-specific term is almost four times as large as the variance of the common term. To some extent this result was foreseeable. As argued above, the incidence of the country-specific variance is expected to decrease with income, which implies that the inclusion of poorer countries increases the average variance of that term. In fact, Figure 8, Panel B, shows the results of this alternative decomposition for the set of countries used in the baseline result and as was the case in Figure 2, the common effect is larger than any of the average values for the other elements. Turning back to the full sample, the dominance of the country-specific term is somewhat reduced when looking at the median value. In this case, the variance of the country-specific term is still the largest, but now the difference with the common effect, which has the second largest variance among all the components of the variance of exports, is significantly reduced.

The results of this alternative exercise in Figure 8 suggest that the conclusions regarding the average and median weight carried by each of the terms in the volatility decomposition are sensitive to the sample of countries included in the analysis. Are the rest of the conclusions of this paper also sensitive to alternative samples and methodologies? The results that are presented below suggest they are not.

First, Figure 9 presents the results of the export volatility decomposition of a 10 year rolling-window sample, focusing on the variance of the common term and the country-specific term. Similar to Figure 3, the variance of the common term was relatively stable when using data prior to 2008, jumps in 2008, and

remains relatively stable at a new high level thereafter. In contrast, the variance of the country-specific term for the average country falls steadily until 2008, increases temporarily during the recovery of the global financial crisis, and the drops back thereafter. A similar pattern emerges when studying the evolution of the variance of the country-specific term for the median country. Moreover, the downward trend of the variance of the country-specific term is statistically significant.[28]

Next we turn to the link between the variance of the country-specific effect and diversification. Section 4 showcased the strong negative correlation between the variance of the country-specific term and the degree of diversification of a country. Moreover, this relation holds even after controlling for variables such as GDP per capita and population. Figure 10 shows that the strong negative correlation between the variance of the country-specific term and the level of diversification is still present in this broader sample of countries.

Hence, despite differences in the relative contribution to total export variance of each of its elements, the trends and the negative correlation between the variance of the country-specific term and the level of diversification highlighted in the benchmark exercise remain in the alternative decomposition using a broader sample. This suggests that while the conclusions about the salience of each of the terms contributing to the variance of exports may be sensitive to the data used, conclusions about the evolution over time and changes in the relative weight of each of the terms are not subject to this caveat. Moreover, both the benchmark and alternative exercise provide evidence of the role of diversification as a driver of stability.

6 Concluding remarks

This paper presents the results of a volatility decomposition exercise for trade flows. The exercise sheds light on the forces shaping the volatility of trade flows over the past two decades. In particular, the exercise suggests that, for the countries included in the sample used in this paper, trade growth volatility is largely attributable to a factor common to all countries. Country-specific factors also appear to have a large incidence in overall trade volatility, albeit smaller than the common factor. In contrast, products and partners effects appear to have a negligible effect on aggregate trade volatility.

The paper also documents significant differences in the behavior of the variance of the country-specific term and that of the common term. The former declined steadily over the course of the 2000s for the average country in the sample, while the latter experienced a sharp increase after the global financial crisis. The

[28] We estimated a regression of the variance of the country-specific term in levels and logs on a time trend and the coefficient for the time trend is negative and statistically significant.

paper provides some evidence that the process of trade diversification in developing countries triggered by trade liberalization may be an important force behind the steady decline in the variance of the country-specific term.

This paper opens the door to further research on the determinants and implications of trade volatility. The volatility decomposition presented here is performed over a limited sample of countries and broad sectoral categories, which allows us to overcome some problems in estimating the gravity equation. However, these choices come at a cost, as they prevent the empirical exercise from giving robust predictions on a number of issues. First, the broad sectoral aggregation is likely to attenuate the incidence of sectoral volatility. Moreover, it precludes the paper from understanding the impact of trade on intermediates, and value chains on trade volatility. Second, our choice of data may affect the generality of some of the results in the paper. For instance, we show that the results from an alternate methodology that allows for the inclusion of a broader set of countries suggests a larger incidence of the country-specific term at the expense of the common factor in comparison to the benchmark results. Future research could aim at tackling these limitations, for instance by adapting the volatility decomposition to alternative estimation techniques that are better suited for samples with a large share of zeroes, and as a byproduct a larger set of countries.

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APPENDIX A: Estimation and Methodological Details

The main empirical exercise performed in this paper follows from the decomposition presented in equation (4). More specifically, the exercise follows from the following approximation of trade growth:

$$\widehat{\ln(X_{\iota t})} \cong \widehat{\alpha_t} + \widehat{\gamma_{\iota t}} + \sum_{\mathrm{j}\in \mathrm{J_{it}}} a_{ijt} \times \widehat{\lambda_{jt}} + \sum_{\mathrm{k}\in \mathrm{K_{it}}} a_{ikt} \times \widehat{\eta_{kt}} + \sum_{\mathrm{j}\in \mathrm{J_{it}}} a_{ijt} \times \widehat{\xi_{\iota jt}} + \sum_{\mathrm{j}\in \mathrm{J_{it}}} \sum_{\mathrm{k}\in \mathrm{K_{ijt}}} a_{ijkt} \times \widehat{\epsilon_{\iota jkt}} \tag{A1}$$

Where the interpretation of each of the components is presented in the main text, and the "hat" notation refers to first differences.

Equation (4) states that the aggregate trade growth of country i's exports can be expressed as the sum of the growth of the world effect, country i's exporter effect and the trade-weighted sum of its partners' effects, sectorial effects, resistance effects and idiosyncratic effects.

Redefining, for each exporter i, $\widehat{\ln(X_{\iota t})}$ as g'_{it} and the trade-weighted sum of the importer, sectorial, resistance and idiosyncratic effects as λ_{it}, η_{it}, ξ_{it} and ϵ_{it} respectively and taking the variance over time we obtain:

$$\begin{aligned} \sigma^2_{g_i} = {} & \sigma^2_{\alpha_i} + \sigma^2_{\gamma_i} + \sigma^2_{\lambda_i} + \sigma^2_{\eta_i} + \sigma^2_{\xi_i} + \sigma^2_{\epsilon_i} \\ & + 2 \times Cov(\alpha_{it}, \gamma_{it}) + 2 \times Cov(\alpha_{it}, \lambda_{it}) + 2 \times Cov(\alpha_{it}, \eta_{it}) + 2 \times Cov(\alpha_{it}, \xi_{it}) \\ & + 2 \times Cov(\alpha_{it}, \epsilon_{it}) + 2 \times Cov(\gamma_{it}, \lambda_{it}) + 2 \times Cov(\gamma_{it}, \eta_{it}) + 2 \times Cov(\gamma_{it}, \xi_{it}) \\ & + 2 \times Cov(\gamma_{it}, \epsilon_{it}) + 2 \times Cov(\lambda_{it}, \eta_{it}) + 2 \times Cov(\lambda_{it}, \xi_{it}) + 2 \times Cov(\lambda_{it}, \epsilon_{it}) \\ & + 2 \times Cov(\eta_{it}, \xi_{it}) + 2 \times Cov(\eta_{it}, \epsilon_{it}) + 2 \times Cov(\xi_{it}, \epsilon_{it}) \end{aligned} \tag{A2}$$

Where $\sigma^2_{g_i}$ is exporter i's total trade growth variance, $\sigma^2_{\gamma_i}$ is the variance of i's exporter effect and $\sigma^2_{\lambda_i}$, $\sigma^2_{\eta_i}$, $\sigma^2_{\xi_i}$ and $\sigma^2_{\epsilon_i}$ are the variances of the weighted sums of i's partner's, sectorial, resistance and idiosyncratic effects.

Estimating the model

To quantify the different components of the trade variance we follow a three-step method, where the exporter-importer pair specific resistance effects are extracted from a cross-section fixed effects regression followed by the calculation of the world effect, later used to compute exporter, importer and sectorial effects via the solution of simultaneous equations. Finally the idiosyncratic effect is calculated as the residual.

For each period $t = 1, \dots, T$ we run the regression:

$$\begin{aligned}\ln(X_{ijkt}) = Constant_t + E_{it} + I_{jt} + S_{kt} + \beta_{ijt}^{1} \ln(distance_{ij}) + \beta_{ijt}^{2} common\ border_{ij} \\ + \beta_{ijt}^{3} common\ legal\ system_{ij} + \beta_{ijt}^{4} common\ language_{ij} \\ + \beta_{ijt}^{5} colonial\ ties_{ij} + \beta_{ijt}^{6} free\ trade\ agreement_{ijt} + \phi_{ijkt}\end{aligned} \quad (A3)$$

E_{it}, I_{jt} and S_{kt} are exporter, importer, and sectorial fixed effects; $distance_{ij}$ is the distance bilateral distance between exporter i and importer j; $common\ border_{ij}$, $common\ legal\ system_{ij}$, $common\ language_{ij}$, and $colonial\ ties_{ij}$ are time-invariant pair specific dummies; and $free\ trade\ agreement_{ijt}$ is a binary variable indicating the existence of at least one free trade agreement between exporter i and importer j in period t.

From each regression we recover the resistance effect as:

$$\begin{aligned}\xi_{ijt} = \widehat{\beta_{ijt}^{1}} \ln(distance_{ij}) + \widehat{\beta_{ijt}^{2}} common\ border_{ij} + \widehat{\beta_{ijt}^{3}} common\ legal\ system_{ij} \\ + \widehat{\beta_{ijt}^{4}} common\ language_{ij} + \widehat{\beta_{ijt}^{5}} colonial\ ties_{ij} \\ + \widehat{\beta_{ijt}^{6}} free\ trade\ agreement_{ijt}\end{aligned} \quad (A4)$$

Which allows the calculation of the world effect:

$$\alpha_t = \frac{\sum_{i \in I} \sum_{j \in J_{it}} \sum_{k \in K_{ijt}} \ln(X_{ijkt}) - \xi_{ijt}}{\sum_{i \in I} \sum_{j \in J_{it}} |K_{ijt}|} \quad (A5)$$

The importer, exporter, and sectorial effects are obtained from the solution of the following simultaneous equations:

$$
\begin{aligned}
&\sum_{j\in J_{it}}\sum_{k\in K_{ijt}}\left[\ln\left(X_{ijkt}\right)-\xi_{ijt}\ \right]-\alpha_t\times\sum_{j\in J_{it}}\left|\mathrm{K_{ijt}}\right| \\
&\qquad=\gamma_{it}\times\sum_{j\in J_{it}}\left|\mathrm{K_{ijt}}\right|+\sum_{j\in J_{it}}\left[\left|\mathrm{K_{ijt}}\right|\times\lambda_{jt}\right]+\sum_{k\in K_{it}}\left[\left|\mathrm{J_{ikt}}\right|\times\eta_{kt}\right],\forall i\in I \\
&\sum_{i\in I_{jt}}\sum_{k\in K_{ijt}}\left[\ln\left(X_{ijkt}\right)-\xi_{ijt}\ \right]-\alpha_t\times\sum_{i\in I_{jt}}\left|\mathrm{K_{ijt}}\right| \\
&\qquad=\lambda_{jt}\times\sum_{i\in I_{jt}}\left|\mathrm{K_{ijt}}\right|+\sum_{i\in I_{kt}}\left[\left|\mathrm{K_{ijt}}\right|\times\gamma_{it}\right]+\sum_{k\in K_{jt}}\left[\left|\mathrm{I_{jkt}}\right|\times\eta_{kt}\right],\forall j\in J \\
&\sum_{i\in I_{kt}}\sum_{j\in J_{ikt}}\left[\ln\left(X_{ijkt}\right)-\xi_{ijt}\ \right]-\alpha_t\times\sum_{i\in I_{kt}}\left|\mathrm{J_{ikt}}\right| \\
&\qquad=\eta_{kt}\times\sum_{i\in I_{kt}}\left|\mathrm{J_{ikt}}\right|+\sum_{i\in I_{kt}}\left[\left|\mathrm{J_{ikt}}\right|\times\gamma_{it}\right]+\sum_{j\in J_{kt}}\left[\left|I_{\mathrm{jt}}\right|\times\lambda_{jt}\right],\forall k\in K
\end{aligned}
\tag{A6}
$$

Finally, the idiosyncratic effect is calculated as the residual effect:

$$
\epsilon_{ijkt}=\ln\left(X_{ijkt}\right)-\alpha_t-\gamma_{it}-\lambda_{jt}\ -\eta_{kt}\ -\xi_{ijt},\forall i\in I,j\in J_{it},k\in K_{ijt} \tag{A7}
$$

APPENDIX B: Gravity Estimation Results

The following table report the gravity equation regression results for each resistance term including exporter, importer, and sector fixed effects (see equation (2) in the main text).

Table B2. Sectors 1991-2011 - Sample 00

	Log of Bilateral Distance	Common Border Dummy	Common Legal Dummy	Common Language Dummy	Colonial Ties Dummy	FTA Dummy	Constant	Exp. FE	Imp. FE	Sec. FE	Min. Sector Effect	Max. Sector Effect	Obs.	R2
91	-1.022***	-0.0392	0.338***	0.0688	0.497***	0.394***	19.57***	Yes	Yes	Yes	-1.009	0.408	5,666	0.721
	(0.0329)	(0.0965)	(0.0489)	(0.0668)	(0.102)	(0.0651)	(0.259)							
92	-1.028***	0.0109	0.282***	0.140**	0.596***	0.411***	19.58***	Yes	Yes	Yes	-0.922	0.461	5,766	0.725
	(0.0341)	(0.0994)	(0.0492)	(0.0672)	(0.102)	(0.0660)	(0.270)							
93	-1.042***	0.0435	0.301***	0.145**	0.659***	0.333***	19.51***	Yes	Yes	Yes	-0.932	0.561	5,804	0.726
	(0.0347)	(0.0973)	(0.0485)	(0.0663)	(0.102)	(0.0669)	(0.272)							
94	-0.998***	0.0361	0.327***	0.0973	0.631***	0.456***	19.47***	Yes	Yes	Yes	-0.94	0.615	5,849	0.734
	(0.0357)	(0.0944)	(0.0461)	(0.0641)	(0.0998)	(0.0695)	(0.275)							
95	-1.003***	0.0619	0.336***	0.0748	0.630***	0.466***	19.92***	Yes	Yes	Yes	-0.95	0.667	5,930	0.740
	(0.0360)	(0.0898)	(0.0455)	(0.0627)	(0.0999)	(0.0692)	(0.267)							
96	-0.999***	0.0754	0.332***	0.0373	0.621***	0.474***	19.98***	Yes	Yes	Yes	-0.934	0.739	5,953	0.736
	(0.0366)	(0.0902)	(0.0461)	(0.0632)	(0.0990)	(0.0709)	(0.271)							
97	-0.985***	0.0389	0.325***	0.0737	0.651***	0.547***	20.09***	Yes	Yes	Yes	-0.923	0.791	5,989	0.738
	(0.0373)	(0.0882)	(0.0456)	(0.0636)	(0.0984)	(0.0725)	(0.270)							
98	-1.015***	0.0431	0.301***	0.0738	0.598***	0.477***	20.35***	Yes	Yes	Yes	-0.936	0.817	5,948	0.744
	(0.0365)	(0.0908)	(0.0453)	(0.0630)	(0.0920)	(0.0742)	(0.268)							
99	-1.020***	0.0249	0.337***	0.152**	0.554***	0.479***	20.04***	Yes	Yes	Yes	-0.932	0.782	5,938	0.749
	(0.0359)	(0.0904)	(0.0451)	(0.0622)	(0.0954)	(0.0727)	(0.265)							
00	-1.013***	0.0576	0.333***	0.144**	0.578***	0.559***	19.78***	Yes	Yes	Yes	-0.964	0.845	5,954	0.756
	(0.0341)	(0.0908)	(0.0451)	(0.0631)	(0.0959)	(0.0660)	(0.260)							
01	-1.006***	0.0618	0.280***	0.186***	0.541***	0.445***	19.66***	Yes	Yes	Yes	-0.773	0.901	6,026	0.759
	(0.0327)	(0.0853)	(0.0429)	(0.0599)	(0.0925)	(0.0638)	(0.252)							
02	-1.010***	0.0373	0.272***	0.208***	0.611***	0.509***	18.74***	Yes	Yes	Yes	-0.73	0.867	6,051	0.762
	(0.0333)	(0.0870)	(0.0435)	(0.0600)	(0.0931)	(0.0651)	(0.258)							
03	-1.005***	0.0457	0.283***	0.256***	0.581***	0.472***	19.06***	Yes	Yes	Yes	-0.746	0.895	6,070	0.769
	(0.0339)	(0.0870)	(0.0430)	(0.0594)	(0.0917)	(0.0615)	(0.262)							
04	-1.017***	0.00954	0.300***	0.266***	0.525***	0.450***	19.53***	Yes	Yes	Yes	-0.756	0.93	6,085	0.761
	(0.0348)	(0.0920)	(0.0437)	(0.0604)	(0.0938)	(0.0639)	(0.265)							
05	-1.043***	0.0458	0.283***	0.262***	0.528***	0.412***	19.75***	Yes	Yes	Yes	-0.781	0.965	6,109	0.764
	(0.0336)	(0.0897)	(0.0431)	(0.0604)	(0.0928)	(0.0604)	(0.257)							
06	-1.049***	0.0579	0.270***	0.258***	0.573***	0.397***	19.98***	Yes	Yes	Yes	-0.78	0.952	6,139	0.765
	(0.0335)	(0.0909)	(0.0430)	(0.0605)	(0.0934)	(0.0594)	(0.258)							
07	-1.045***	0.0680	0.290***	0.261***	0.558***	0.400***	20.15***	Yes	Yes	Yes	-0.793	0.937	6,147	0.761
	(0.0347)	(0.0907)	(0.0427)	(0.0599)	(0.0923)	(0.0595)	(0.264)							
08	-1.033***	0.0472	0.305***	0.279***	0.498***	0.432***	20.41***	Yes	Yes	Yes	-0.846	0.918	6,161	0.755
	(0.0344)	(0.0893)	(0.0431)	(0.0599)	(0.0937)	(0.0587)	(0.266)							
09	-1.004***	0.0909	0.276***	0.295***	0.471***	0.475***	19.85***	Yes	Yes	Yes	-0.779	0.842	6,139	0.759
	(0.0341)	(0.0881)	(0.0424)	(0.0590)	(0.0934)	(0.0563)	(0.266)							
10	-1.001***	0.119	0.332***	0.231***	0.458***	0.475***	19.95***	Yes	Yes	Yes	-0.846	0.835	6,167	0.752
	(0.0360)	(0.0901)	(0.0432)	(0.0607)	(0.0970)	(0.0587)	(0.276)							
11	-1.015***	0.121	0.325***	0.222***	0.468***	0.445***	20.41***	Yes	Yes	Yes	-0.891	0.813	6,175	0.749
	(0.0355)	(0.0896)	(0.0438)	(0.0611)	(0.0979)	(0.0576)	(0.0464)							

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

APPENDIX C: Sample Selection

In order to calculate the different trade growth variance components consistently over time and to limit observations with zero trade among country pairs we follow a two-step procedure to select a suitable sample for the analysis we perform.

First, we select countries that import and export every year of the selected time period. This guarantees that we are able to calculate exporter and importer effects for every period and hence compute variance across time that is balanced among countries.

Second, we employ an algorithm that limits zero trade among country pairs. The algorithm outputs a set of countries that all trade with each other in every year of a selected time frame while maximizing the set's cardinality.[29]

1. Keep exporter-importer pairs that trade every year of the time period.
2. Count number of destinations for each exporter.
3. If the minimum number of destinations is equal to the total number of potential trading partners, go to step 5.
4. Remove countries that have the minimum number of destinations. Go to step 2.
5. Recover the last set of removed countries. If the set of recovered countries contains one element, stop.
6. For each element of the power set of the recovered set of countries:
    a. Remove countries contained in the selected element.
    b. Count number of destinations for each exporter.
    c. If the minimum number of destinations is equal to the total number of potential trading partners, save solution.
7. Among the set of saved solutions keep those that contain the maximum number of countries.

The algorithm outputs a set of country lists, each with an equal number of countries. All countries have non zero bilateral trade among each other in every year of the selected time period.

The final criteria we use to define the selected sample is choose the solution that contains the most countries from the Latin America and Caribbean region.

[29] Note that the algorithm does not render a unique solution.

The algorithm is employed with two different time periods for robustness checks. Sample 90 includes countries with complete non-zero bilateral trade for the period 1991-2011 whereas sample 00 does so for the period 2001-2011. Both samples are shown in Table C1.

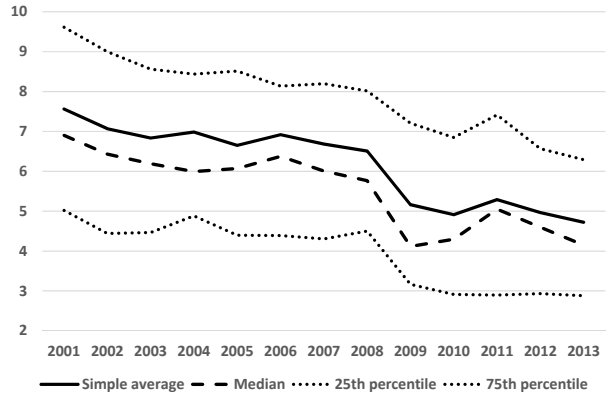
Table C1 - Samples

Sample 00				Sample 90			
ARG	EGY	ITA	PHL	ARG	ESP	MEX	THA
AUS	ESP	JPN	POL	AUS	FIN	MYS	TUR
AUT	FIN	KOR	PRT	AUT	FRA	NLD	USA
BRA	FRA	LKA	ROM	BRA	GBR	NOR	
CAN	GBR	MEX	SGP	CAN	GRC	NZL	
CHL	GRC	MYS	SWE	CHL	HUN	PER	
CHN	HUN	NLD	THA	CHN	IRL	POL	
COL	IDN	NOR	TUR	COL	ITA	PRT	
DEU	IRL	NZL	USA	DEU	JPN	SGP	
DNK	ISR	PER	ZAF	DNK	KOR	SWE	

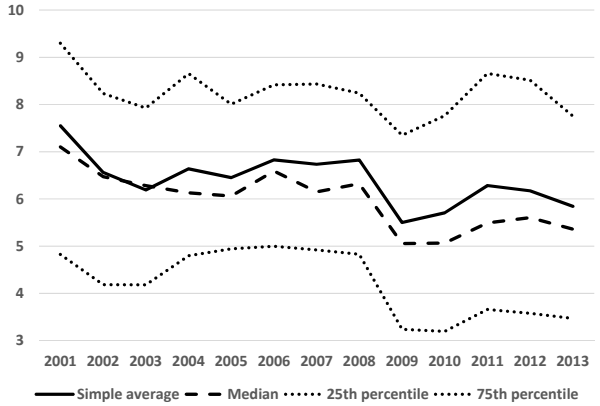
APPENDIX D: Figures and Tables of the Main Text

Figure 1 – Trend in international trend—1990-2013

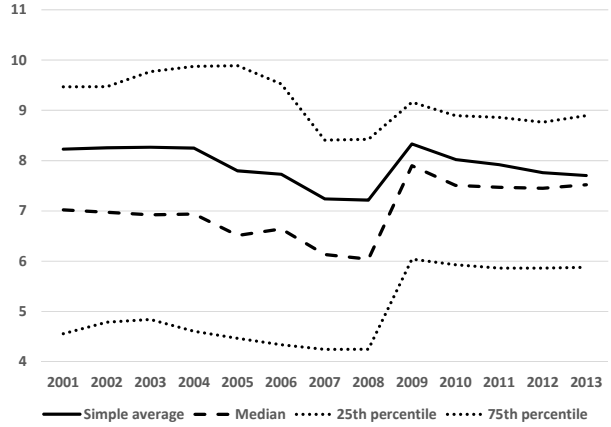
Average export growth-10 year moving window



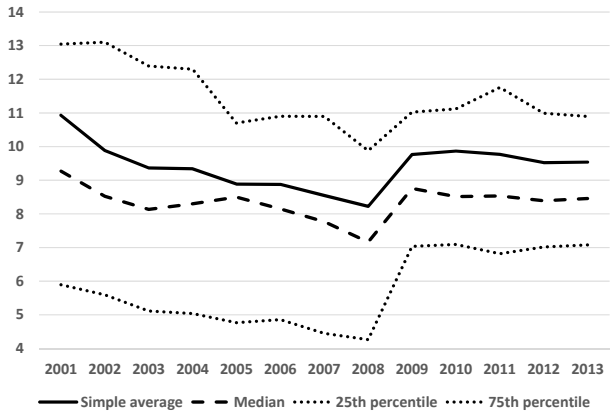
Average import growth-10 year moving window



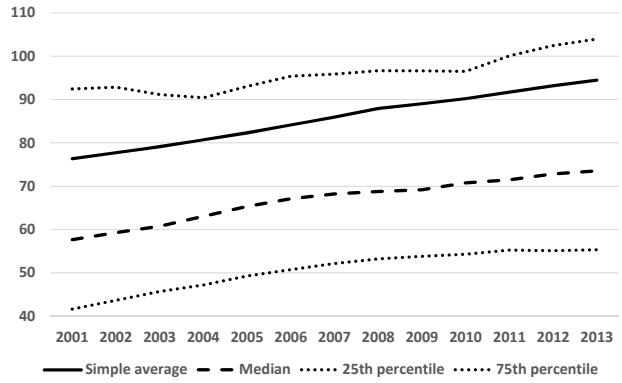
Export growth volatility-10 year moving window



Import growth volatility-10 year moving window

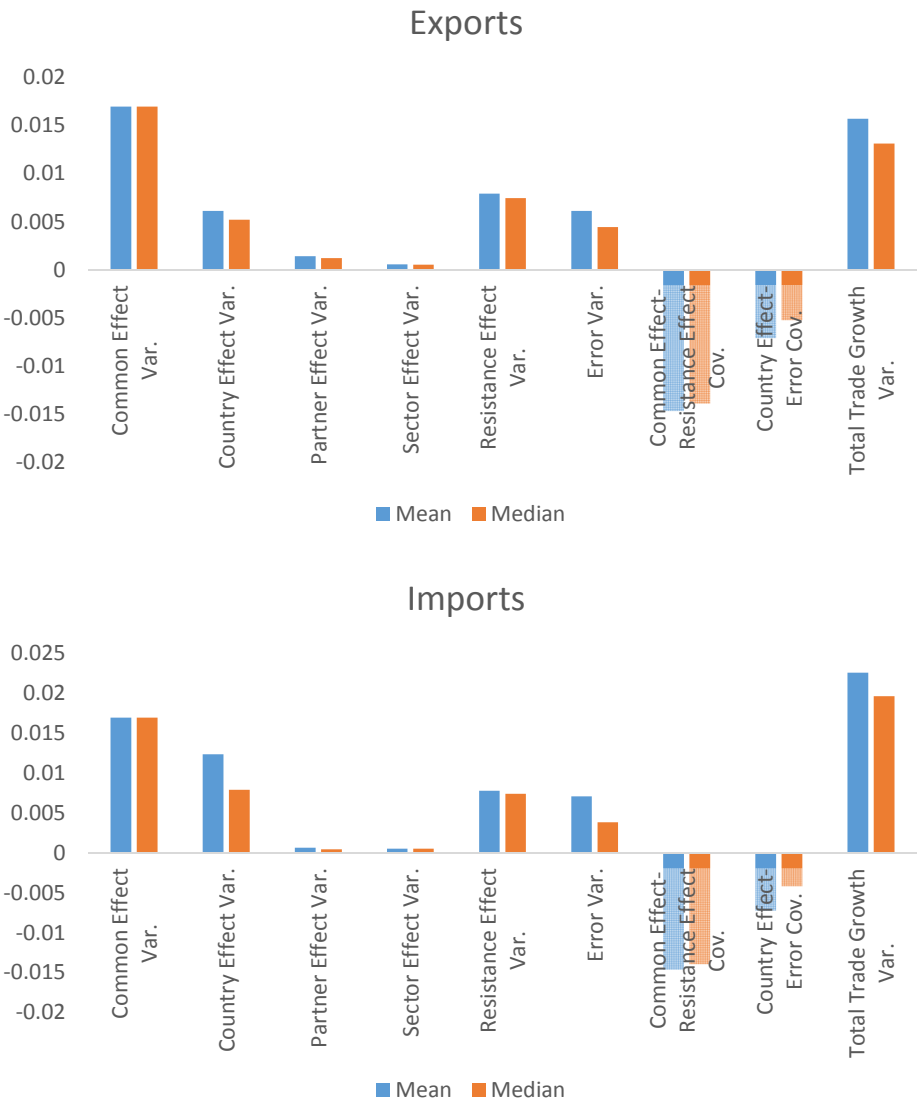


Average trade openness-10-year moving window



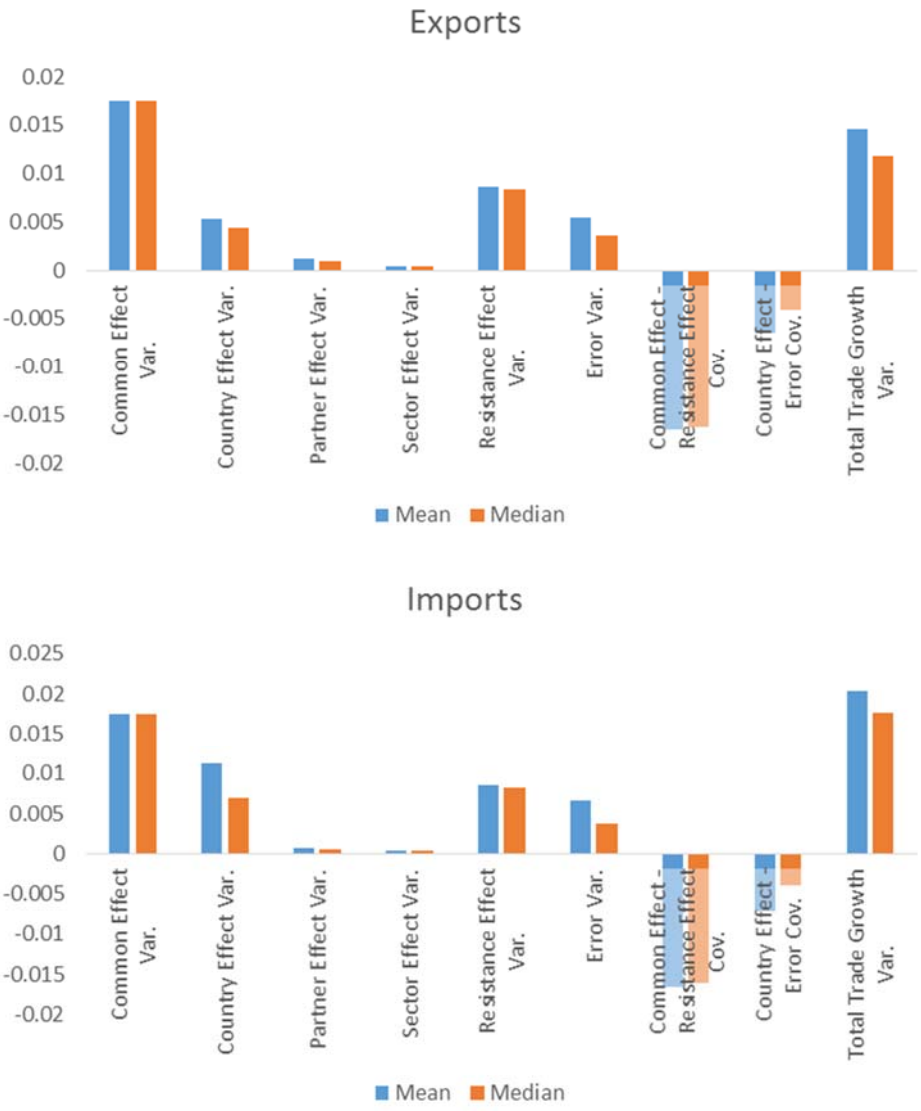
Source: Authors' calculations from World Bank's World Development Indicators. Note: All graphs present results for a set of countries from high-income and emerging economies reporting trade data for all years since 1979.

Figure 2 – Volatility Decomposition, 1990-2011



Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

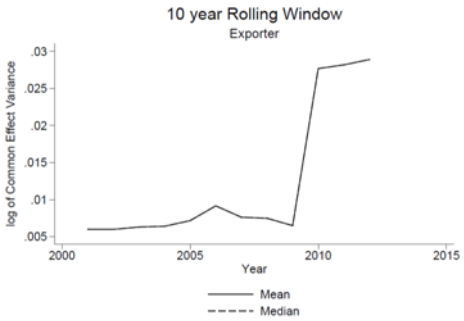
Figure 3 – Volatility Decomposition: Moving Average Extension



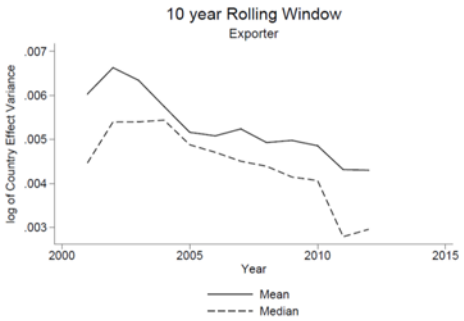
Sources: Authors' calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Figure 4A – Exports: Evolution of Variance Terms

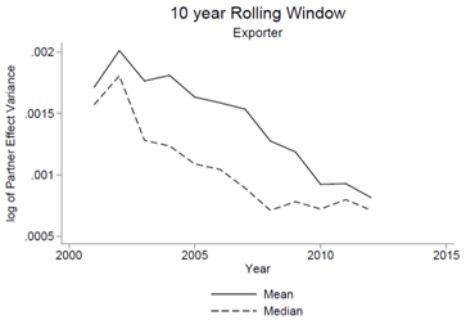
Common Effect Variance



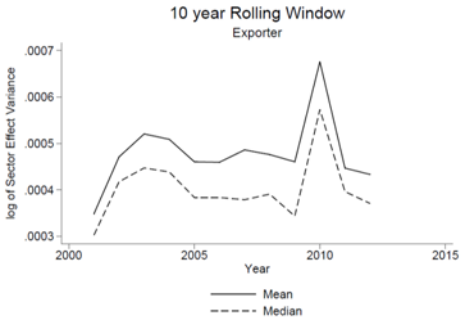
Country Effect Variance



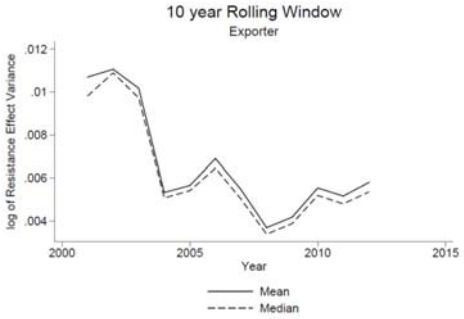
Partner Effect Variance



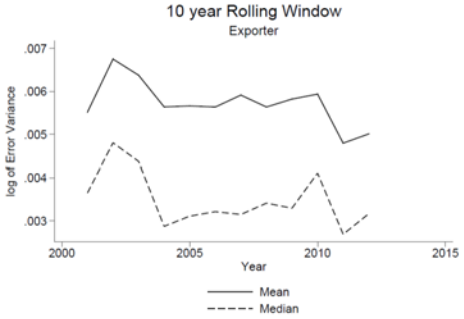
Sector Effect Variance



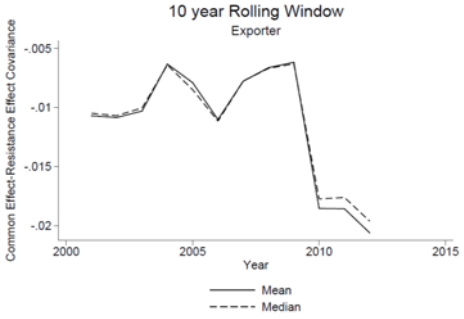
Resistance Effect Variance



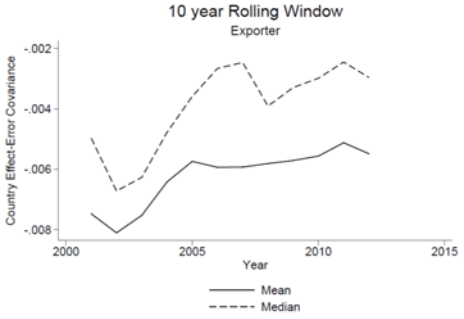
Error Variance



Common Effect-Resistance Effect Covariance



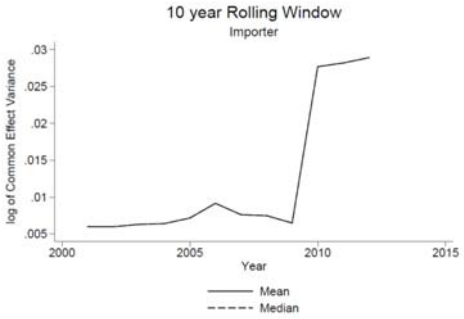
Country Effect-Error Effect Covariance



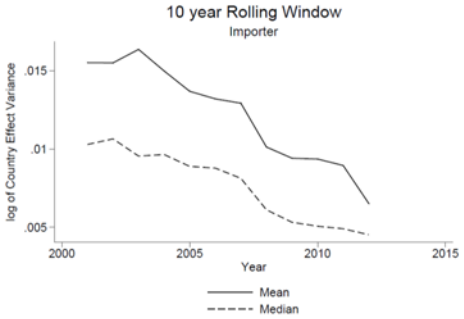
Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Figure 4B – Imports: Evolution of Variance Terms

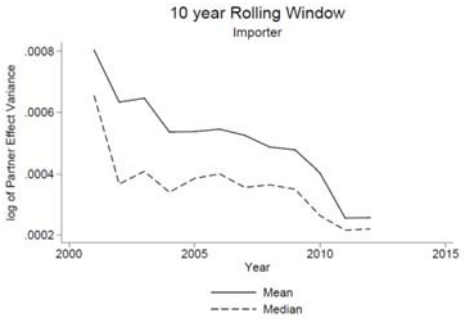
Common Effect Variance



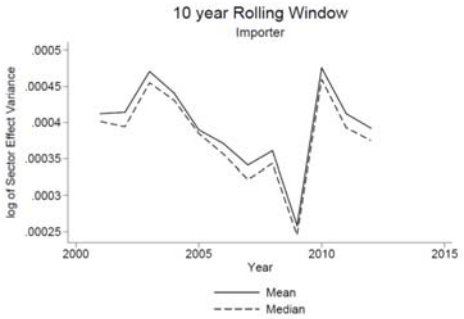
Country Effect Variance



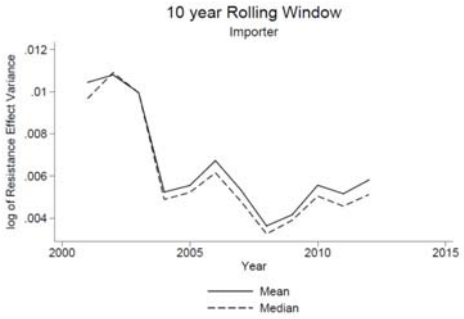
Partner Effect Variance



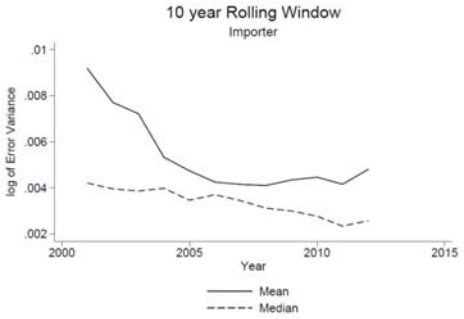
Sector Effect Variance



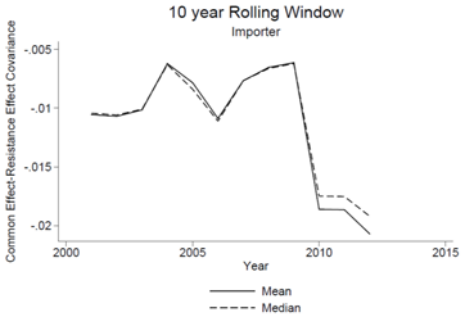
Resistance Effect Variance



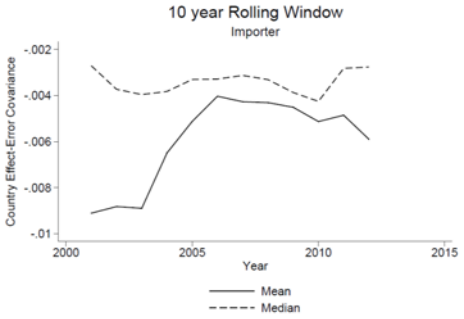
Error Variance



Common Effect-Resistance Effect Covariance



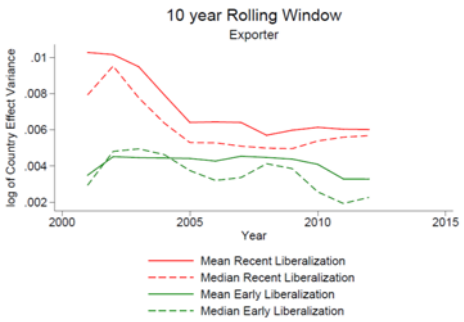
Country Effect-Error Effect Covariance



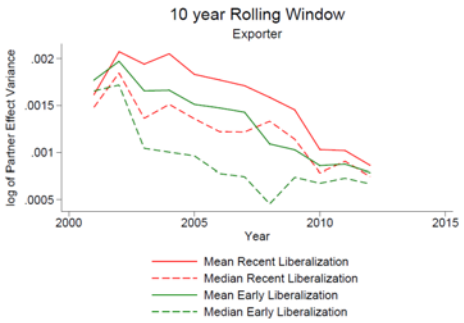
Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Figure 5A – Exports: Evolution of Variance Terms, Early Liberalized Countries vs. Recently Liberalized Countries

Country Effect Variance

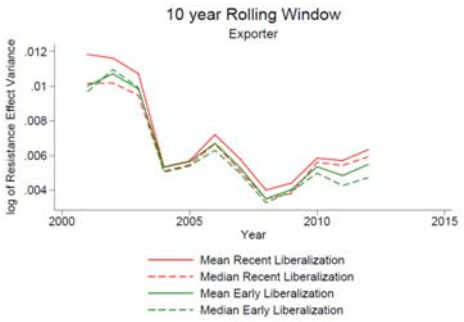


Partner Effect Variance

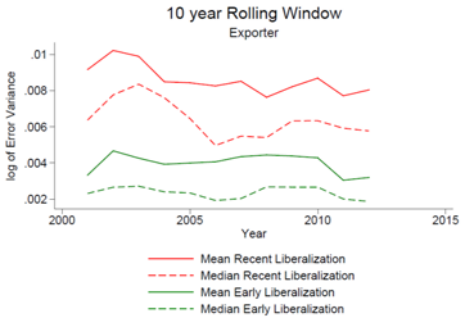


Sector Effect Variance

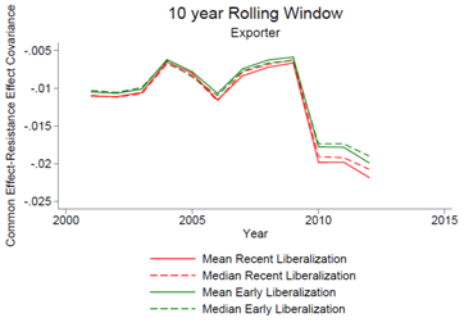
Resistance Effect Variance



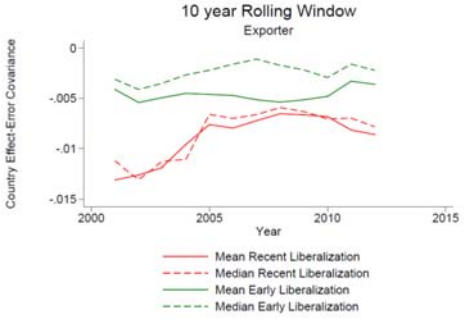
Error Variance



Common Effect-Resistance Effect Covariance



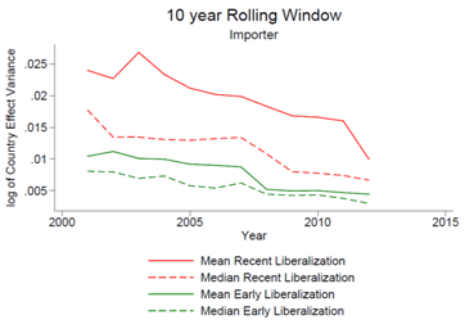
Country Effect-Error Effect Covariance



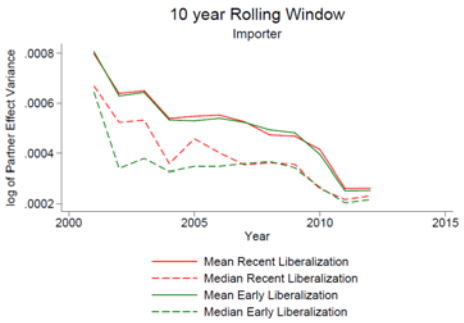
Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Figure 5B – Imports: Evolution of Variance Terms, Early Liberalized Countries vs. Recently Liberalized Countries

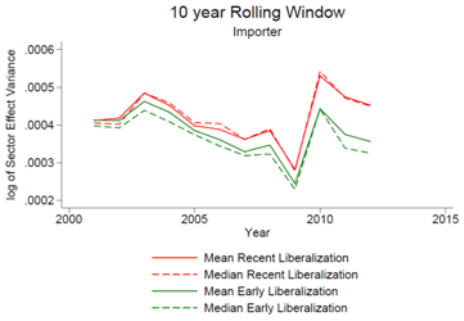
Country Effect Variance



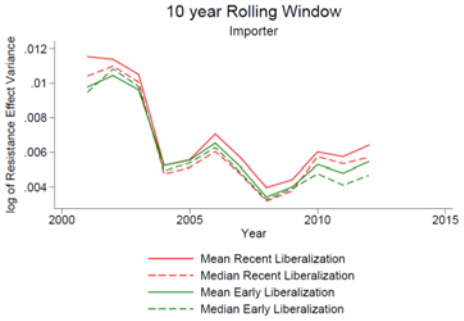
Partner Effect Variance



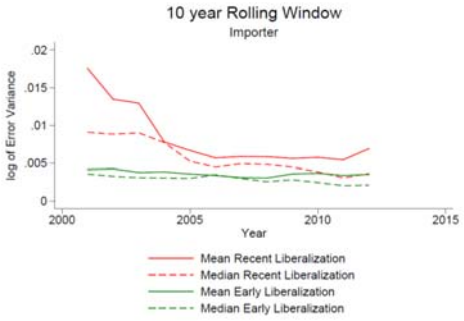
Sector Effect Variance



Resistance Effect Variance

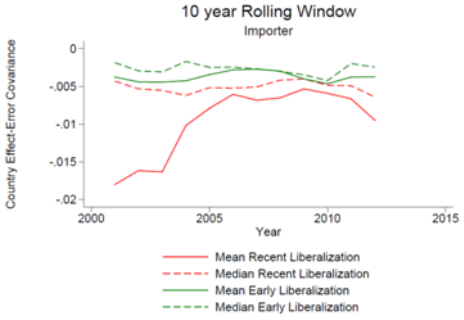


Error Variance



Common Effect-Resistance Effect Covariance

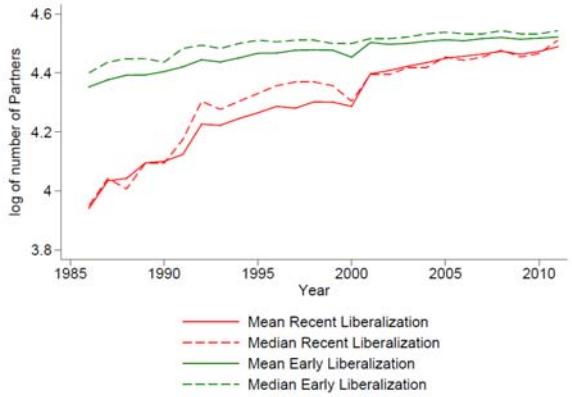
Country Effect-Error Effect Covariance



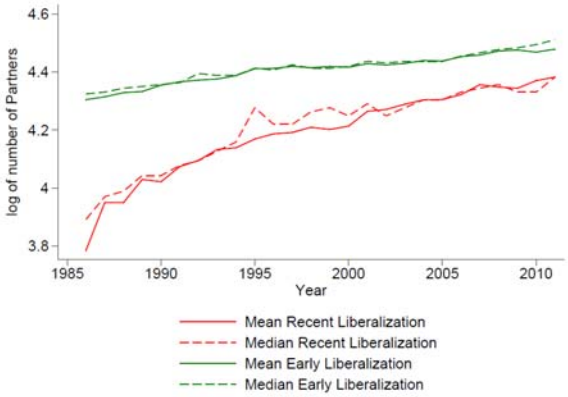
Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Figure 6 – Trade Liberalization and Diversification

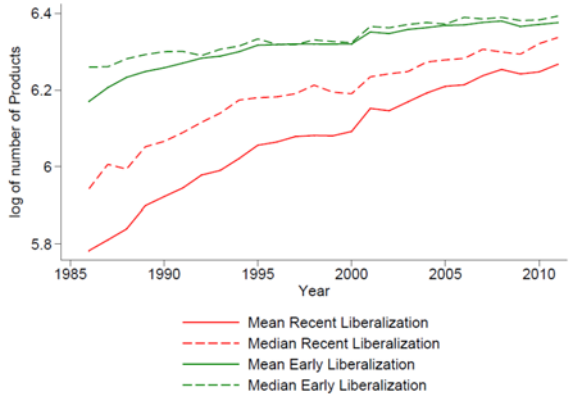
Log of the Number of Export Partners



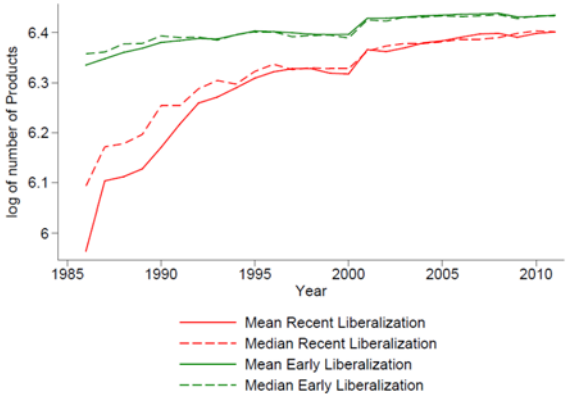
Log of the Number of Import Partners



Log of the Number of Export Products



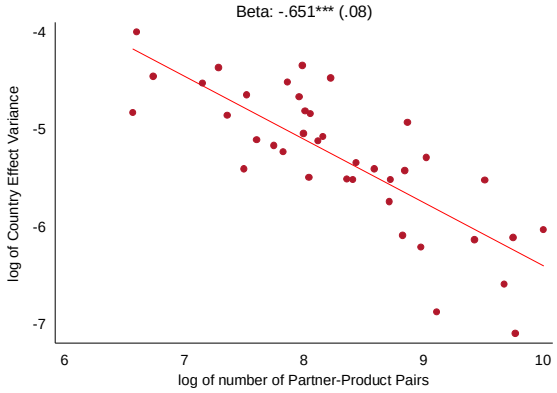
Log of the Number of Import Products



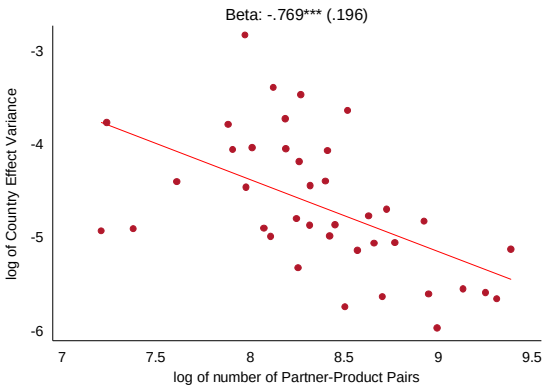
Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2.

Figure 7 – Country-Specific Volatility and Diversification

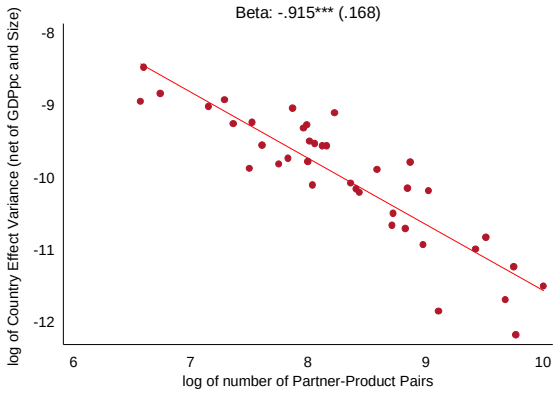
Panel A Exports: Country Effect Variance and Initial Diversification, Simple Correlation



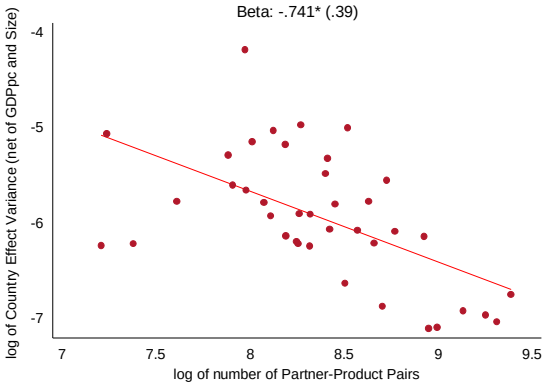
Panel B Imports: Country Effect Variance and Initial Diversification, Simple Correlation



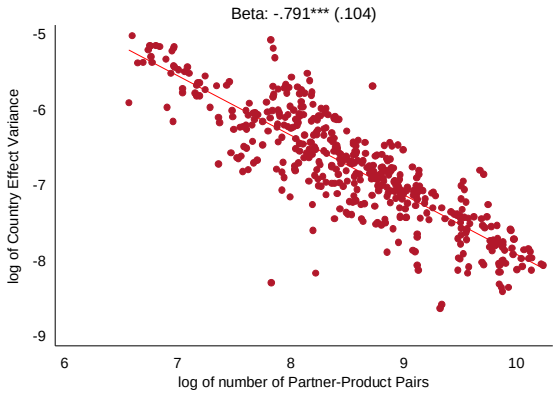
Panel C Exports: Country Effect Variance and Initial Diversification, Controlling for GDP and Size



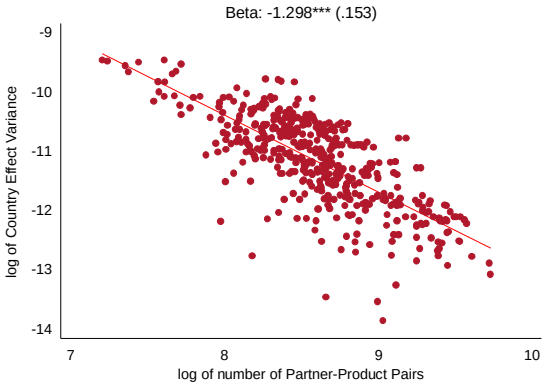
Panel D Imports: Country Effect Variance and Initial Diversification, Controlling for GDP and Size



Panel E Exports: Country Effect Variance and Diversification, Controlling for Country Fixed Effects

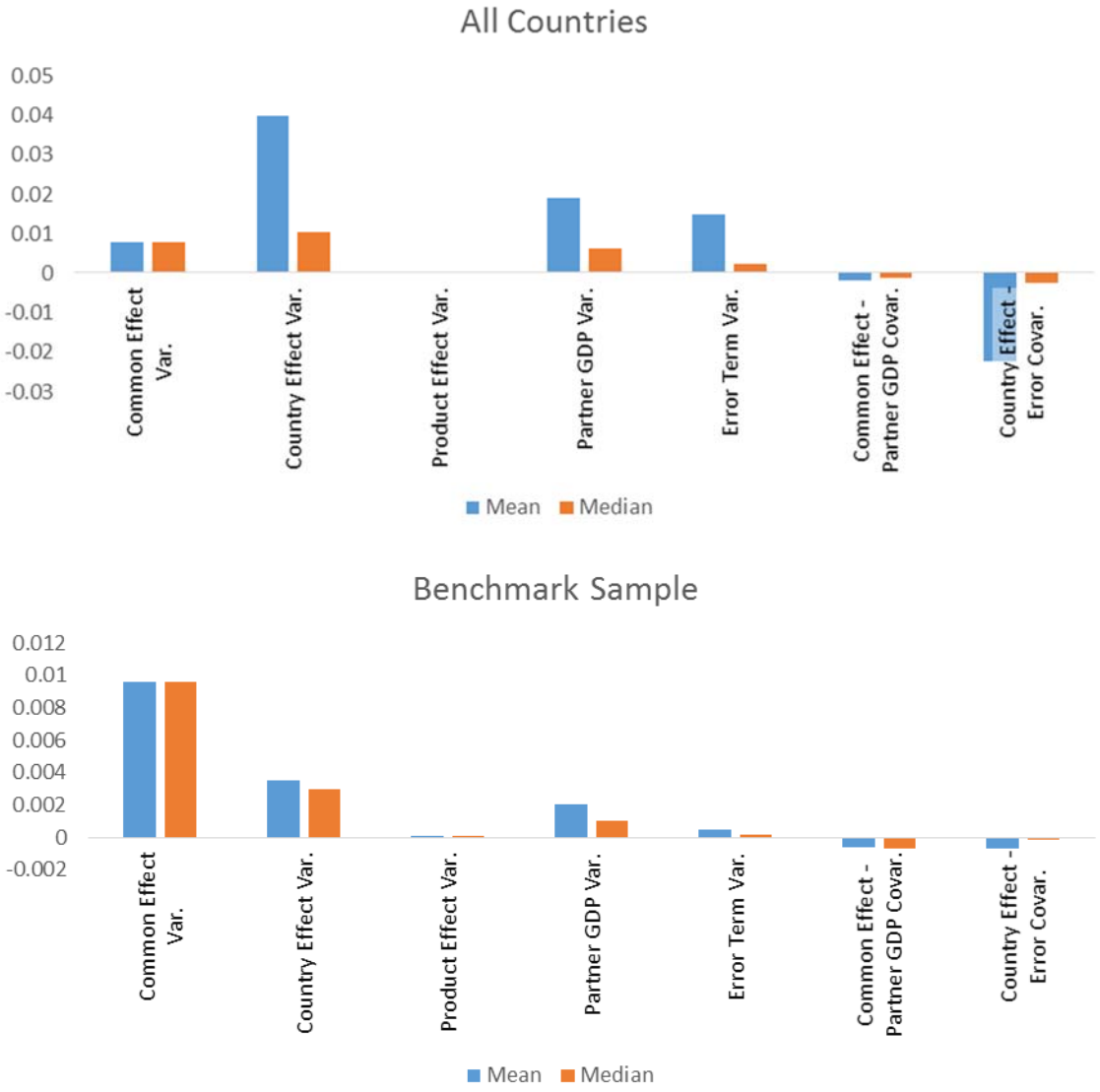


Panel F Imports, Country Effect Variance and Diversification, Controlling for Country Fixed Effects



Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

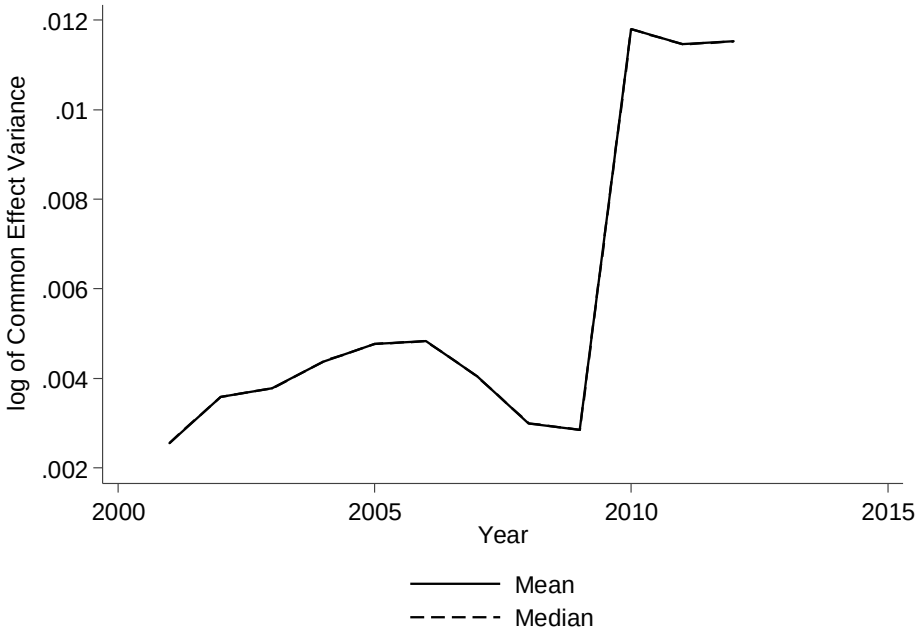
Figure 8 – Volatility Decomposition, 1990-2011, Extended Sample



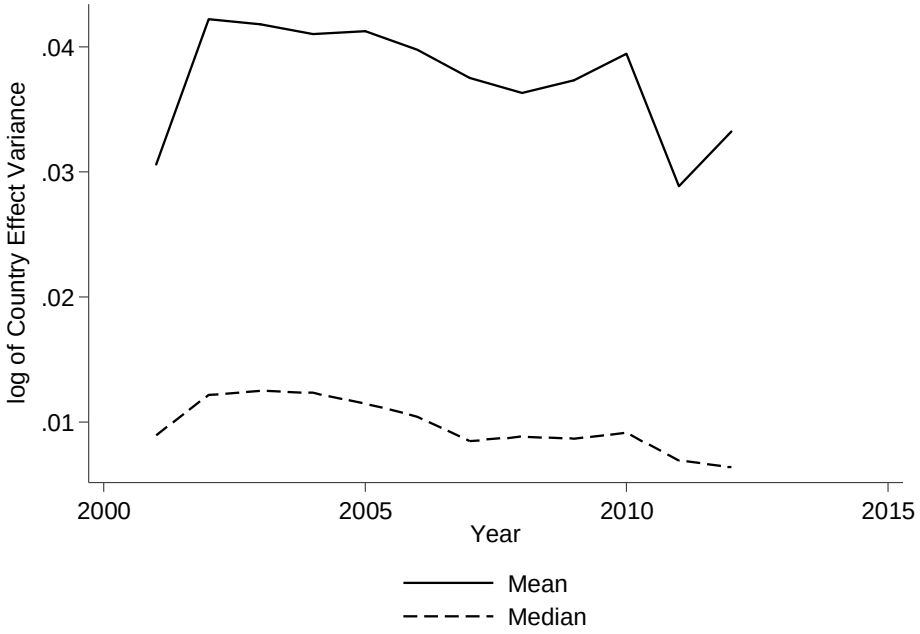
Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Figure 9 – Evolution of the Common Term and Country-Specific Term Variances, Extended Sample

Panel A. Evolution of the Variance of the Common Term

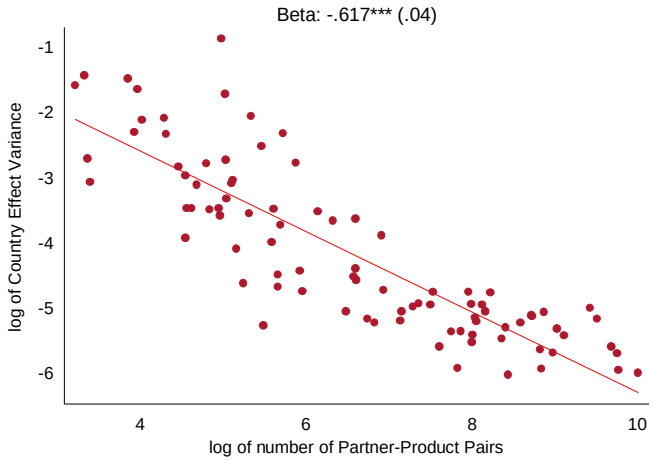


Panel B. Evolution of the Variance of the Country-Specific Term (Exporter)



Sources: Authors' calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Figure 10 – Exports: Volatility of the Country-Specific and Diversification, Extended Sample



Sources: Authors'calculations using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2. Note: Details on the calculations of variances and covariances can be found in the main text.

Table 1. Evolution Over Time of the Country-specific Term, by Timing of Trade of Liberalization

Dependent Variable	log Var. of the Country-Specific Term	log Var. of the Country-Specific Term	log Var. of the Country-Specific + Error Terms	log Var. of the Country-Specific + Error Terms
	Exports	Imports	Exports	Imports
	(1)	(2)	(3)	(4)
Time Trend	-0.0259***	-0.0767***	-0.00978	-0.104***
	(0.00673)	(0.00802)	(0.00706)	(0.00753)
Interaction (trend*recently liberalized)	-0.0305***	-0.00826	-0.0201*	0.00449
	(0.0110)	(0.0131)	(0.0115)	(0.0123)
Constant	108.1***	167.9***	54.16***	198.0***
	(17.43)	(20.79)	(18.30)	(19.52)
Observations	480	480	480	480
R-squared	0.788	0.753	0.723	0.805
Country FE	YES	YES	YES	YES

Source: Authors' calculation using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2

Note: ***p<0.01, **p<0.05, *p<0.1. Recently liberalized is a dummy variable taking value 1 for countries whose trade liberalization year according Wacziarg and Welch (2008) is greater than 1985 and zero otherwise. Details on the calculation of the variance of the county-specific term and the sum of the country-specific term and error term can be found in the main text.

Table 2. Trade Liberalization and Trade Diversification

Panel A. Exports

Dependent Variable:	log of Number of Partners	log of Number of Products	log of Number of Partners	log of Number of Products	log of Number of Partners	log of Number of Products	log of Number of Partners	log of Number of Products
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liberalized	0.592***	0.916***	0.594***	1.031***	0.253***	0.218***	0.0489***	0.112***
	(0.0185)	(0.0318)	(0.0196)	(0.0340)	(0.0142)	(0.0187)	(0.0135)	(0.0192)
Constant	3.520***	4.754***	3.779***	5.116***	2.920***	4.708***	3.137***	4.936***
	(0.0138)	(0.0237)	(0.0539)	(0.0938)	(0.0480)	(0.0633)	(0.0416)	(0.0590)
Observations	3,589	3,589	3,589	3,589	3,589	3,589	3,589	3,589
R-squared	0.221	0.188	0.294	0.245	0.793	0.873	0.886	0.919
Year FE	NO	NO	YES	YES	NO	NO	YES	YES
Country FE	NO	NO	NO	NO	YES	YES	YES	YES

Panel B. Imports

Dependent Variable:	log of Number of Partners	log of Number of Products	log of Number of Partners	log of Number of Products	log of Number of Partners	log of Number of Products	log of Number of Partners	log of Number of Products
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liberalized	0.502***	0.414***	0.479***	0.384***	0.315***	0.250***	0.131***	0.0616***
	(0.0139)	(0.0138)	(0.0143)	(0.0149)	(0.0133)	(0.0124)	(0.0127)	(0.0139)
Constant	3.648***	5.762***	3.887***	5.813***	3.199***	5.400***	3.423***	5.442***
	(0.0105)	(0.0103)	(0.0391)	(0.0408)	(0.0447)	(0.0417)	(0.0389)	(0.0427)
Observations	3,515	3,515	3,515	3,515	3,515	3,515	3,515	3,515
R-squared	0.270	0.205	0.382	0.249	0.694	0.702	0.831	0.773
Year FE	NO	NO	YES	YES	NO	NO	YES	YES
Country FE	NO	NO	NO	NO	YES	YES	YES	YES

Source: Authors' calculation using data from NBER-UN and described in Feenstra et al. (2005) merged with UN COMTRADE 4-digit SITC Rev. 2

Note: ***p<0.01, **p<0.05, *p<0.1. Liberalized is a dummy variable taking value 1 for years after the trade liberalization year identfied in Wacziarg and Welch (2008) and zero otherwise. Number of partners and number of products is the count of partners and products that each country has each year, respectively. For more details see the main text.