Do trade agreements actually reduce trade volatility?

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Abstract. A frequently stated objective of regional and multilateral trade agreements is to provide a more stable and certain trading environment. Does this translate into reduced volatility of trade flows? Using a structural gravity approach, we identify two potential channels through which international trade institutions may influence the volatility of bilateral trade flows: by affecting the variance of trade barriers and by affecting the covariance of economic outcomes between the trading partners. We then use a panel of bilateral industry-level trade data to empirically examine the effects of regional trade agreements and GATT/WTO membership on export earnings volatility. We find some evidence that joining a multilateral trade agreement such as the GATT makes export earnings less volatile. However, we find even stronger evidence that membership in a regional trade agreement *increases* the measured volatility in bilateral exports with other regional trading partners, and this rise in volatility increases as the agreement becomes deeper and more integrated. This increased volatility could be due to increased co-movements of economic outcomes across regional trading partners; we also demonstrate that regional trade agreements increase the industry-level covariance of importer expenditure and exporter production among member countries.

Résumé. Les accords commerciaux réduisent-ils réellement la volatilité des échanges? Les accords commerciaux régionaux et multilatéraux ont souvent pour objectif de créer un environnement commercial stable et sûr, mais entraînent-ils réellement une réduction de la volatilité des flux commerciaux? À l'aide d'un modèle gravitaire structurel, nous relevons deux canaux potentiels par lesquels les institutions commerciales internationales peuvent influencer la volatilité des flux commerciaux bilatéraux : en affectant la variance des barrières commerciales et en affectant la covariance des résultats économiques entre les partenaires commerciaux. Nous utilisons ensuite un panel de données sur le commerce bilatéral à l'échelle des industries pour examiner empiriquement les effets des accords commerciaux régionaux et l'appartenance au GATT/à l'OMC sur la volatilité des recettes d'exportation. Nous constatons que l'adhésion à un accord commercial multilatéral comme le GATT réduit la volatilité des recettes d'exportation. Cependant, nous trouvons des preuves encore plus solides que l'adhésion à un accord commercial régional augmente la volatilité mesurée des exportations bilatérales avec d'autres partenaires commerciaux régionaux, et que cette augmentation de la volatilité s'accentue avec l'approfondissement et l'intégration de l'accord. Cette volatilité accrue pourrait être due à l'augmentation des co-mouvements des résultats économiques entre les partenaires commerciaux régionaux; nous démontrons également que les accords commerciaux régionaux augmentent la covariance

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à l'échelle des industries des dépenses des importateurs et de la production des exportateurs parmi les pays membres.

JEL classification: F13, F14, F15

1. Introduction

A common goal of international trade agreements is not simply a reduction in trade barriers but also the creation of a more stable and predictable trading environment. For example, in their stated goals for negotiating free trade agreements (FTAs), the US International Trade Administration (ITA) argues that the aim of trade agreements is not only to "open up foreign markets" but also to create "a more stable and transparent trading and investment environment." Similarly, the preamble to the recent Australia-Hong Kong FTA envisioned it not only creating an "expanded" market but also a more "secure market for goods and services in the Parties and a stable and predictable environment for investment."[1] Thus, international cooperation is viewed not simply as a means for achieving negotiated tariff concessions but as a means of increasing the stability of the international trading system by securing those market access commitments against unilateral infringement. However, do countries that join a trade agreement in fact experience more stability in their trade relations with other member countries? In this paper, we conduct a large-scale empirical test of this question using industry-level bilateral trade flow data and a gravity specification approach.

Our paper makes three main contributions to this issue. First, we utilize a panel of industry-level bilateral trade data, covering nearly 200 countries and over 600 industries from 1964 to 2012, to uncover an interesting new empirical regularity. Specifically, while we find some evidence that World Trade Organization (WTO) membership reduces trade volatility among member countries, we find robust and consistent evidence that membership in a regional trade agreement (RTA) actually *increases* bilateral trade volatility. Indeed, the positive impact of RTA membership on trade volatility increases as the member countries become more integrated (i.e., progress from an FTA, to a customs union, to a common market) and as the agreement becomes deeper (i.e., involves more domestic policy issues). It should also be noted that this increase in trade volatility occurs on the *intensive* margin of trade and thus is not simply driven by the expansion of trade relations into new products or markets.[2]

Second, we provide a possible explanation for this surprising result by showing how it can be generated through increased covariance between member countries. Specifically, using a standard structural gravity model we show that, after controlling for intranational volatility, variation in bilateral trade flow volatility comes from two sources: (i) variation in bilateral trade costs and (ii) the covariance in economic outcomes between the importing

1 For discussion of the ITA's goals in tariff negotiations, see `https://legacy.trade.gov/fta/`. For the preamble to the Australia-Hong Kong FTA, see https://www.dfat.gov.au/trade/agreements/in-force/a-hkfta/a-hkfta-text/Pages/a-hkfta-preamble. Both Mansfield and Reinhardt (2008) and Rose (2005) provide numerous other examples of the stated intentions of trade agreement being to increase the stability of trade relationships.

2 It is somewhat tautological that going from zero trade (no volatility) to positive trade would, by definition, increase year-to-year trade volatility. Thus, the focus on this paper is of the impact of RTAs on existing trade relationships (the intensive margin).

and exporting countries.[3] Indeed, a key lesson of our paper is that a trade agreement, even if it achieves its stated goal of creating a more stable trading environment by reducing the volatility of trade barriers, could still increase the year-to-year volatility of trade flows among member countries if it also results in increased co-movements of economic outcomes.

This naturally raises the question of whether RTAs actually increase the covariance in economic outcomes between trading partners. Indeed, there is a small literature suggesting that trade agreements have increased aggregate business cycle co-movements between member countries (e.g., see Bejan 2011 and De Pace 2013). Thus, the third contribution of our paper is to investigate the impact of trade agreements on the covariance between industry-level expenditure (by the importing country) and production (by the exporting country). Utilizing a panel of industry-level international and intranational trade data, covering nearly 200 countries and over 150 industries from 1988 to 2017, we find that, indeed, there does appear to be increased co-movements of economic outcomes among trade agreement members. Of course, if this is the case in general, it suggests that the dual goals of increased integration and reduced trade flow volatility might be fundamentally incompatible.

This issue of trade agreements and trade stability is topical because several recent events have focused attention on the potential ability of trade agreements to provide more stability in trade relationships. The first was China's ascension into the WTO and the subsequent explosion in Chinese exports. As many researchers have noted (e.g., Feng et al. (2017)), China was already afforded most-favoured nation (MFN) status by many WTO members, including the United States, prior to its entry into the WTO. Thus, the large increase in Chinese exports has been attributed primarily to China obtaining access to the WTO's mechanisms for providing stability and certainty in trade relationships.[4] The second event was the trade collapse during the global recession in 2007 to 2009. The almost unprecedented fall in the global volume of trade (which far outweighed the fall in global output) has sparked a large literature on its causes and discussion of policy changes to prevent future events.[5] The third event, the COVID-19 pandemic, also caused a large reduction in trade in 2020 as well as the introduction of multiple export restrictions on the part of governments to increase access to medical supplies.[6] All three of these recent events have generated interest

3 The focus of the trade literature has been on the first source: how trade agreements can provide more certainty with respect to bilateral trade barriers (i.e., increased policy certainty as in Handley 2014, Limao and Maggi 2015 and Handley and Limao 2015). As a result, much of the discussion has focused on how policy certainty within trade agreements can lead not only to increases in trade volume but also, potentially, to stability in trade flows among member countries (e.g., see the discussion in Mansfield and Reinhardt (2008) and Rose (2005)). However, our theory suggests that trade agreements affect bilateral trade volatility not only through policy certainty but also through a second source that has received less attention: the covariance of economic outcomes. This also emphasizes the importance of distinguishing between trade policy certainty (as studied by Handley 2014, Limao and Maggi 2015 and Handley and Limao 2015) and trade flow stability (as studied in this paper).

4 Indeed, Handley and Limao (2017) estimate that one-third of the export growth between the United States and China can be attributed to greater certainty about US trade policy.

5 Potential explanations for the trade collapse proposed in the literature are vertical production linkages (Levchenko et al. 2010), compositional effects (Engel and Wang 2011, Eaton et al. 2016), trade finance (Amiti and Weinstein 2011, Chor and Manova 2012) and inventory adjustment (Alessandria et al. 2010).

6 See Hoekman (2020) and Wolfe (2020).

in the potential role of trade agreements to act as a force for trade stability and certainty to ameliorate the size and impact of future such trade shocks.[7]

Given the centrality of achieving stability and certainty in the objective statements of most international trade agreements, it is perhaps not surprising that the empirical correlation between trade agreements and trade flow volatility has been investigated previously (although the dearth of studies is perhaps surprising). Specifically, Rose (2005), Mansfield and Reinhardt (2008) and Chowdhury et al. (2021) also empirically investigate this subject in a gravity trade context. Obviously, our theoretical section leads to a new consideration of the impacts of RTAs on economic co-movements. However, the biggest empirical difference in our approach to trade flow volatility is, consistent with the gravity model in section 2 of our paper, our inclusion of time-varying exporter-industry and importer-industry fixed effects to control for intranational volatility.[8] This distinction appears important because all three previous papers found that RTA membership tends to reduce trade volatility, whereas we find the opposite.[9]

In what follows, section 2 provides a structural approach to investigating the link between trade policy membership and bilateral trade volatility, and section 3 introduces the data. We present the analysis of trade agreements and trade flow volatility in section 4 and the analysis of trade agreements and economic co-movements in section 5. Finally, we conclude in section 6.

2. Model

Consider a standard sectoral structural gravity relationship between bilateral trade and its determinants, as derived by Yotov et al. (2016), where i denotes the exporting country, j denotes the importing country and k denotes the sector:[10]

$$X_{ijk} = \frac{Y_{ik}E_{jk}}{Y_k}\left(\frac{t_{ijk}}{\pi_{ik}P_{jk}}\right)^{1-\sigma_k}. \tag{1}$$

7 This concern about increasing the stability of trade relationships to limit trade shocks is not surprising, given the negative impacts of export earnings volatility on economic growth and stability. High trade volatility introduces macroeconomic uncertainty, complicating development planning and discouraging investment from risk-averse firms. This can hinder economic growth, as evidenced by Bleaney and Greenaway (2001), who find that terms of trade volatility adversely affected growth in sub-Saharan Africa. Additionally, Ghosh and Ostry (1994) demonstrate that developing countries often increase their national savings to buffer against volatile export revenues. di Giovanni and Levchencko (2009) highlight that greater trade openness makes countries more susceptible to external shocks, leading to higher output volatility. This effect is particularly pronounced in countries with concentrated exports, which face greater trade volatility, as shown by Haddad et al. (2013).

8 See Head and Mayer (2014) for discussion of how the treatment of fixed effects in gravity regressions can lead to quite different gravity regression estimates of policy impacts.

9 Results with respect to General Agreement on Tariffs and Trade/World Trade Organization (GATT/WTO) membership are more ambiguous: Rose (2005) concludes that GATT/WTO membership has no effect on trade volatility while Mansfield and Reinhardt (2008) and Chowdhury et al. (2021) both conclude that GATT/WTO membership reduces trade volatility.

10 The derivation of this gravity equation follows Larch and Wanner (2017) and Anderson and Yotov (2016).

Trade flows from exporter i to destination j in sector k, X_{ijk}, can be decomposed into three determinants: exporter size, Y_{ik}; importer size, E_{jk}; and a trade cost term, $\left(\frac{t_{ijk}}{\pi_{ik}P_{jk}}\right)^{1-\sigma_k}$. Y_{ik} is defined as the value of production or nominal income in country i and sector k, and E_{jk} denotes expenditure in country j and sector k (the product of the two is normalized by aggregate world production $Y_k \equiv \sum_i Y_{ik}$). The trade cost term consists of three parts. First, the bilateral trade cost between countries i and j, t_{ijk}, which is sector-specific, captures both time-invariant aspects of the bilateral relationship (e.g., geographic or cultural distance) and time-varying aspects (e.g., tariffs or shipping costs). The other two terms, π_{ik} and P_{jk}, capture the standard multilateral resistance terms discussed in Anderson and Van Wincoop (2003).[11] They, too, are sector-specific and measure the ease of relative market access of the exporter i and importer j, respectively.

Assuming that the structural gravity equation (1) holds for every period t, it can be log-linearized to yield the familiar gravity equation:

$$\ln X_{ijkt} = \ln E_{jkt} + \ln Y_{ikt} - \ln Y_{kt} + (1-\sigma_k)\ln t_{ijkt} - (1-\sigma_k)\ln P_{jkt} - (1-\sigma_k)\ln \pi_{ikt}. \tag{2}$$

Since we are interested in the volatility of trade flows, we compute the variance of these logged trade flows, $Var(lnX_{ijkt})$, which can be expressed as the sum of variance and covariance terms:

$$Var(\ln X_{ijkt}) = V_{ikt} + V_{jkt} + (1-\sigma_k)^2 Var(\ln t_{ijkt}) + CV_{ijkt}, \tag{3}$$

where V_{ikt} is a collection of variance and covariance terms specific to the exporting country and V_{jkt} is a collection of variance and covariance terms specific to the importing country. In our empirical specification, we absorb these variance terms into time-varying exporter-industry and importer-industry fixed effects, α_{ikt} and α_{jkt}.

The focus of this paper is on the last two terms of this expression, which capture the bilateral variation in trade volume volatility. First, $Var(\ln t_{ijkt})$ is the variance in bilateral trade costs across time. This encompasses the variance in any trade frictions between partner countries, including shipping costs (e.g., variance in fuel costs which could be a function of distance) and trade barriers (e.g., variance in tariffs). A key question is the extent to which a trade agreement between country i and j leads to more predictability in trade flows by reducing the year-to-year variability of these trade barriers. Thus, we model the variability of trade costs as given by

$$(1-\sigma_k)^2 Var(\ln t_{ijkt}) = \gamma_{ijk} + \delta TA_{ijt} + \mu_{ijkt}, \tag{4}$$

where γ_{ijk} represents an intrinsic component to this variability (e.g., distance or product characteristics), μ_{ijkt} is an additive error term and $TA_{ijt} \in \{0,1\}$ is an indicator variable that takes the value of 1 if the two countries have a trade agreement in year t.

The impact of trade agreements on $Var(\ln t_{ijkt})$ represents the traditional goal of trade agreements in creating certainty and stability with respect to trade barriers. For example, in Limao and Maggi (2015), policy certainty is modelled as a mean-preserving compression of trade barriers across states of the world, while in Handley and Limao (2015) it is

11 Specifically, $\pi_{ik}^{1-\sigma_k} = \sum_j \left(\frac{t_{ijk}}{P_{jk}}\right)^{1-\sigma_k} \frac{E_{jk}}{Y_k}$ and $P_{jk}^{1-\sigma_k} = \sum_i \left(\frac{t_{ijk}}{\pi_{ik}}\right)^{1-\sigma_k} \frac{Y_{ik}}{Y_k}$. Finally, note that $\sigma_k > 1$ is the elasticity of substitution between product varieties in the underlying constant elasticity of substitution preferences.

a reduction in the arrival rate of a trade policy shock. International trade agreements are thought to reduce the variability of such trade barriers through several mechanisms. First, of course, they secure any market access commitments achieved through negotiations directly via restrictions on a country's trade policies (e.g., binding tariff ceilings and export subsidy restrictions). Second, they constrain the use of domestic policy (either intentional or unintentional) that might reduce market access below negotiated levels (see especially Article 3 of GATT).[12] Finally, they provide greater transparency and clarity about foreign trade barriers, thus imposing a cost to either introducing new trade barriers or "reinterpreting" old ones (because any changes would be subject to either retaliation or dispute settlement procedures). Therefore, the underlying assumption is that the existence of a trade agreement leads to greater policy certainty in trade barriers between the trading partners and, thus, $\delta \leq 0$.[13]

Second, CV_{ijkt} in equation (3) is a collection of cross-country covariance terms[14] (e.g., $Cov(\ln E_{jkt}, \ln Y_{ikt})$). Once again, these bilateral covariance terms could be a function of time-invariant factors (e.g., how similar the countries are in production structures). However, it is also reasonable to assume that these cross-country covariance terms are a function of how much the two economies are intertwined. For example, more integrated economies might lead to the greater transmission of shocks across borders. Thus, we model the cross-country covariance between a trading pair as being given by

$$CV_{ijkt} = \lambda_{ijk} + \rho TA_{ijt} + \nu_{ijkt}, \tag{5}$$

where λ_{ijk} represents the intrinsic component to this variability and ν_{ijkt} is an additive error term. In this case, ρ represents the impact of trade agreements on the degree of integration and, thus, the degree of economic co-movements among trading partners. For example, production decisions in the exporting country might be more responsive to demand shocks in the importing country ($Cov(\ln Y_{ikt}, \ln E_{jkt}) > 0$) if the countries are members of an RTA that has facilitated trade connections. The conventional wisdom is that international agreements tend, through increased connections and standardization of various policies, to lead to greater synchronizations of aggregate business cycles across member countries (see Bejan 2011 and De Pace 2013). Thus, our prior expectation is that $\rho \geq 0$ (and, indeed, we find evidence that RTAs do increase cross-country co-movements among member countries in section 5 of this paper).

Combining the above, the resulting empirical gravity equation for the volatility of trade flows is given as the following:

$$Var(\ln X_{ijkt}) = \beta TA_{ijt} + \alpha_{ikt} + \alpha_{jkt} + \alpha_{ijk} + \epsilon_{ijkt}. \tag{6}$$

12 For a discussion, see Bagwell and Staiger (2001).

13 For example, Jakubik and Piermartini (2019) find that WTO accession reduced the probability that import shocks would lead to changes in trade policy.

14 Specifically,

$$\begin{aligned} CV_{ijkt} = {} & 2Cov(\ln E_{jkt}, \ln Y_{ikt}) + 2(1-\sigma_k)Cov(\ln E_{jkt}, \ln t_{ijkt}) \\ & - 2(1-\sigma_k)Cov(\ln E_{jkt}, \ln \pi_{ikt}) + 2(1-\sigma_k)Cov(\ln Y_{ikt}, \ln t_{ijkt}) \\ & - 2(1-\sigma_k)Cov(\ln Y_{ikt}, \ln P_{jkt}) - 2(1-\sigma_k)Cov(\ln Y_{kt}, \ln t_{ijkt}) \\ & - 2(1-\sigma_k)^2Cov(\ln t_{ijkt}, \ln P_{jkt}) - 2(1-\sigma_k)^2Cov(\ln t_{ijkt}, \ln \pi_{ikt}) \\ & + 2(1-\sigma_k)^2Cov(\ln P_{jkt}, \ln \pi_{ikt}). \end{aligned}$$

Note, however, that the sign of β is ambiguous because it is a combination of the negative effect of trade agreements on the variability of trade costs ($\delta \leq 0$) and the potentially positive effect of trade agreements on the cross-country covariance terms ($\rho \geq 0$). Indeed, an important lesson of equation (3) is that even if a trade agreement achieves its stated goal of policy certainty (i.e., a reduction in $Var(lnt_{ijkt})$), this will not necessarily translate into reduced volatility of bilateral trade *flows* (i.e., a reduction in $Var(lnX_{ijkt})$). The estimated impact of trade agreements on trade flow volatility is, therefore, an empirical question that we explore in the following sections.

3. Data

The data on RTAs are from the NSF-Kellogg Institute Economic Integration Agreements (EIA) database,[15] which records the level of economic integration of each country pair from 1950 to 2012. Given our utilization of time-varying exporter (importer) fixed effects, estimation of the RTA coefficient comes from comparing the volatility of trade relations between member countries of an RTA before and after its origin relative to the change in the volatility of their trade relations with nonmember countries. At the beginning of our sample (1965), only about 6% of country pairs had some type of RTA, increasing to 27% of country pairs by 1990 and 43% of country pairs by the end of the sample (2012). The RTA ranking variable is a multichotomous index defined for each country pair each year; it ranges from 0 to 6 (see table 1 for interpretations).

Data on General Agreement on Tariffs and Trade/World Trade Organization (GATT/WTO) membership are obtained from Tomz et al. (2007), and the GATT/WTO binary variable is equal to 1 if both exporter and importer are formal members or nonmember participants of the GATT or WTO and equal to 0 otherwise. At the beginning of our sample (1965), around 66% of importers in our data were members of the GATT agreement; this rose to approximately 80% by 1990 (i.e., the time of the Uruguay Round), where it has remained fairly constant since. Thus, most of the variation in the WTO coefficient comes from the first several decades of our data set (which could explain why our estimates for the GATT/WTO variable are not as statistically significant or robust as our estimates for

TABLE 1
Regional trade agreement ranking

Type of agreement	Ranking	Description
No country	—	At least one of the two countries does not exist or have independence
No agreement	0	Do not have any economic integration agreement
Nonreciprocal PTA	1	Preferential terms given to developing countries
PTA	2	Preferential terms given to members
FTA	3	No (or substantially low) trade barriers to members
Customs union	4	Same as FTA but equal treatment of nonmembers
Common market	5	Same as customs union but free movement of labour and capital
Economic union	6	Same as common market but monetary and fiscal policy coordination

NOTES: —, not applicable; FTA, free trade agreement; PTA, preferential trade agreement.
SOURCE: NSF-Kellogg Institute Economic Integration Agreements (EIA) database (https://kellogg.nd.edu/nsf-kellogg-institute-data-base-economic-integration-agreements).

15 Available at https://kellogg.nd.edu/nsf-kellogg-institute-data-base-economic-integration-agreements.

the RTA variable). Summary statistics for both the RTA and GATT/WTO binary variable are provided in the online appendix.

Finally, the trade data are from the UN Comtrade Database.[16] Export values in current US dollars for each exporter(reporter)-importer(partner)-industry at the SITC Rev. 1 four-digit level from 1962 to 2014 are used to compute the export earnings volatility measures (to be defined in the next section). One of the complications in investigating the link between trade agreements and trade volatility is that there are many ways of measuring volatility, and these measures are invariably ad hoc.[17] However, our structural framework in section 2 provides some guidance in how we measure volatility.

3.1. Measures of volatility

Our measures focus on year-to-year volatility and are similar to those used in Rose (2005) and Mansfield and Reinhardt (2008) as well as in a related literature on the determinants of export volatility (e.g., see Massell 1964, Wong 1986, and Han 2021).[18] Specifically, Var_{ijkt} is the variance or average squared deviation from the 5-year mean log export value for each exporter-importer-industry (ijk), computed over rolling 5-year periods centred on the year of the observation:

$$Var_{ijkt} = \frac{1}{T}\sum_{t}(\ln X_{ijkt} - \overline{\ln X_{ijk}})^2, \tag{7}$$

where $\overline{\ln X_{ijk}} = \frac{1}{T}\sum_t \ln X_{ijkt}$. Larger values represent wider year-to-year deviations from the 5-year moving average.

A potential concern with this standard measure of volatility is that country pairs experience growth in trade, particularly after integrating into the world trading system, and this trade growth may be mistaken for an increase in volatility. To separate the long-run growth of exports over the period from short-run fluctuations around the growth path, the trend can be eliminated from the export series before constructing volatility measures as in Massell (1970), Lawson (1974), Cariolle and Goujon (2015), and Han (2021). We use a linear trend to predict log export values of each exporter-importer-industry (ijk).[19]

The detrended measure of volatility (Var^*_{ijkt}) is computed from these residuals and is denoted by an asterisk.Specifically, the variance of residual log exports (Var^*) for each exporter-importer-industry (*ijk*) over overlapping 5-year intervals is the average squared deviation of residual log exports from the 5-year mean, centred on the year of the observation. Massell (1970) and Lawson (1974) use a similar measure as what they call the *export instability index,*which is defined as the standard deviation of the residuals from the trend.[20]

16 Available at https://comtradeplus.un.org/TradeFlow.

17 An extensive literature has investigated the determinants of export volatility. See Massell (1970), MacBean and Nguyen (1980), Love (1986), and Han (2021). A consistent point of discussion in this literature is the proper measure of volatility as well as the need to test robustness of results to various measures.

18 As discussed previously, we repeat the analysis with multiple alternative measures of volatility and find similar results. Details are provided in the online appendix.

19 This is equivalent to using an exponential trend to predict export values. The trend is estimated for each exporter-importer-industry.

20 In Massell (1970), the instability index is calculated for each of 55 countries using data for the entire period (1950 to 1966), and a cross-sectional analysis is conducted. Similarly,

TABLE 2
Summary statistics: Measures of volatility

	Mean	Median	SD	Min	Max
Var	0.708	0.307	1.112	0	54.179
*Var**	0.678	0.290	1.074	0	50.241
Exporters			180		
Importers			194		
Industries (SITC Rev. 1 four-digit)			620		
Observations			23,231,304		

NOTES: SD, standard deviation; Var, 5-year variance of log exports; $Var*$, the respective detrended variable; SITC Rev.1, Standard International Trade Classification Revision 1.

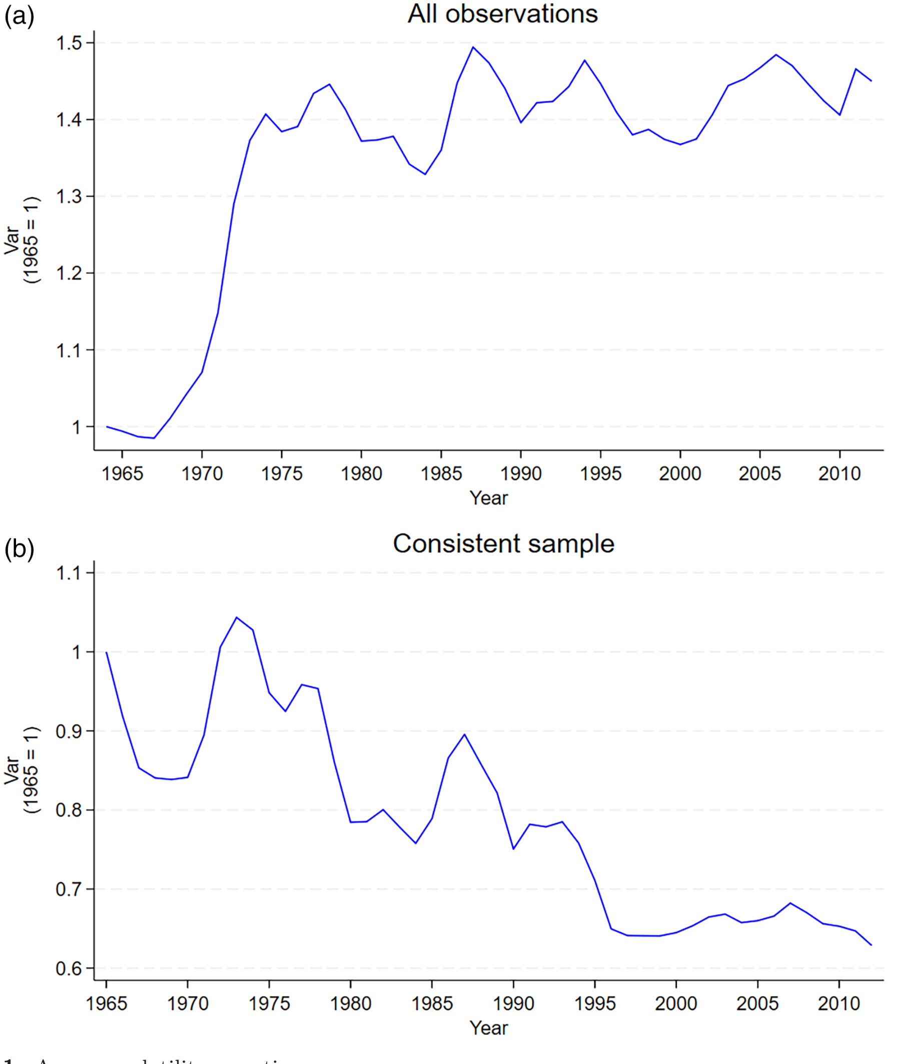

FIGURE 1 Average volatility over time
NOTES: Var is the 5-year variance of log exports. Panel (a) includes all observations in the analysis; panel (b) restricts the sample to the 102,572 exporter-importer-industry observations included in all years of the 49-year panel.

TABLE 3
Trade agreements and export volatility

	(1) Var	(2) Var^*
RTA	0.038***	0.027***
	(0.004)	(0.004)
GATT/WTO	−0.052***	−0.026*
	(0.016)	(0.015)
L.ln(exports)	−0.158***	−0.114***
	(0.001)	(0.001)
Exporter-industry-year (α_{ikt})	Yes	Yes
Importer-industry-year (α_{jkt})	Yes	Yes
Exporter-importer-industry (α_{ijk})	Yes	Yes
Observations	23,231,304	23,231,304
Adjusted R^2	0.464	0.465

NOTES: All regressions include exporter-industry-year (α_{ikt}), importer-industry-year (α_{jkt}), and exporter-importer-industry (α_{ijk}) fixed effects. Standard errors are clustered at the exporter-importer pair level and reported in parentheses. GATT/WTO, General Agreement on Tariffs and Trade/World Trade Organization; L.ln(exports), log of export value lagged one period; RTA, regional trade agreement; Var, 5-year variance of log exports; Var^*, detrended variance. $^*p < .10$. $^{**}p < .05$. $^{***}p < .01$.

Summary statistics for these two measures of volatility are provided in table 2.[21] The average values for the original (not detrended) measures are plotted in figure 1 (scaled so that 1965 = 1). In panel (a) of figure 1, volatility appears to increase substantially over time, including an especially rapid rise at the beginning of the sample period. However, this increase is primarily due to the addition of newer (and smaller) high-volatility trade relations, which raises average volatility considerably. In panel (b), we restrict the sample to ijk triplets with observations for all years in the sample (mostly long-standing trade relations between developed countries). In this case, volatility declines consistently and substantially over time. This distinction is one of the reasons that we conduct our analysis at the disaggregated industry level (see discussion below).

Our measures of volatility have several characteristics to assist with the anaylsis. First, to be consistent with our derived equation (6) we focus on the volatility in log trade. As a result, our measures of volatility are based more on year-to-year (approximate) percentage changes in trade flows than on absolute changes in trade volume. However, in the online appendix we provide some robustness checks using alternative measures of volatility (including some based on nonlogged trade flows) and find similar results. Since we don't have a multiplicative version of our trade variance equation (6), estimation via Poisson Pseudo Maximum Likelihood, which has become standard in the gravity trade literature (see Silva and Tenreyro 2006), would not be appropriate. In addition, as we show in the online appendix, detrending the trade data prior to calculating volatility does assist in dealing with heteroscedasticity.

Second, we calculate volatility at a disaggregated four-digit SITC level (as opposed to aggregated country-level measures). This allows for a more accurate picture of bilateral volatility; to the extent that volatility varies across sectors (e.g., see Han 2021 for evidence that durable goods tend to have higher levels of trade volatility), more aggregate measures

Lawson (1974) computes the weighted instability index for a set of countries over two time periods: 1950 to 1959 and 1960 to 1969.

21 It is clear from table 2 that there are some large outliers in volatility. Results were comparable when we repeated the estimation in tables 3 and 4 excluding the highest 1% of each dependent variable.

TABLE 4
RTA depth and export volatility

	(1) Var	(2) Var^*	(3) Var	(4) Var^*
Nonreciprocal PTA	0.022***	0.018***		
	(0.006)	(0.006)		
PTA	0.020***	0.013**		
	(0.006)	(0.006)		
FTA	0.045***	0.033***		
	(0.005)	(0.004)		
Customs union	0.036***	0.018**		
	(0.009)	(0.009)		
Common market	0.077***	0.063***		
	(0.008)	(0.008)		
Economic union	0.105***	0.091***		
	(0.011)	(0.011)		
Deep			0.083***	0.058***
			(0.012)	(0.012)
GATT/WTO	−0.050***	−0.024	−0.042***	−0.015
	(0.016)	(0.015)	(0.016)	(0.015)
L.ln(exports)	−0.158***	−0.114***	−0.154***	−0.112***
	(0.001)	(0.001)	(0.001)	(0.001)
Exporter-industry-year (α_{ikt})	Yes	Yes	Yes	Yes
Importer-industry-year (α_{jkt})	Yes	Yes	Yes	Yes
Exporter-importer-industry (α_{ijk})	Yes	Yes	Yes	Yes
Observations	23,231,304	23,231,304	21,716,110	21,716,110
Adjusted R^2	0.464	0.465	0.468	0.469

NOTES: In columns 1 and 2, we use the RTA classifications defined in Table 1. In columns 3 and 4, we replace the RTA classifications with *Deep*, which is a measure of the depth of the agreement. All regressions include exporter-industry year (α_{ikt}), importer-industry-year (α_{jkt}) and exporter-importer-industry (α_{ijk}) fixed effects. Standard errors are clustered at the bilateral pair level and reported in parentheses. FTA, free trade agreement; GATT/WTO, General Agreement on Tariffs and Trade/World Trade Organization; L.ln(exports), log of export value lagged one period; PTA, preferential trade agreement; RTA, regional trade agreement; Var, 5-year variance of log exports; Var^*, detrended variance. $^*p < .10$. $^{**}p < .05$. $^{***}p < .01$.

of bilateral trade volatility could be determined by the set of industries traded (which would also be influenced by trade agreements). Indeed, figure 1 demonstrates that standard measures of volatility are influenced by such selection effects. In addition, this approach provides analysis at a level of aggregation that policy makers are more likely to care about, unlike the more disaggregated HS10 (product) level.[22] However, as a robustness check, we also run the regression at the aggregate country-level (provided in the online appendix) as well as a more

22 The fact that the vast majority of trade barriers do not vary across firms—and that many firms produce multiple HS10-level products—leads to the formation of industry-level lobbying groups to influence governmental policy. Thus, many models of the political economy of trade protection model trade protection as emerging from a lobbying game between politically organized industries and governmental policy makers (e.g., Grossman and Helpman 1994). While the exact level of aggregation is not always specified in theoretical models, the vast majority of empirical studies of the political economy of trade protection in the United States are at the three or four-digit SIC level (see Gawande and Krishna 2004), which is similar to the four-digit SITC level that we adopt in this paper. SITC, Standard International Trade Classification (https://unstats.un.org/unsd/trade/dataextract/datapage.htm); SIC, Standard Industrial Classification (https://www.naics.com/everything-sic/); HS10, Harmonized System 10 digit (https://www.trade.gov/harmonized-system-hs-codes).

aggregated industry level (see section 5) and uncover a similar pattern in that membership in a regional agreement tends to increase bilateral trade volatility among member countries, and this rise in volatility increases as the agreement becomes deeper.[23]

Third, it is trivial that countries that do not trade exhibit no trade volatility and, thus, that the creation of new trade relations (i.e., increases in the extensive margin of trade) will tautologically increase trade volatility. The focus of our paper and structural model (which assumes positive trade flows) is on volatility in the *intensive* margin of trade which, according to Bernard et al. (2009), accounts for the majority of year-to-year changes in exports.[24] As a result, we analyze only existing, stable trade relationships between country pairs. Specifically, our data set includes only observations with exports that exceed US$500 in each of the surrounding 5 years.[25] Thus, our finding that RTAs increase trade volatility is a statement about the intensive margin of trade and is not driven by entry into new products or new markets.[26]

4. Trade agreements and the volatility of trade flows

To empirically examine the effects of trade agreements on export earnings volatility, we estimate equation (6). The presence of trade agreements is captured by the RTA ranking or depth measure and the GATT/WTO binary variable. A potential concern is that the decision to join a trade agreement is endogenous. Here, given our panel data approach, we follow the trade literature in the use of fixed effects to account for any latent factors that might determine both trade flows and agreement participation (see discussion in Head and Mayer 2014). Thus, as in Baier and Bergstrand (2007), we employ country-pair fixed effects to account for any time-invariant bilateral determinants of agreement participation.[27] Likewise, we employ time-varying exporter and importer fixed effects to control for any time-varying determinants of trade agreement membership, as in Aichele and Felbermayr (2015), as well as intranational volatility as discussed in section 2.

23 We also estimate a specification dropping the oil and gas industries, given their intrinsic volatility. Results were unchanged.

24 Bernard et al. (2009) find that short-run (year-to-year) changes in aggregate US exports are predominantly accounted for by changes in the intensive margin and argues that it is because recently added or dropped product-country trade flows are, on average, smaller than continuing product-country trade flows.

25 Prior to 2000, the minimum trade value reported was US$501. However, any positive dollar value has been reported since 2000. For consistency, the sample is restricted throughout to export values that exceed US$500. The 5-year requirement also ensures that we do not have to deal with the complications of zero-trade flows in our volatility measures. Since the US$500 figure is somewhat ad hoc, we also ran the specifications with a US$5,000 cutoff (resulting in the number of observations falling by around 15%). Results were consistent, although the WTO variable lost statistical significance.

26 Of course, the impact of trade agreements on fixed and sunk costs and, therefore, potential volatility in the *extensive* margin of trade is an area of separate interest. There exists an empirical literature on the durability of trade relations (see, especially, Besedes and Prusa 2006a, 2006b), and Besedes et al. 2018 investigate how international trade agreements might affect such durability.

27 Other papers that employ fixed effects to control for endogenous agreement membership include Regolo (2013), Baier et al. (2014) and Soete and Van Hove (2017).

It should be noted that our use of time-varying exporter (importer) fixed effects to control for country-specific shocks means that we are picking up only the direct impact of a trade agreement on the volatility of member-country trade flows relative to their trade relations with nonmember countries. Thus, if membership in a trade agreement were to uniformly change the volatility of all trade relations, this would be absorbed by our fixed effects. This is important for the interpretation of our estimates; a separate literature investigates the general link between trade openness and countrywide growth volatility (e.g., see Rodrik (1997), Raddatz (2007), di Giovanni and Levchencko (2009) and Kpodar and Imam (2016)). Any such countrywide impacts would not be captured by our estimation technique.

4.1. Results

In this section, we present results of estimating an empirical gravity equation for the volatility of trade flows based on equation (6):

$$Var(\ln X_{ijkt}) = \beta_1 WTO_{ijt} + \beta_2 RTA_{ijt} + \alpha ln X_{ijkt-1} + \alpha_{ikt} + \alpha_{jkt} + \alpha_{ijk} + \epsilon_{ijkt}, \quad (8)$$

where the dependent variable, $Var(\ln X_{ijkt})$, is one of our measures of volatility (Var or detrended Var^*) for exporter i and importer j in industry k at time t. We include an indicator variable for joint membership in the GATT/WTO, WTO_{ijt}, and an indicator variable for existence of an RTA between the trading partners, RTA_{ijt}, which takes the value 1 for category 3 (FTA) and higher and 0 otherwise. In addition, we include time-varying exporter-industry and importer-industry fixed effects, α_{ikt} and α_{jkt}, to control for intranational volatility and a time-invariant country-pair-industry fixed effect to control for selection effects.

Finally, we include the (lagged) log of export volume, lnX_{ijkt-1}, to isolate the direct effect of trade agreements on trade volatility.[28] Intuitively, our theoretical decomposition of section 2 models the direct impact of trade agreements on trade volatility (reduced volatility of trade costs and increased covariance of economic outcomes), holding the volume of trade constant (i.e., we are not modelling level changes in trade costs and trade volume). Because trade volume is mechanically correlated with any measure of trade volatility (e.g., measuring volatility in percentage terms, increases in trade volume are correlated with decreases in volatility since specific trade shocks are attenuated), we include trade volume to control for any such indirect scale effects in order to isolate the direct effects discussed in section 2. Thus, our empirical strategy is to compare changes in the volatility of bilateral trade, controlling for the size of the trading relationship (i.e., comparing trading relationships of similar trade volume).[29]

It should be noted, therefore, that we are not estimating the total average casual effect of a trade agreement on volatility; rather, by using export volume as a mediator variable,

28 For the estimates provided in this paper, we lag export volume one period. As a robustness check, we also ran specifications lagging two or three periods; results were robust with the exception that the GATT/WTO coefficient estimate lost statistical significance.

29 Indeed, as can be seen in table 3, export volume is *negatively* correlated with each volatility measure (i.e., large percentage changes are less common with large trade flows). In contrast, when we experimented with volatility measures based on absolute (nonlogged) changes, export volume was, not surprisingly, strongly *positively* correlated with our measures of volatility.

we are estimating the controlled direct effect (CDE) of the trade agreement (see Cinelli et al. 2022). As discussed in Heckman and Pinto (2015) and Fagerang et al. (2021), the estimation of the CDE relies on the assumption that any unobserved mediator variables are uncorrelated with the observed mediator variable (trade volume) and the outcome variable (trade volatility). Intuitively, this means our high-dimensional fixed effects need to control for not only confounders of the treatment-outcome relationship but also the confounders of the mediator-outcome relationship.

The first column of table 3 presents the results of estimating equation (8) with the 5-year variance of log exports (*Var*) as the dependent variable, with the second column using the alternate detrended measure.[30] As can be seen, the consistent pattern that emerges is that membership in an RTA increases the degree of trade volatility between the regional trading partners (i.e., $\beta_2 > 0$), while membership in the multilateral GATT/WTO reduces trade volatility (i.e., $\beta_1 < 0$).

Thus, our first main empirical finding is that bilateral trade flows between members of an RTA exhibit significantly *increased* year-to-year trade volatility, and this positive correlation is both statistically and economically significant across all of our measures of volatility. In addition, as we will show in section 4.1.2, this rise in volatility increases as the RTA becomes deeper and more integrated. Interpreting the magnitude of the impact, we find that on the enactment of an RTA, the variance of trade flows (*Var*) rises by 0.04, which is 12.4% of the median (holding GATT/WTO membership and trade volume constant).

In contrast, bilateral trade flows between GATT/WTO members exhibit less year-to-year trade volatility than other trade relationships. When both exporting and importing countries are members of the GATT/WTO, *Var* decreases by 0.05, which is 16.94% of the median. It should be noted that the GATT/WTO estimates are not statistically significant for all measures of volatility and are not robust in all of our specifications.[31] However, the negative coefficient in table 3 provides some evidence of the ability of multilateral institutions to fulfill their role of providing stability and certainty in trade relationships between member institutions.

Why do RTAs appear to be correlated with increased trade volatility, whereas multilateral agreements (GATT/WTO) are correlated with decreased trade volatility? A possible answer is suggested by our structural gravity approach: To the extent that RTAs are more likely to increase the covariance of economic outcomes across member countries, they are also less likely to contribute to decreased volatility in bilateral trade flows. We see two possible reasons why RTAs might result in higher (positive) bilateral co-movements. First, RTAs have often moved past the scope of the WTO to increase the degree of cooperation over a host of domestic policies (e.g., product standards, investment rules, antitrust) in an attempt to create greater regional integration. Thus, in section 4.1.2 we investigate the impact of the "depth" of the RTA on bilateral trade volatility. Second, the GATT/WTO is a multilateral agreement that stresses nondiscrimination across all member countries, suggesting that it might be less likely to increase the covariance between any two bilateral trading partners (i.e.,

30 Given the potential for serial correlation, reported standard errors are clustered at the bilateral pair level.

31 For example, the WTO estimate loses significance when one controls for RTA depth (see section 4.1.2). Likewise, the WTO coefficient loses significance when one lags the volume of trade more than one period. Finally, to control for potential correlation between GATT/WTO and RTA formation, we estimated table 3 on a subsample of observations without RTA pairs; the WTO coefficient also became statistically insignificant in this specification.

integration is spread out over more trading partners). Of course, this raises the possibility that the proliferation of RTAs might actually serve to decrease the covariance (and thus volatility) of any particular bilateral trading relationship. Thus, in the online appendix, we investigate the possibility of such "spillovers" across RTAs.

4.1.1. Event study

As further empirical evidence on the connection between signing an RTA and increased trade volatility, we also conduct an event study following Clark and Tapia-Schythe (2021) and Schmidheiny and Siegloch (2023). The event, for each country pair ij, is the signing of an RTA at a unit-specific time RTA_{ij}.[32] We omit any country pairs with an existing RTA at the beginning of the sample period.[33] In this section, the treatment effect is allowed to vary over a time window from $\underline{l} < 0$ periods prior to the event to $\bar{l} \geq 0$ periods after the event. Thus, our new estimating equation is given by

$$Var(\ln X_{ijkt}) = \beta WTO_{ijt} + \sum_{l=\underline{l}}^{\bar{l}} \beta_l RTA^l_{ijt} + \alpha ln X_{ijkt-1} + \alpha_{ikt} + \alpha_{jkt} + \alpha_{ijk} + \epsilon_{ijkt}. \quad (9)$$

In this specification, RTA^l_{ijt} is a treatment indicator for the event occurring $l \in [\underline{l}, \bar{l}]$ periods away from t. In what follows, we set a lead period of 10 years (i.e., $\underline{l} = -10$) and a lag period of 10 years (i.e., $\bar{l} = 10$), and we estimate only on those treated groups with data available for all 10 leads and lags, resulting in a sample of 13,474,883 observations. Trade relationships in which an RTA is never signed act as the counterfactual, and the difference between this control group and the treatment group is anchored at 0 in the omitted base period (i.e., as is standard, we use the period 1 year prior to the event as the baseline omitted case).

Since our interest here is in the year-to-year change in volatility following the implementation of an RTA, we use a year-to-year version of our volatility measure—the squared log difference in trade volume between year $t-1$ and t—as our measure of trade volatility.[34] Figure 2 graphically illustrates the coefficient estimates of our event study indicators (and the corresponding confidence intervals) for both the squared log difference (the left panel) and the detrended analogue (the right panel). The enactment of the FTA occurs at time period 0. It is clear from the figures that the pretrend years (labelled −5, −10, etc.) support the assumption of parallel trends (the p values for the F statistics for these are .52 in the top panel and .40 for the detrended bottom panel).

Next, the positive coefficient estimates during the post-trend years are consistent with the positive correlation found between RTA membership and trade volatility found in the previous section. Joint significance tests of the post-trend coefficients support the positive correlation between the enactment of an FTA and increased bilateral trade volatility (the

32 Notice that, as in the previous section, we define an RTA as a regional trade agreement of category 3 (free trade agreement) or higher.

33 Seven country pairs with RTAs end before the sample period; they are dropped after the RTA ends. We also exclude one country pair in the period 1993 to 1994 that resulted in much higher point estimates and standard errors for two postevent periods, although including these observations does not affect the results or statistical significance.

34 See the online appendix for more detail about the squared log difference.

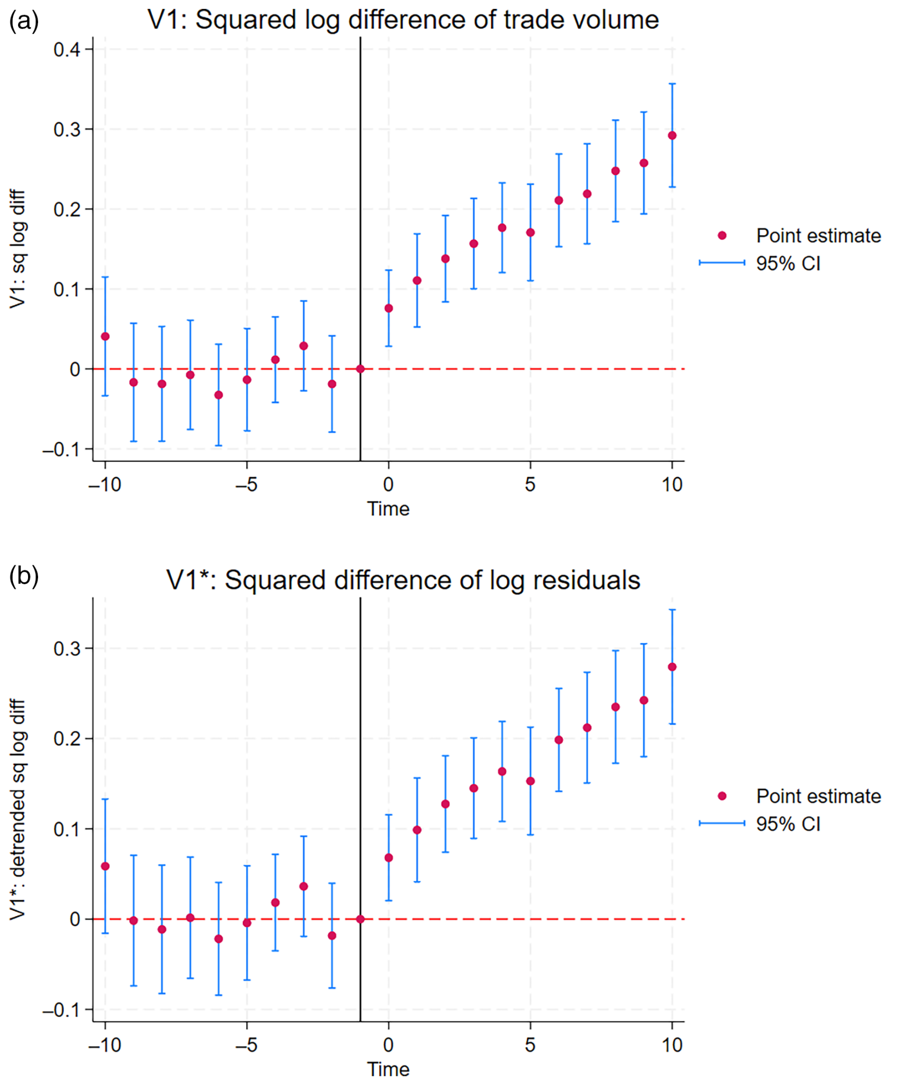

FIGURE 2 Event study: Trade volatility
NOTES: Panel (a) (top) is the event study analysis for the squared log difference of trade volume. Panel (b) (bottom) is the detrended analog, which is the squared difference of log residuals. CI, confidence interval.

corresponding F statistics are 8.25 for the top panel and 8.09 for the detrended bottom panel, both with p values below .0005). Finally, the gradual upward trajectory of the coefficient estimates is indicative of a gradual increase in volatility over time emerging from trade integration (as opposed to a sudden jump in volatility).

4.1.2. RTA depth and trade volatility

One of the more surprising results of the previous section is that trade volatility increases between country pairs that enter into an RTA. Although the GATT and WTO have been very effective in reducing traditional border policies (i.e., tariffs and quotas), RTAs have increasingly focused on domestic policies (e.g., health and safety regulations, product standards, antitrust laws and investment policies) with the motivation of creating deeper economic integration between regional trading partners. A potential explanation for the increased volatility, then, is that regional agreements lead to greater bilateral integration which, in turn, increases the covariance of economic outcomes between trading partners (and increases bilateral volatility). This suggests that "deeper" or more integrated RTAs might be associated with larger increases in bilateral trade volatility. In this section, we investigate the impact of the depth of RTA integration on bilateral trade volatility.

First, in columns 1 and 2 of table 4, we use the RTA classifications defined in table 1 and allow the coefficient estimates to vary over the different levels of integration. As can be seen in table 4, as country pairs become more regionally integrated, the estimated coefficient becomes larger (i.e., export earnings volatility is increasing in regional integration).[35] For example, in column 1, moving from no agreement to an FTA (category 3) would increase Var, the 5-year variance in log exports, by 0.045, which is about 14.65% of its median value. However, going from no agreement to a much more integrated agreement such as an economic union (category 6) would increase Var by more than twice as much, 0.105, or 34.2% of the median value.

As an additional measure of the depth of the RTA, we use the World Bank Content of Deep Trade Agreements database (Hofmann et al. 2017). The database includes 52 provisions of trade agreements, ranging from tariffs on industrial goods and export taxes to human rights and cultural cooperation. A "deep" agreement involves not only an agreement that addresses multiple issues but also the implication that countries are making binding commitments with respect to those issues. Thus, as our measure of the depth of a trade agreement, *Deep,* we use the number of legally enforceable provisions[36] contained in the RTA, scaled by the maximum number possible (52). Thus, the *Deep* variable ranges from zero in the case of no agreement to 0.73 in the case of the European Union countries (since 2004), with 38 of 52 categories of legally enforceable provisions.

In columns 3 and 4 of table 4, we replace the RTA classifications with this new measure of the depth of the agreement. The variable *Deep* is positive and statistically significant in both regressions, indicating that as trade agreements become "deeper" by adding more areas of commitment, our measures of bilateral trade volatility increase. Magnitudes are also comparable to the first two columns as, taken literally, going from no agreement ($Deep = 0$) to an agreement equivalent to the depth of the European Union ($Deep = 0.73$) increases Var by about 20% of its median value.[37]

The consistent pattern that emerges from our analysis is that membership in an RTA is correlated with higher trade volatility between regional trading partners, and this effect is more pronounced in deeper agreements. Specifically, as country pairs become more integrated across multiple economic dimensions, the year-to-year volatility of their trade flows increases.

35 RTAs are ordered so that the least integrated RTA (nonreciprocal PTA) has a value of 1 while the most integrated RTA (economic union) has a value of 6.

36 In the database, a provision is considered legally enforceable if the "language used is sufficiently precise and committing and if it has not been excluded from dispute settlement procedures under the PTA" (see Hofmann et al. 2017)

37 Equivalently, we can focus on the 18 "core" provisions suggested by Hofmann et al. (2017) and calculate *Deep* by using the percentage of legally enforceable core provisions included in the agreement (in which case the EU's depth would be 1.0 because it contains all 18 core provisions). Coefficient estimates for this alternative measure of RTA depth were very consistent: Going from no agreement ($Deep = 0$) to an EU-type agreement ($Deep = 1.0$) increases Var by a little over 18% of its median value.

A possible explanation for this pattern can be found in our structural gravity approach: The greater the depth of the RTA, the more tightly the member countries are tied together and, thus, the greater the covariance of their economic outcomes.

5. Regional trade agreements and cross-country covariance

In the previous section, we uncovered a new and surprising empirical regularity: that the signing of an RTA is associated with an *increase* in bilateral trade volatility. Our theoretical framework suggested that this could be due to the impact of the trade agreement on the co-movements of economic outcomes across trading partners; so far, however, that is only conjecture. In this section, we examine directly the impact of trade agreements on such co-movements.

Specifically, we investigate the effect of signing a trade agreement on the cross-country correlation between industry-level domestic expenditure by the importing country and industry-level domestic production by the exporting country (i.e., $Cov(lnE_{jkt}, lnY_{ikt})$). We focus on this particular covariance for two reasons. First, the introduction of a new data set, the International Trade and Production Database, allows us to compute industry-level production and expenditure data across multiple countries for a sufficiently long time-period for estimation. Second, we think that there is a sufficiently clear sign prediction, in that increased integration implies that a positive demand shock (i.e., increased expenditure) in the importing country leads to increased production among RTA-member trading partners (relative to other non-RTA trading partners).

5.1. Data

As mentioned, we compute industry-level expenditure and production data from the recently released International Trade and Production Database (ITPD; for more complete description, see Borchert et al. 2022). This database provides domestic and international trade data for the years 1986 to 2019 for more than 200 countries and 170 industries (the industry classification code is unique to the database but is most similar to the ISIC classification codes). From these data we can calculate industry-level domestic expenditure (E_{jkt}) and production (Y_{ikt}) for each country in the sample.[38]

Since the ITPD data set has international trade data, we can again calculate our measure of export volatility (Var). Doing so in a manner consistent with that of section 4 results in an unbalanced panel of 195 exporters, 195 importers and 153 industries for 1988 to 2017.[39] Summary statistics for the volatility measure are comparable to those in section 4, and appear, along with summary statistics of the independent variables, in the online appendix.

Next, we can use the ITPD data on industry-level expenditure and production data to calculate cross-country covariances. Our measure of the covariance between importer expenditure and exporter production is chosen to parallel the standard measure of volatility we used in section 4. Similar to the 5-year variance, we calculate a measure of covariance around a 5-year moving average. Specifically, Cov is the product of the deviations of expenditure

38 Specifically, domestic production (Y_{ikt}) can be found by summing domestic trade and total exports for country i and industry k, while domestic expenditure (E_{jkt}) can be found by summing domestic trade and total imports.

39 As before, we focus on the intensive margin (consistent positive trade relation) and merchandise trade (we drop the service industries to be consistent with the UN Comtrade data).

TABLE 5
Summary statistics: Measures of covariance

	Mean	Median	SD	Min	Max	*N*
Cov	1.328	0.543	3.692	−235.794	206.248	2,125,515

NOTES: *Cov*, 5-year cross-country covariance between importer expenditure and exporter production; SD, standard deviation.

and production from their individual expected values for each exporter-importer-industry (ijk), computed over rolling 5-year periods centred on the year of the observation:

$$Cov = \frac{1}{T}\sum_{t}\left(lnY_{ikt} - \overline{lnY_{ik}}\right)\left(lnE_{jkt} - \overline{lnE_{jk}}\right). \tag{10}$$

Note that larger positive values represent greater positive co-movements, which, in turn, would result in greater export earnings volatility.[40] Summary statistics for our measure of covariance are provided in table 5. One item to note is that the breadth of the data available for domestic expenditure and production is much less than that for international trade flows (e.g., most of the internal trade data does not even begin until 1988). To make coverage as broad as possible, we do not require expenditure and production data for all 5 years; rather, we require data for at least 3 years within the 5-year window.

5.2. RTAs and export volatility

Given that we are using a new data set, we first replicate our results from section 4 to verify that membership in an RTA is still associated with an increase in bilateral trade volatility. Results are given in the online appendix; as before, membership in an RTA is correlated with higher export volatility in the bilateral pair (i.e., $\beta_2 > 0$), while membership in the multilateral GATT/WTO is correlated with lower trade volatility (i.e., $\beta_1 < 0$).[41] Interpreting the magnitude of the impact on the variance of trade flows (Var) we find that moving from no agreement to an RTA is correlated with an increase of 0.034 in Var, which is 10.05% of the median (holding GATT/WTO membership and trade volume constant). This is very consistent with the estimates provided in section 4.

5.3. RTAs and cross-country covariance

Next, we estimate the impact of RTA membership on the cross-country covariance between importer expenditure and exporter production within the trading relationship. Thus, we estimate the following equation, which parallels equation (8):

$$Cov(\ln E_{jkt}, lnY_{ikt}) = \beta_1 WTO_{ijt} + \beta_2 RTA_{ijt} + \alpha_{ikt} + \alpha_{jkt} + \alpha_{ijk} + \epsilon_{ijkt}, \tag{11}$$

where the dependent variable, $Cov(\ln E_{jkt}, lnY_{ikt})$, is our measure of cross-country covariance between exporter i and importer j in industry k at time t. We retain the time-varying

40 As a robustness check, we repeated the analysis with two other measures of cross-country covariance: (i) the product of log first-differences between exporter production and importer expenditure and (ii) the correlation coefficient (the cross-country covariance of expenditure and production divided by the product of their standard deviations). Results were consistent and are provided in the online appendix.

41 It should be noted that we have very little time series variation in the WTO variable; thus, our focus in this section is on β_2 (the coefficient estimate for RTAs).

exporter-industry and importer-industry fixed effects, α_{ikt} and α_{jkt}, and the time-invariant country-pair-industry fixed effects, since they assist in controlling for the endogeneity of the RTAs. Given the lack of time-series variation in WTO membership, our focus in this section is on β_2 (the impact of regional agreements on cross-country co-movements).

Results of estimating equation (11) are provided in table 6. In column 1, RTA_{ijt} is an indicator variable for existence of an RTA between the trading partners, which takes the value 1 for category 3 (FTA) and higher and 0 otherwise. As can be seen, and consistent with our conjecture, membership in an RTA is associated with an increase in cross-country covariance between expenditure and production (i.e., $\beta_2 > 0$).[42] Interpreting the magnitude, we find that joint membership in an RTA is associated with a 0.161 increase in Cov (the 5-year cross-country covariance), which is 29.65% of its median value.[43]

In column 2 of table 6, we replace the RTA indicator variable with our measure of RTA depth ($Deep$) from section 4.1.2 and similarly find that deeper agreements result in greater co-movements. Specifically, going from no agreement ($Deep = 0$) to an agreement equivalent to the depth of the European Union ($Deep = 0.73$) increases Cov by 89% of its median value.

We can also allow the coefficients to vary over the type of agreement to investigate whether greater integration is associated with greater (positive) cross-country co-movements. As can be seen in column 3 of table 6, as country pairs become more integrated, the estimated coefficient becomes larger (i.e., the cross-country covariance is increasing in regional integration). For example moving from no agreement to an FTA (category 3) is associated with an increase in Cov of 0.147, which is about 27% of its median value. However, going from no agreement to a much more integrated agreement, such as an economic union (category 6), is predicted to increase Cov by almost 3 times as much (0.449), or 82% of the median value.

Thus, the results of this section provide some evidence that trade agreements can lead to increased covariance of economic outcomes and that those co-movements are increasing in the depth and degree of integration of the agreement. This finding is important because it provides a degree of plausibility to our conjecture that RTAs (and bilateral integration) are correlated with increased volatility of trade flows due to an increased covariance channel. The somewhat pessimistic policy implication is that, if our finding is true in general, the joint goals of increased bilateral integration and reduced bilateral trade flow volatility might be fundamentally incompatible.

6. Conclusion

The GATT/WTO system has greatly reduced trade barriers over the past 70 years. However, even as existing trade barriers have fallen to record low levels, RTAs continue to proliferate, partly as a result of the expansion of traditional trade agreements into other areas such as intellectual property rights, but also partly because such agreements are viewed as important sources of stability for existing trade relationships. Indeed, a legal-economics framework has

42 Somewhat surprisingly, membership in the WTO is also positively correlated with the cross-country covariance in some specifications, although the standard errors of the estimates are large, most likely due to the lack of much time-series variation in WTO membership during the time period.

43 In de Soyres and Gaillard (2022), GDP co-movements were higher among trading relationships that were biased towards intermediate goods trade. Thus, we also ran a specification where we allowed the RTA coefficient to vary across product/industry type (intermediate input vs final good). However, we could not reject the hypothesis of similar effects of RTAs on covariances for intermediate and final goods. These results are available on request.

TABLE 6
RTAs and cross-country covariance

	(1)	(2)	(3)
RTA	0.161***		
	(0.030)		
Deep		0.663***	
		(0.074)	
Nonreciprocal PTA			−0.219***
			(0.057)
PTA			0.047
			(0.068)
Free trade agreement			0.147***
			(0.035)
Customs union			−0.128
			(0.121)
Common market			0.341***
			(0.066)
Economic union			0.449***
			(0.080)
GATT/WTO	0.564***	0.370*	0.561***
	(0.209)	(0.214)	(0.208)
Exp-ind-year (α_{ikt})	Yes	Yes	Yes
Imp-ind-year (α_{jkt})	Yes	Yes	Yes
Exp-imp-ind (α_{ijk})	Yes	Yes	Yes
Observations	2,125,515	1,991,607	2,125,515
Adjusted R^2	0.684	0.681	0.684

NOTES: The dependent variable, *Cov,* is the 5-year cross-country covariance between importer expenditure and exporter production. In column 1, we use the *RTA* indicator variable; in column 2, we replace it with our depth measure (*Deep*); and in column 3, we use the RTA classifications to allow coefficients to vary by agreement type. All regressions include exporter-industry year (α_{ikt}), importer-industry-year (α_{jkt}), and exporter-importer-industry (α_{ijk}) fixed effects. Standard errors are clustered at the bilateral pair level and reported in parentheses. *Deep,* RTA depth; FTA, free trade agreement; GATT/WTO, General Agreement on Tariffs and Trade/World Trade Organization; PTA, preferential trade agreement; RTA, regional trade agreement. $^{*}p < .10$. $^{**}p < .05$. $^{***}p < .01$.

emerged (see Bagwell and Staiger 2001 and Bagwell et al. 2002) that views these institutions not simply as a forum for negotiations but also as a means to achieve secure market access to foreign markets. Thus, for example, Canada's objectives in the North American Free Trade Agreement negotiations were not so much to reduce US trade barriers (there was already an existing US-Canada FTA), but rather to curtail the US use of unilateral trade actions (see Mansfield and Reinhardt 2003) and to clarify many of the prior trading rules that might be subject to reinterpretation by the United States (see Abbott 2000). Likewise, Jakubik and Piermartini (2019) argues that one of the main benefits of WTO membership is that it constrains one's trading partners from instituting trade barriers in response to import shocks.

Consistent with its stated goal of ensuring that trade flows as smoothly and predictably as possible, we find some evidence of reduced trade volatility among members of the GATT/WTO. However, we also find that membership in an RTA is correlated with *increasing* bilateral trade volatility among member countries and that this higher volatility is more pronounced as the RTA becomes deeper and more integrated. This finding suggests that, at least among RTAs, the joint goals of integration and reduced trade flow volatility may be at odds with one another; increased bilateral integration may come at a cost of heightened bilateral trade volatility. At the very least, it suggests that the increased policy certainty provided by trade agreements (e.g., see Handley 2014 and Limao and Maggi 2015) does not necessarily translate into reduced year-to-year volatility in trade flows.

In this paper, we argue that this increased trade flow volatility could be due to increased co-movements among member countries and provide evidence of greater responsiveness of production in the exporting country (Y_{ikt}) to expenditure in the importing country (E_{jkt}). However, our gravity model also notes a number of other covariances across the two countries that might be of importance (e.g., between expenditure and the multilateral resistance terms). In addition, our theory and empirics focus on volatility on the intensive margin and do not consider higher moments (e.g., skewness) or changes on the extensive margin. Thus, while there is a large empirical literature on the impact of trade agreements on first moments (i.e., trade volume) and this paper extends that literature to second moments (i.e., trade flow volatility on the intensive margin), a relatively unexplored field involves the impact of trade agreements on higher moments (e.g., skewness) and mixed moments (i.e., covariances). Our results suggest this might be a productive area of future research.

Supporting information

The data and code that support the findings of this study are available in the Canadian Journal of Economics Dataverse at https://doi.org/10.5683/SP3/CVTBIF.

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