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# Time-series dynamics of Baltic trade flows: Structural breaks, regime shifts, and exchange-rate volatility

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## Abstract

**Aim/purpose** – In the decades since their reintegration with the West, the small open economies of Estonia, Latvia, and Lithuania have seen their trade flows grow substantially. While the mix of trade partners has evolved over time, the region has been affected by various political and economic shocks. This study examines the bilateral trade balances between the Baltic countries and nine partners to investigate whether there have been structural breaks due to political or economic events. Because these events may have been "priced into" exchange rates or increased these rates' volatility, connections between these variables and trade balances are also considered.

**Design/methodology/approach** – Monthly data beginning in 1994 are taken from the International Monetary Fund's Direction of Trade Statistics [DOTS]. Trade partners include the Nordic countries of Finland, Sweden, and Norway, as well as Poland, Russia, and the United States and country groupings such as the CIS, Advanced Economies, and the World. Ratios of the export and import values are used to create bilateral trade balances. The Bai–Perron (1998) structural break test is then used to identify "break points" that can classify time periods into regimes. Baltic nominal and real effective exchange rates, both in log changes and as a GARCH-based volatility measure, show whether regimes correspond to competitiveness or risk. Correlations are calculated to show links between bilateral trade balances and real exchange rates.

**Findings** – Each trade balance has at least one structural break; many have more. In fewer than half of the cases do these correspond to specific events such as EU accession or the Global Financial Crisis. Trade with Russia has decreased, particularly for Estonia

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and Latvia. But many partners with historical ties, such as Estonia-Finland, Latvia--Sweden, and Lithuania-Poland have more breaks than do other partners (such as Estonia--Poland). Structural breaks in real exchange-rate returns and volatility do not match those of trade balances, and correlations between returns and trade balances are low.
**Research implications/limitations** – These findings open the door to future research on the macroeconomic and cultural/historical factors behind these trade linkages and any changes in regimes. However, no structural determinants have yet been estimated.
**Originality/value/contribution** – This study isolates changes in trade regimes, which can be further explained by specific events or particular dates. It also shows that variance has changed as well as the mean, but this differs by country and by the partner.

**Keywords:** Trade flows, Baltics, time series, structural breaks.
**JEL Classification:** F14, F4, C1.

## 1. Introduction

Since the collapse of the Soviet Union in 1991, Estonia, Latvia, and Lithuania have eagerly reoriented their trade flows Westward. With historical ties to their northern neighbors along the Baltic Sea, it is not surprising that trade flows within this region have grown substantially over the past 30 years. Likewise, trade between these small open economies has expanded worldwide, with both manufactured goods and agricultural products making up large shares of the exchange. Trade between the Baltics and Russia, while still strong, has not grown to the same degree, however, Kulbacki and Michalczuk (2021) examined multiple types of economic integration and noted that the Baltics have been shifting trade toward the EU and away from Russia.

So far, there has not been an extensive analysis of Baltic trade flows, particularly regarding political and economic events, such as global economic crises, EU accession, and euro adoption. This study fills this gap by incorporating structural breaks (Bai & Perron, 1998; Zeileis, Kleiber, Krämer, & Hornik, 2003; Zeileis, Leisch, Hornik, & Kleiber, 2002) to these trade balances using methods similar to earlier analyses of regional trade (Hegerty, 2022; Ketenci, 2016).

This study aims to explain any structural breaks that are uncovered, before beginning a preliminary investigation of linkages to the real exchange rate. Not only is this price a key driver of exports and imports (Bahmani-Oskooee, Harvey, & Hegerty, 2013; Bahmani-Oskooee & Ratha, 2004; Goldstein & Khan, 1976), it is also expected to "price in" any geopolitical or economic events. Breaks in exchange-rate returns, as well as volatility, are compared to those in the trade balances, and simple nonparametric correlations are calculated to show

bivariate relationships between each bilateral trade balance and a number of effective and bilateral exchange rates.

This paper proceeds as follows: Section 2 provides a literature review. The methodology is explained in Section 3, and the results are discussed in Section 4. The overall conclusions of the study are provided in Section 5.

## 2. Literature review

Studies specifically of Baltic trade flows are relatively rare in the literature. Often, they have been incorporated into larder studies of the European Union or of its "new" members that joined in 2004; other times they were conducted by researchers located in those countries. Of the extant literature, there are a number of interesting studies.

### 2.1. Analyses of Baltic trade flows

In one set of studies, the micro- and macroeconomic determinants of trade flows are investigated. Some studies are theoretical: Bems and Jönsson Hartelius (2006), for example, model Baltic trade before the 2008 crisis, focusing on the role of capital flows in driving trade balances. In an empirical study, Paas, Tafenau, and Scannell (2008) tested a gravity model for a panel of 23 EU members, including eight Central and East European (CEE). The authors found support for the "new trade theory" and intra-industry trade.

Other analyses focus on specific industries, often on a single Baltic country. Fainštein and Netšunajev (2010) noted the rapid reorientation of Estonian trade from Russia toward the EU, before looking at industry characteristics, comparative advantage, and intra-industry trade. Lechman (2014) examined the high-tech and Information and Communication Technology (ICT) industries in nine CEE countries, including the Baltics from 2000 to 2011; the authors uncovered links to international competitiveness. Beņkovskis, Bērziņa, and Zorgenfreija (2016) investigated Latvian re-exports, and Veebel (2020) showed that changes in the Estonian transit sector are driven partially by changes in trade flows.

Most recently, Bošnjak, Novak, and Wittine (2020) included Latvia in a set of five CEE countries, finding evidence of hysteresis (resulting in persistent changes) in the time series. That analysis, which was performed using nonlinear time series methods, arrived at purely technical conclusions. Nonetheless, it did show some evidence of structural change in net exports in one Baltic country.

## 2.2. Regime shifts and structural breaks

Regime shifts and structural breaks in export and/or import flows have been studied for decades. In early analysis, Mah (1993) examined Korean imports, but the methodology has since been criticized for applying traditional techniques to nonstationary data. More appropriate methods using cointegration analysis were later applied by Arize (2002), including structural breaks in a study of the relationship between exports and imports in a set of 50 countries. It is important to note that in many analyses, structural breaks are merely included to ensure the appropriate model specification, and are not the key variables of interest. Akbas and Sancar (2021), for example, incorporated breaks in a panel of 22 emerging and developed economies, and besides reporting break dates, did not thoroughly investigate the impact of specific events on the cointegrated relationship between trade dynamics and net exports. Other examples include Jeelani, Tomar, Das, and Das (2019), who included India's trade as a determinant of India's exchange rate; and Afonso, Huart, Jalles, and Stanek (2020), who found that incorporating structural breaks in a panel of EU current accounts does not make them stationary.

Many analyses of this type focus on one of the world's major exporters: China. These apply standard time-series methods: unit root tests (to determine whether a series is stationary) and cointegration analysis (to find a stationary long-run relationship between nonstationary variables). Wu and Zhang (1998), for example, found multiple structural breaks while conducting a unit root test on U.S. exports and imports vis-à-vis China; Camarero, Gómez, and Tamarit (2013) also found breaks in the European Monetary Union's trade with China. Yalta and Sivrikaya (2018) included breaks in a study of the persistence of China's current account.

Some studies do in fact focus on the importance of specific break dates. Fidrmuc, Kaufmann, and Resch (2008) found the year 1973 to have represented a regime shift in Austrian exports and imports with Bulgaria, Czechoslovakia, Poland, Hungary, and the Soviet Union. Nag and Mukherjee (2012) examined unit roots and cointegration between India's exports and imports, and noted structural breaks in the 1970s, the mid-1980s, and the period of the Global Financial Crisis. Li, Lai, Wang, and Hsu (2019) asked whether the Belt and Road caused a structural break, applying unit root tests on China's trade balances versus 64 countries. Wang (2019) found no such regime shift related to the Global Financial crisis in China's trade.

There are, however, fewer macroeconomic analyses of bilateral trade flows in the Baltic, particularly of regime shifts in trade balances. Ketenci (2016) investigated quarterly bilateral trade flows from the European Union and 10 partners; incorporating structural breaks shows that income drives trade more than exchange rates. While this supports the idea proposed here that exchange rates automatically incorporate these shifts, the Baltics were not treated separately in that analysis. In a very recent study, however, Hegerty (2022) examined the Baltics' trade with China, Japan, and India. There is evidence of multiple structural breaks among the nine trade balances, and cointegration analysis found that the real effective exchange rate has a significant effect on only two trade balances (both involving India).

## 2.3. Connections between exchange rates and trade balances

Such connections between real exchange rates – a measure of the relative price that helps drive exports and imports – are generally left to multivariate analyses. Rafiq (2013) found that correlations between trade balances and real exchange rates depend on the type of macroeconomic shock, and supported incorporating structural breaks into a full model. As noted by Bahmani-Oskooee and Ratha (2004), cointegration methods are typically used; nearly every trade partner has since been analyzed. But the Baltics are often omitted. Bahmani-Oskooee and Kutan (2009), for example, examined 11 CEE countries, but not the Baltics. In one of the few Baltic-specific analyses, Hegerty (2022) found that volatility in the real effective exchange rate increases Estonia's trade balance with China, but no other pairs are affected. However, more geographically proximate trade partners are not included in that study. The current analysis aims to fill this gap with a preliminary bivariate analysis that will inform future research using cointegration methods on a full macroeconomic model.

## 3. Research methodology

Monthly trade data from the International Monetary Fund's Direction of Trade Statistics [DOTS] for Estonia, Latvia, and Lithuania vs. nine partners were used for this study. The data begin in January 1994 and end in July 2021. While a key focus here was on the Nordic nations of Finland, Norway, and Sweden, other partners such as Russia, Poland, and the U.S. were also included, as

well as three country groups – the Commonwealth of Independent States (CIS), the IMF's Advanced Economies group, and the World. All flows were depicted from the Baltic "point of view" (e.g., Latvian-Polish trade is in terms of Latvian exports and imports). All flows were deseasonalized using the Census-X12 procedure.

After plotting exports and imports separately, each trade balance was calculated as the ratio of exports to imports. While the original flows were in U.S. dollars and unadjusted for inflation, this new measure was unit-free. Balanced trade, where X = M, equals 1; trade surpluses and deficits fall above and below this threshold, respectively.

The key procedure applied next was the Bai–Perron (1998) tests for structural breaks. In a given equation, a set of breaks *z* can be identified:

$$y_t = x_t'\beta + z_t'\delta_j + u_t \tag{1}$$

The R package *strucchange* (Zeileis et al., 2002, 2003) was used for these calculations. Here, each TB was simply regressed on a constant to capture changes in mean. The starting points of each new "regime" were noted; they were compared against major dates in the region. Within each subperiod, the mean and standard deviation of the trade balance were calculated. Of particular importance is whether the means – and particularly the variances – are increasing or decreasing. Each Baltic country, and each partner country, was expected to behave idiosyncratically. Particular differences may stand out by country, or over time.

To test the second hypothesis – that the exchange rate automatically incorporated these structural breaks – monthly effective exchange rates (both nominal and real, 2010 = 100) for the three Baltic countries were taken from the Bank for International Settlements [BIS] through the FRED database. These were converted into annualized rates of return as $1200 * \Delta ln(EER_t)$. The volatility of each rate of return was modeled as a GARCH(1,1) process, using the methodology of Bollerslev (1986) with a mean equation following an AR(1) process:

$$x_t = \alpha + \rho x_{t-1} + \varepsilon_t \tag{2a}$$

$$h_t = \omega + \beta \varepsilon_{t-1}^2 + \gamma h_{t-1}^2 \tag{2b}$$

Here, *x* is log changes in the NEER or REER for the Baltic country in question. Structural break dates were calculated for the series generated here.

To assess bivariate connections between exchange rates and the trade balances, nonparametric Spearman correlations were calculated for each pair. This type of correlation is similar to the "standard" Pearson measure, but it is based on ranks rather than distances from the mean and is, therefore, less sensitive to outliers. While effective exchange rates were the main focus here – to capture global conditions that affect small open economies, correlations were also calculated both for bilateral rates (for each pair) and between each Baltic country and the U.S. dollar. These results, particularly using bilateral rates, might help inform a future study that includes additional variables in a multivariate cointegration model.

## 4. Research findings

The monthly deseasonalized export and import flows by Baltic country and by the partner are presented in Figure 1. It is clear that the dollar value of both flows has increased for all three countries, but that trade with Russia is rather flat. Nordic flows have generally been increasing; as has trade with Poland. One interesting finding is that while Latvia and Estonia have persistently run trade deficits with Poland, Lithuania has not. This might be related to historical or geographical ties. Table 1 provides the share of each country's bilateral export and import flows as a share of its world trade. A number of major partners are highlighted. Estonia had the highest share (more than 75 percent) among the three Baltic nations of trade with the set of Advanced Economies. Estonia also enjoyed large trade shares with Finland and Sweden. Lithuania had the highest proportions of both exports and imports with both Russia and the CIS, as well as with Poland. Latvia did not seem to have a major trading partner and had the lowest shares of exports and imports vis-à-vis the United States.

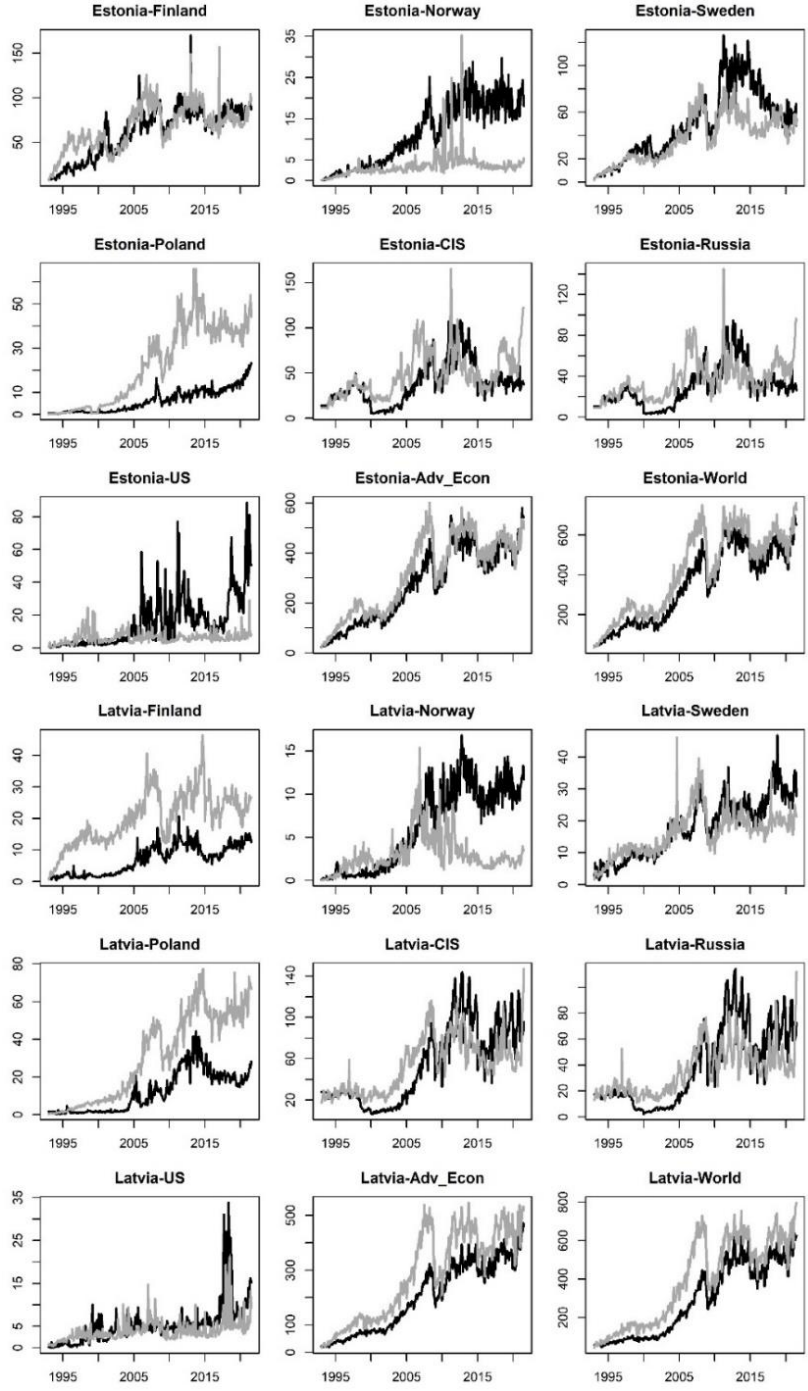
**Table 1.** Shares of world trade by partners

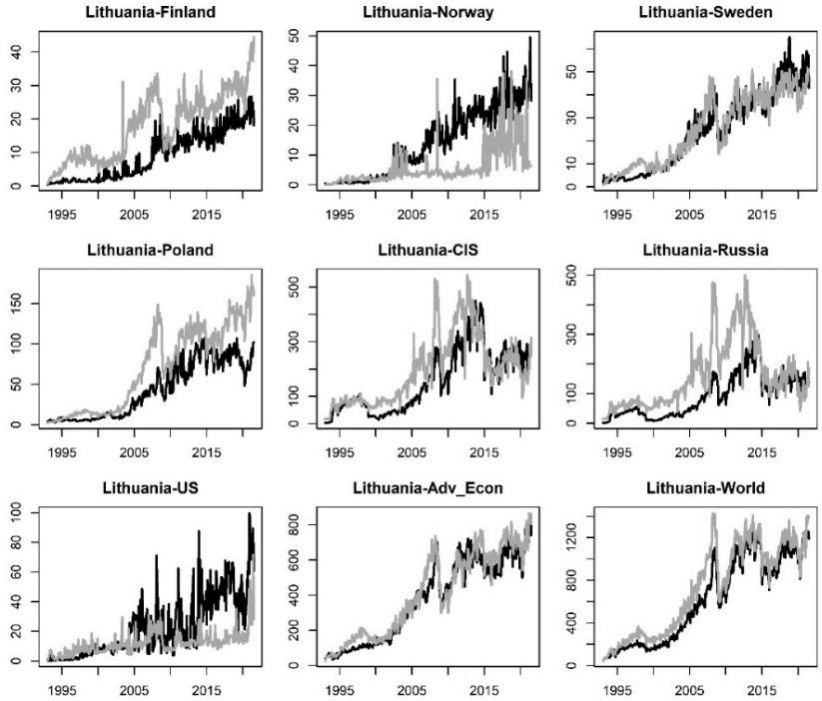
| Partner | Estonia | | Latvia | | Lithuania | |
|---|---|---|---|---|---|---|
| | X | M | X | M | X | M |
| Adv. Econ | 78.98 | 75.66 | 69.42 | 72.3 | 61.29 | 57.14 |
| CIS | 10.67 | 11.3 | 18.56 | 13.43 | 25.39 | 26.4 |
| Finland | 17.39 | 15.56 | 2.36 | 4.95 | 1.49 | 2.44 |
| Norway | 3.38 | 0.8 | 2.15 | 0.72 | 2.36 | 0.82 |
| Poland | 1.86 | 5.57 | 4.28 | 8.05 | 7.11 | 9.84 |
| Russia | 8.36 | 8.61 | 13.58 | 8.88 | 15.11 | 21.42 |
| Sweden | 14.23 | 9.08 | 6.07 | 4.02 | 4.04 | 3.48 |
| US | 4.58 | 1.42 | 1.84 | 1.01 | 3.77 | 1.62 |
| World | 100 | 100 | 100 | 100 | 100 | 100 |

Note: X = exports and M = imports.

Source: Author's own calculations.

**Figure 1.** Exports and imports (millions of USD) by country pair





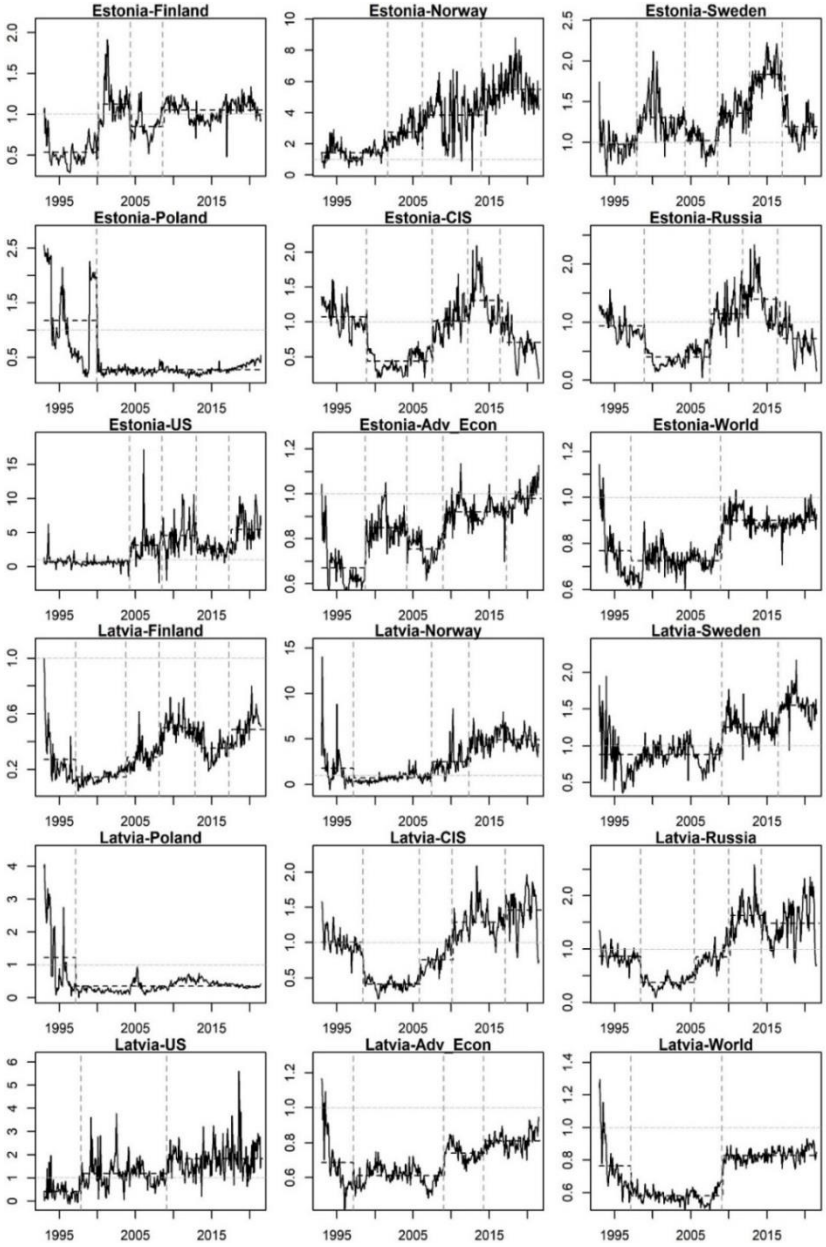

Note: Black = exports and grey = imports.

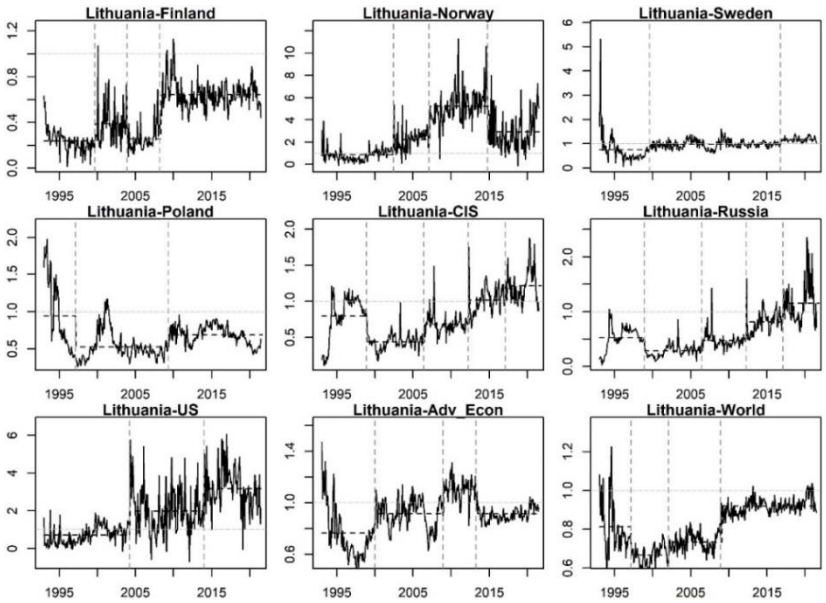
Source: Direction of Trade Statistics [DOTS] (1993-2021).

Focusing on ratios of exports to imports, there is clear evidence that all these trade balances have undergone shifts. Latvian trade with Norway, for example, went from near-balance to a clear surplus after 2005. A similar change appears to have occurred, but to a lesser extent, with Sweden and both Latvia and Estonia. The trade balances and their corresponding structural breaks will help characterize these changes.

The ratios of these flows are depicted in Figure 2. Trade deficits vis-à-vis Poland are represented by values less than one; these also tend to be stable over time. Latvia's growing trade surpluses with Sweden and Norway are clear, as are the "official" breaks between regimes. While trade has expanded between the Baltic countries and their Nordic and other EU neighbors, they have also registered increases in their trade balance with Russia and the CIS as a whole.

**Figure 2.** Trade balances and structural breaks by country pair






Note: Vertical lines = structural breaks. Horizontal lines = regime means.

Source: DOTS (1993-2021).

In particular, Estonia and Latvia went from trade deficits in the late 1990s to surpluses after 2005; these surpluses decreased, though, in the mid-2010s. Perhaps this is due to the countries' adoption of the euro in 2011 and 2014, respectively. Or, it could be related to economic sanctions on Russia following the 2014 events in Ukraine. Lithuania, however, ran trade deficits longer and did not see a decrease in its trade balance with Russia, later in the period.

The regimes depicted can be matched precisely to world events. Table 2 gives specific structural break dates. Many of the trade balances had such a break in 1998, which might reflect exposure to Russia following the Asian Crisis. (While many flows have a break in March 1997, this precedes the crisis by several months, and is worth further investigation in its own right.) Four of the Estonian flows had breaks in 2004; this was far more than the other two Baltic countries.

**Table 2.** Bai–Perron structural break dates, trade balances

| Pair | Year (m) | Year (m) | Year (m) | Year (m) | Year (m) |
|---|---|---|---|---|---|
| *1* | *2* | *3* | *4* | *5* | *6* |
| Estonia-Adv_Econ | 1998(10) | 2004(3) | 2008(12) | 2017(4) | |
| Estonia-CIS | 1998(12) | 2007(7) | 2012(3) | 2016(6) | |
| Estonia-Finland | 2000(2) | 2004(5) | | | |
| Estonia-Norway | 2001(9) | 2006(4) | 2013(12) | | |
| Estonia-Poland | 1999(12) | | | | |

**Table 2 cont.**

| *1* | *2* | *3* | *4* | *5* | *6* |
|---|---|---|---|---|---|
| Estonia-Russia | 1998(12) | 2007(7) | 2011(11) | 2016(6) | |
| Estonia-Sweden | 1997(12) | 2004(4) | 2008(7) | 2012(10) | 2017(1) |
| Estonia-US | 2004(4) | 2008(7) | 2013(1) | 2017(4) | |
| Estonia-World | 1997(3) | 2008(12) | | | |
| Latvia-Adv_Econ | 1997(3) | 2009(1) | 2014(4) | | |
| Latvia-CIS | 1998(6) | 2005(11) | 2010(2) | 2017(2) | |
| Latvia-Finland | 1997(3) | 2003(10) | 2008(2) | 2012(11) | 2017(4) |
| Latvia-Norway | 1997(3) | 2007(6) | 2012(5) | | |
| Latvia-Poland | 1997(3) | | | | |
| Latvia-Russia | 1998(6) | 2005(7) | 2010(1) | 2014(4) | |
| Latvia-Sweden | 2009(2) | 2016(7) | | | |
| Latvia-US | 1997(11) | 2009(2) | | | |
| Latvia-World | 1997(3) | 2009(2) | | | |
| Lithuania-Adv_Econ | 2000(1) | 2008(12) | 2013(4) | | |
| Lithuania-CIS | 1998(12) | 2006(6) | 2012(4) | 2017(2) | |
| Lithuania-Finland | 1999(9) | 2003(12) | 2008(3) | | |
| Lithuania-Norway | 2002(6) | 2007(2) | 2014(10) | | |
| Lithuania-Poland | 1997(3) | 2009(5) | | | |
| Lithuania-Russia | 1998(12) | 2006(6) | 2012(4) | 2017(2) | |
| Lithuania-Sweden | 1999(8) | 2016(10) | | | |
| Lithuania-US | 2004(4) | 2014(1) | | | |
| Lithuania-World | 1997(3) | 2002(2) | 2008(12) | | |

Source: Author's own calculation.

Roughly half of the trade balances had a structural break in 2008 or 2009, but fewer seem to correspond to the 2008-2009 Global Financial Crisis. It is quite possible that even "global" shocks can have an impact on a bilateral trade balance, particularly if the shock is not felt equally in both countries, or if specific sectors (such as construction materials) that make up one country's exports or imports are disproportionately affected. However, the most closely-timed structural breaks occurred between all three Baltic countries and with both the U.S. and the World. This might reflect the origin of the global crisis. Latvia and Lithuania also exhibited structural breaks vis-à-vis the Advanced Economies. Estonia's breaks appear to precede Latvia's by a few months, perhaps reflecting the capital--inflow-induced "bubble" that took place in the run-up to the crisis. In one interesting – but idiosyncratic – finding, trade with Poland had among the fewest regime switches, with a single break for each of Latvia and Estonia, and two for Lithuania.

It is also interesting to note expected times when structural breaks did not happen. Estonia had no breaks with any country since 2011, when it adopted the euro. The same is true for Latvia (2014) and Lithuania (2015). On the one hand,

reduced currency risk is expected to have an impact on the trade balance, on the other, it is possible that, given that the transitions were expected, there were no disruptions in invoicing in what was essentially a well-run accounting transition.

Table 3 shows the means and standard deviations for each trade balance within the "regimes" or subperiods. These, like the break dates, match the visual depictions in Figure 2. Norway's trade had increasing means, particularly with Estonia, indicating the growing deficits for Norway and increasing surpluses for Estonia. The same can be said for Latvia and Lithuania's trade balances vis-à-vis the United States. As we have seen, trade with Russia experienced a decrease early in the sample, followed by an increase. Many of the other trade balances "oscillated," with alternating decreases and increases.

**Table 3.** Means and standard deviations by regime

| Pair | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| *1* | *2* | *3* | *4* | *5* | *6* | *7* |
| Estonia-Adv_Econ | 0.671<br>(0.102) | 0.85<br>(0.07) | 0.754<br>(0.055) | 0.921<br>(0.059) | 0.98<br>(0.059) | |
| Estonia-CIS | 1.075<br>(0.196) | 0.439<br>(0.155) | 1.013<br>(0.232) | 1.31<br>(0.315) | 0.71<br>(0.239) | |
| Estonia-Finland | 0.536<br>(0.159) | 1.124<br>(0.27) | 0.849<br>(0.154) | 1.051<br>(0.123) | | |
| Estonia-Norway | 1.436<br>(0.501) | 2.756<br>(0.706) | 3.85<br>(1.36) | 5.479<br>(1.145) | | |
| Estonia-Poland | 1.174<br>(0.754) | 0.278<br>(0.132) | | | | |
| Estonia-Russia | 0.936<br>(0.209) | 0.399<br>(0.159) | 1.145<br>(0.309) | 1.396<br>(0.374) | 0.717<br>(0.255) | |
| Estonia-Sweden | 0.974<br>(0.174) | 1.306<br>(0.244) | 1.022<br>(0.131) | 1.359<br>(0.17) | 1.835<br>(0.198) | 1.192<br>(0.186) |
| Estonia-US | 0.665<br>(0.685) | 3.103<br>(2.547) | 4.608<br>(2.386) | 2.603<br>(0.989) | 5.441<br>(2.409) | |
| Estonia-World | 0.769<br>(0.127) | 0.725<br>(0.054) | 0.9<br>(0.046) | | | |
| Latvia-Adv_Econ | 0.687<br>(0.176) | 0.613<br>(0.053) | 0.74<br>(0.048) | 0.811<br>(0.051) | | |
| Latvia-CIS | 1.006<br>(0.179) | 0.411<br>(0.087) | 0.75<br>(0.16) | 1.286<br>(0.211) | 1.462<br>(0.299) | |
| Latvia-Finland | 0.27<br>(0.191) | | | | | |
| Latvia-Norway | 1.768<br>(2.49) | 0.698<br>(0.475) | 2.459<br>(1.385) | 4.928<br>(1.039) | | |
| Latvia-Poland | 1.219<br>(1.165) | | | | | |
| Latvia-Russia | 0.866<br>(0.159) | 0.372<br>(0.113) | 0.85<br>(0.192) | 1.632<br>(0.31) | 1.485<br>(0.39) | |

**Table 3 cont.**

| *1* | *2* | *3* | *4* | *5* | *6* | *7* |
|---|---|---|---|---|---|---|
| Latvia-Sweden | 0.878<br>(0.236) | 1.255<br>(0.159) | 1.551<br>(0.178) | | | |
| Latvia-US | 0.421<br>(0.398) | 1.184<br>(0.6) | 1.819<br>(0.705) | | | |
| Latvia-World | 0.763<br>(0.17) | 0.579<br>(0.041) | 0.829<br>(0.041) | | | |
| Lithuania-Adv_Econ | 0.762<br>(0.209) | 0.914<br>(0.115) | 1.102<br>(0.092) | 0.912<br>(0.055) | | |
| Lithuania-CIS | 0.792<br>(0.306) | 0.442<br>(0.115) | 0.684<br>(0.145) | 1.019<br>(0.195) | 1.212<br>(0.24) | |
| Lithuania-Finland | 0.238<br>(0.105) | 0.388<br>(0.187) | 0.257<br>(0.109) | 0.643<br>(0.124) | | |
| Lithuania-Norway | 0.862<br>(0.605) | 2.232<br>(1.024) | 5.246<br>(1.55) | 2.935<br>(1.743) | | |
| Lithuania-Poland | 0.942<br>(0.491) | 0.527<br>(0.189) | 0.687<br>(0.124) | | | |
| Lithuania-Russia | 0.526<br>(0.216) | 0.281<br>(0.109) | 0.475<br>(0.155) | 0.811<br>(0.213) | 1.154<br>(0.395) | |
| Lithuania-Sweden | 0.755<br>(0.67) | 0.974<br>(0.173) | 1.167<br>(0.102) | | | |
| Lithuania-US | 0.713<br>(0.483) | 1.988<br>(1.228) | 3.175<br>(1.124) | | | |
| Lithuania-World | 0.813<br>(0.136) | 0.666<br>(0.049) | 0.735<br>(0.048) | 0.919<br>(0.043) | | |

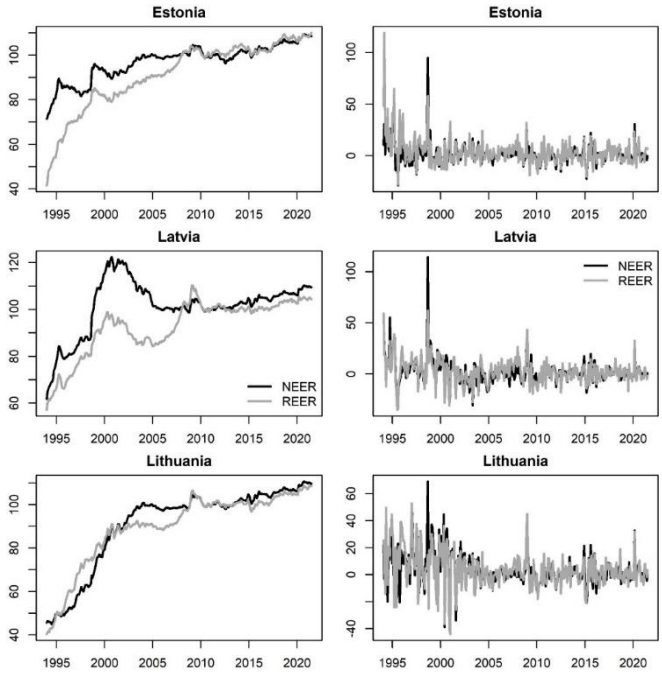
Note: Standard deviations are in parentheses. Regimes separated by structural breaks and listed in chronological order.

Source: Author's own calculations.

Variance, interestingly, decreased across regimes for all three Baltic countries versus the World. This suggests that this largest aggregate stabilized. At the same time, variability underwent increases in pairs such as Latvia and the U.S., and Estonia and Norway, which corresponds to the increasing means that are also presented. As an exception, the standard deviation decreased between Lithuania and the World, even though its averages were increasing just like Estonia's and Latvia's were.

Overall, even though uncertainty increased throughout the region and the world, there is little evidence of sharply increasing variability in Baltic trade balances. Instead, the trade balances were relatively stable. In some cases, such as between Lithuania and Poland, variability tended to decrease even as deficits widened or shrunk.

**Figure 3.** Effective exchange rates (levels and log changes)



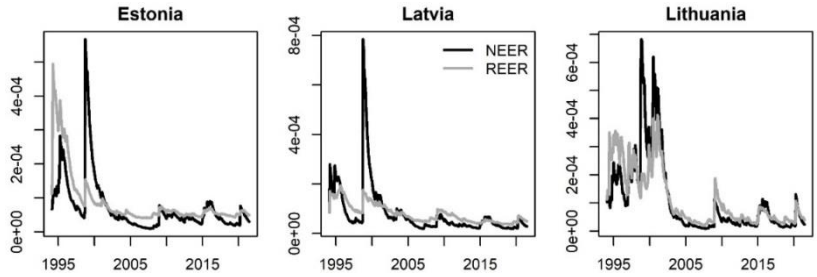

Note: Black = NEER and grey = REER.

Source: Bank for International Settlements [BIS] (1993-2021).

## 4.1. Relationship to effective exchange rates

Figure 3 depicts the Baltic effective exchange rates, both in levels and log changes, from 1994 to 2021. There was massive appreciation – driven by capital inflows – before the 2008 financial crisis. Since then, changes have been smaller. Table 4 provides dates for the structural breaks in exchange-rate returns. All series had a break in 1999, except for Estonia NEER, which had its break in late 1997. This is likely due to the introduction of the euro in 1999. The GARCH volatility series, shown in Figure 4, tend to have breaks at similar times, as well as during the 2000-2001 recession. Only Latvian REER volatility had more than two breaks. None of these, however, correspond directly to EU accession or the 2008-2009 Global Financial Crisis. This implies that if events had been indeed "priced in" to exchange rates, it was more subtle. It might also reflect asymmetric effects due to events; since exchange rates are based on weighted baskets, the rate might not efficiently process world events.

**Figure 4.** EER volatility series




Note: Black = NEER and grey = REER.

Source: Author's own calculations based on BIS data from https://fred.stlouisfed.org

**Table 4.** Bai–Perron structural break dates, exchange rates

| REER | 1 | VOL | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|
| EE_NEER | 1997 (11) | EE_NEER_VOL | 2000(3) | | | |
| EE_REER | 1997 (9) | EE_REER_VOL | 1997(1) | 2001(2) | | |
| LT_NEER | 1999 (9) | LT_NEER_VOL | 1997(1) | 2001(2) | | |
| LT_REER | 1999 (4) | LT_REER_VOL | 2001(4) | | | |
| LV_NEER | 1999 (4) | LV_NEER_VOL | 1997(8) | 2001(9) | | |
| LV_REER | 1999 (4) | LV_REER_VOL | 1999(9) | 2003(10) | 2007(11) | 2011(12) |

Source: Author's own calculations.

Finally, Spearman correlations were calculated between all trade balances and all exchange-rate series. The Phillips–Perron (1988) test results in Table 5 show that all series are stationary. In Table 6, we see that all correlations are uniformly negative: Appreciations reduced the trade balance. However, these (absolute) values were rather low. Focusing on the REER, which included goods prices, it is interesting to see that the CIS and Poland had some of the lowest correlations across the board. Sweden, Finland, and Advanced Economies had the highest. Additional work will build an econometric model that includes domestic and partner income, as well as some additional factors discussed below.

**Table 5.** Phillips–Perron stationarity test results

| Pair | PP (p-val.) | Pair | PP (p-val.) | Pair | PP (p-val.) |
|---|---|---|---|---|---|
| *1* | *2* | *3* | *4* | *5* | *6* |
| Estonia-Adv_Econ | −9.758 (0.01) | Latvia-Adv_Econ | −9.06 (0.01) | Lithuania-Adv_Econ | −8.116 (0.01) |
| Estonia-CIS | −4.634 (0.01) | Latvia-CIS | −5.273 (0.01) | Lithuania-CIS | −6.679 (0.01) |
| Estonia-Finland | −5.909 (0.01) | Latvia-Finland | −8.559 (0.01) | Lithuania-Finland | −11.134 (0.01) |
| Estonia-Norway | −13.898 (0.01) | Latvia-Norway | −8.806 (0.01) | Lithuania-Norway | −11.092 (0.01) |

**Table 5 cont.**

| *1* | *2* | *3* | *4* | *5* | *6* |
|---|---|---|---|---|---|
| Estonia-Poland | −4.609 (0.01) | Latvia-Poland | −6.377 (0.01) | Lithuania-Poland | −4.631 (0.01) |
| Estonia-Russia | −5.198 (0.01) | Latvia-Russia | −6.129 (0.01) | Lithuania-Russia | −8.569 (0.01) |
| Estonia-Sweden | −6.574 (0.01) | Latvia-Sweden | −11.857 (0.01) | Lithuania-Sweden | −11.507 (0.01) |
| Estonia-US | −11.568 (0.01) | Latvia-US | −14.004 (0.01) | Lithuania-US | −13.647 (0.01) |
| Estonia-World | −9.32 (0.01) | Latvia-World | −6.429 (0.01) | Lithuania-World | −8.461 (0.01) |
| Pair | PP (p−val.) | | | | |
| EE_NEER | −12.955 (0.01) | | | | |
| EE_REER | −13.498 (0.01) | | | | |
| LT_NEER | −11.856 (0.01) | | | | |
| LT_REER | −12.831 (0.01) | | | | |
| LV_NEER | −14.008 (0.01) | | | | |
| LV_REER | −13.049 (0.01) | | | | |

Source: Author's own calculations.

**Table 6.** Correlations between trade balances and effective exchange rates

| Trade balance | NEER | REER | Trade balance | NEER | REER |
|---|---|---|---|---|---|
| Estonia-Adv_Econ | −0.072 | −0.265 | Latvia-Adv_Econ | −0.149 | −0.188 |
| Estonia-CIS | 0.093 | 0.087 | Latvia-CIS | −0.119 | −0.086 |
| Estonia-Finland | 0.001 | −0.219 | Latvia-Finland | −0.267 | −0.244 |
| Estonia-Norway | 0.016 | −0.133 | Latvia-Norway | −0.209 | −0.191 |
| Estonia-Poland | −0.047 | 0.073 | Latvia-Poland | −0.165 | −0.079 |
| Estonia-Russia | 0.081 | 0.056 | Latvia-Russia | −0.168 | −0.140 |
| Estonia-Sweden | −0.037 | −0.237 | Latvia-Sweden | −0.208 | −0.231 |
| Estonia-US | −0.099 | −0.198 | Latvia-US | −0.124 | −0.255 |
| Estonia-World | −0.041 | −0.218 | Latvia-World | −0.136 | −0.127 |
| Lithuania-Adv_Econ | −0.166 | −0.247 | | | |
| Lithuania-CIS | 0.053 | −0.005 | | | |
| Lithuania-Finland | −0.109 | −0.212 | | | |
| Lithuania-Norway | −0.211 | −0.203 | | | |
| Lithuania-Poland | 0.017 | −0.169 | | | |
| Lithuania-Russia | 0.019 | −0.027 | | | |
| Lithuania-Sweden | −0.130 | −0.220 | | | |
| Lithuania-US | −0.145 | −0.192 | | | |
| Lithuania-World | −0.078 | −0.210 | | | |
| Lithuania-Adv_Econ | −0.166 | −0.247 | | | |

Note: Spearman correlations; exchange rates in log changes for each Baltic country.

Source: Author's own calculations.

Because effective exchange rates included multiple partners, bilateral real exchange rates were also calculated. These series used nominal euro rates; as a result, they begin in 1999. They also used each country's Consumer Price Index. Each bilateral real exchange rate was calculated as units of foreign currency to domestic currency; increases, therefore, represent Baltic real appreciations. Dollar real rates were also included since invoicing might be conducted in U.S. currency. Table 7 presents the correlations between these rates and each of the six trade balances.

**Table 7.** Correlations between trade balances and real bilateral exchange rates

| Trade balance | Bilateral | vs. USD | Trade balance | Bilateral | vs. USD |
|---|---|---|---|---|---|
| Estonia-Finland | −0.082 | −0.024 | Latvia-Finland | −0.058 | 0.077 |
| Estonia-Norway | 0.101 | 0.008 | Latvia-Norway | 0.035 | 0.016 |
| Estonia-Poland | −0.007 | −0.142 | Latvia-Poland | 0.009 | −0.062 |
| Estonia-Russia | 0.087 | 0.001 | Latvia-Russia | 0.178 | 0.048 |
| Estonia-Sweden | −0.002 | −0.163 | Latvia-Sweden | −0.053 | −0.066 |
| Estonia-US | | −0.007 | Latvia-US | | −0.047 |
| Lithuania-Finland | −0.312 | −0.211 | | | |
| Lithuania-Norway | −0.085 | −0.076 | | | |
| Lithuania-Poland | −0.089 | −0.137 | | | |
| Lithuania-Russia | 0.146 | −0.066 | | | |
| Lithuania-Sweden | −0.105 | −0.072 | | | |
| Lithuania-US | | −0.085 | | | |

Note: Spearman correlations calculated for data beginning in 1999. Log differences calculated for real exchange rates.

Source: Author's own calculations.

One interesting finding is that the expected negative sign – whereby a Baltic real appreciation resulted in reduced trade, was not found for all pairs. The correlations were positive for all Baltic countries and Russia (and were larger for Latvia than for Estonia). Correlations between trade balances versus Norway and both real rates were positive as well. The values using the bilateral real rate tend to be larger than those using the bilateral real rate (in slightly more than half the cases). It is left to a future study, which incorporates the real rate as one variable in a multivariate cointegration model, to further untangle these connections.

## 5. Discussion

In general, the three Baltic countries' trade balances exhibit their unique behavior. These often correspond to the historical and cultural ties. Lithuania's trade with Sweden had far fewer fluctuations or growth than do Latvia's or Estonia's, while Lithuania and Poland had a structural break in the late 2000s that the others did not. Estonia ran a small trade surplus with Finland, while the other two Baltic nations ran deficits. The number and timing of structural breaks differed as well.

Further research could incorporate "gravity" effects, to capture the role of geographical distance in determining the strength of trade partners, but the results here suggest the importance of cultural proximity as well. Lithuania's long historical ties with Poland, where the two nations shared a Commonwealth centuries ago and have a common religion today. The Hanseatic League, the maritime consortium along the Baltic Sea in the 15$^{th}$ century, has vestiges today in the form of trading connections with Scandinavia. Likewise, Estonia and Finland have languages in common as well as strong financial ties. While common languages, historical backgrounds, and other non-economic variables are often included in gravity models, these are worthy of investigation on their own.

Second, the hypothesis that the real exchange rate incorporates all relevant events, which was put into question by the lack of similar structural breaks and the low correlations with trade balances, is worthy of further investigation as well. It is quite possible that an econometric model that includes structural breaks, as well as the real (effective) exchange rate and/or exchange-rate volatility will find the latter two variables to be insignificant. A future study will apply cointegration analysis to investigate the macroeconomic determinants of these trade balances, incorporating these structural breaks.

Overall, these findings provide important context to events in the region over the last 30 years. Western reintegration is confirmed, with Baltic trade with the World, Advanced Economies, and Nordic neighbors increasing greatly. This is true for both export and import flows. As noted previously, trade with Russia and the CIS has not enjoyed such gains. Structural breaks are visually evident as well as statistically determined; these can be used to explain history as well as be explained by history. People with economic interests with various partners would benefit from understanding these trade flows and shifts as well.

## 6. Conclusions

Over the past three decades, the Baltic nations' trade patterns vis-à-vis various neighbors have undergone long-run reintegration with the West as well as short-run shocks and political changes. While trade flows have grown enormously in the aggregate, as well as with partners such as their Nordic neighbors, trade with Russia has experienced declines. This study examines the trade balances of Estonia, Latvia, and Lithuania with nine different partners, testing whether trade flows have exhibited structural breaks that can be tied to political or economic events. These events, however, require further investigation beyond the simple identification conducted here.

Many such breaks are uncovered, with clear changes in mean and variance as a result. Interestingly, there are more breaks when the trade partners share important historical linkages, indicating that shocks have more of an effect in these cases. At the same time, there are only weak correlations and few common breaks between effective exchange-rate returns and these trade balances, raising questions regarding the hypothesis that exchange rates incorporate information about these shocks. Likewise, exchange-rate volatility shows almost no common breaks with these trade balances.

Further investigation, therefore, is needed to model these trade flows using macroeconomic determinants (domestic and foreign GDPs, as well as exchange rates), or cultural and historic ties (incorporating components of a gravity model). These estimations might help explain the findings shown here – that each trade balance behaves uniquely, and that idiosyncratic factors cause these structural breaks. This will help business people and other leaders understand events that might improve or worsen a country's competitive position in the world.

### Disclosure statement

No potential conflict of interest was reported by the author(s).

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