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JEL Classification: N51, N53, N71, N73

Keywords: British Empire, Canada, Globalization, market integration, United Kingdom, United States, wheat

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Globalization and Empire: Market integration and international trade between Canada, the United States and Britain, 1750-1870

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Abstract

Previous work has demonstrated the potential for wheat market integration between the US and the UK before the 'first era of globalization' in the second half of the nineteenth century. It was however frequently interrupted by policy and 'exogenous' events such as war. This paper adds Canada to this story by looking at trade and price data, as well as contemporary debates. We find that she faced similar barriers to the US, and that membership of the British Empire was therefore not a great benefit. We also describe the limitations she faced accessing the US market, in particular after American independence. Transportation costs do not appear to be the main barrier to the emergence of a globalized economy before around 1850.

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1 Introduction

Recent research has demonstrated that the history of the growth of the importance of the wheat trade between the United States and the United Kingdom – often considered to be the cornerstone of the late nineteenth century's 'first era of globalization' – has a longer story behind it. The American supply of wheat was important for many years prior to the onset of the French and Napoleonic Wars (Sharp and Weisdorf 2013) and the subsequent prohibitive tariffs on grains under the Corn Laws (Sharp 2010), although it was often interrupted by various 'exogenous' events such as attacks on wheat by insects and war. So, even though contemporaries saw the 'invasion' of cheap American grain with the repeal of the Corn Laws in the 1840s as a new phenomenon, in fact its origins extended back into the eighteenth century. This precedes large improvements in transportation technologies often presented as the reasons for the late nineteenth century globalization (O'Rourke and Williamson 1999). This entails that market integration in the North Atlantic was possible in the age of sail (Jacks 2005; 2006; O'Rourke and Findlay 2005; Sharp and Weisdorf 2013), a possibility that minimizes the relative importance of transportation technologies.[3]

We formally consider this possibility by adding another important supplier of the British market, Canada. A frontier economy, Canada was endowed with similar land to labour ratios as the US (McInnis 1982). As with the US, she also experienced various shocks which impacted on her ability to trade with the UK. Also, the experiences of Canadian farmers wishing to export to Britain reflected to a large extent that of Americans, with the exception of favorable tariff rates on colonial grains from 1815 when trade barriers towards Canada imposed by Britain were eased progressively. In another way, however, Canada presents a mirror image of the American experience, since while the US gained independence in 1783, large parts of Canada, Quebec, were incorporated into the British Empire in 1763 with the Treaty of Paris. Moreover, including Canada in the narrative allows us to explore the importance of intra-North American trade, which has not previously been explored from the perspective of market integration.

Besides the increased understanding of early developments in the North American economy, this paper makes some other more general contributions. Much previous work has focused on the US and Britain, which are clearly geographically very distant, so a focus on these two countries alone makes it difficult to investigate the relative significance of changes in the importance of distance (for example with improvements in transportation technology) and changes in policy (and other shocks to

[3] Some works in business history such as Sharrer (1982) and Hunter (2005) also suggested the same.

trade). Clearly, cheaper transatlantic freight rates made it relatively more attractive to export to the UK at the same time as changes in trade policy would have had similar effects. But trade policy (and politics in general) also impacted on trade between Canada and the US, whereas distance presumably played a relatively minor role. This paper thus contributes to the literature on trade divergence with customs agreements, since we can for example see the effect of Quebec's integration into the British Empire and away from the French Empire.

We gather the available evidence on Canadian trade with the US and the UK and find that Canadian farmers exported appreciable amounts of wheat to the American colonies as well as the UK from the late eighteenth century. We then look for market integration using the price series for the US and the UK from Sharp and Weisdorf (2012), as well as new price series for the British colonies of Lower and Upper Canada from 1760 to 1858 (Geloso 2019a). We first conduct variance analysis following Federico (2011, 2012) and then measure market integration by estimating a cointegrated VAR model (CVAR), following Sharp and Weisdorf (2013). We find a Canada which is relatively well integrated into the American market prior to American independence, but increasingly integrated with the British market subsequently. There is however evidence of stronger integration between Canada and the US after the Colonial Trade Act of 1831 when the grain trade between the two countries was progressively liberalized. Integration with the UK depended on the general movement towards lower tariffs after 1815.

The remainder of this paper proceeds as follows. Section 2 describes the trade in wheat between Canada, the US, and the UK. Section 3 explains the data and looks at the extent of market integration between the three countries using variance analysis. Section 4 presents results from cointegrated VAR models, while Section 5 discusses the findings and concludes.

2 Canada in the North Atlantic Wheat Trade

2.1 Trade between Canada and Britain

We start by considering how important the Canadian supply of wheat to Britain was in relation to that from the United States. As Figures 1, 2 and 3 illustrate, from 1771 Canadian exports entered Britain almost every year. Sometimes they dominated the US exports, but for most years US supply was the most important.[4] There is no clear pattern which can relate this to the volumes of trade involved. For

[4] However, Canada's population was a fraction of America's and on a per capita basis, Canada exported quite a substantial share.

example, in 1822 Canadian wheat and flour was 54 per cent of total imports as opposed to nine per cent from the US. This does not represent a peak for Canadian imports, however, in contrast to the period in the early 1830s when Canadian imports also dominated at the same time as exports were at a relatively high level. In fact, the main lesson from these graphs is that Canadian exports to Britain experienced large swings, similar to those from the US. On a per capita basis, grain exports were at their greatest during the period between the Conquest in 1760 and the American Revolutionary War, as illustrated in Figure 3.

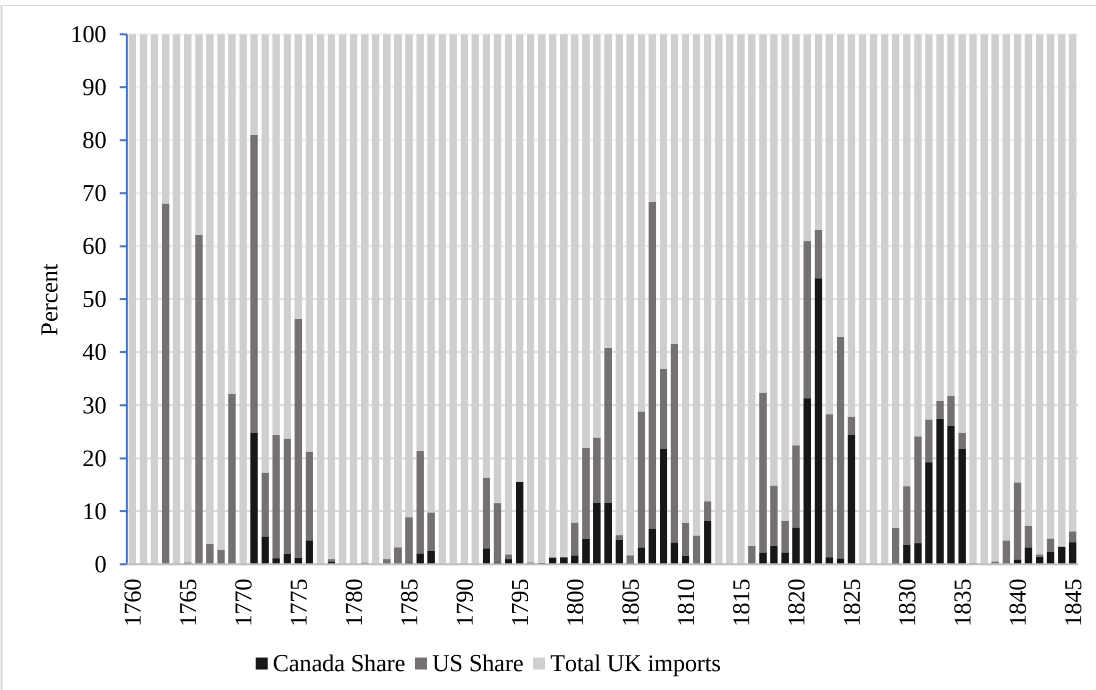

Figure 1: Share of Canadian and US of total wheat and flour imports into Britain

Source: Weisdorf and Sharp (2013) from 1760 to 1839, Mitchell and Deane (1962, pp. 98-101) from 1840 to 1870.

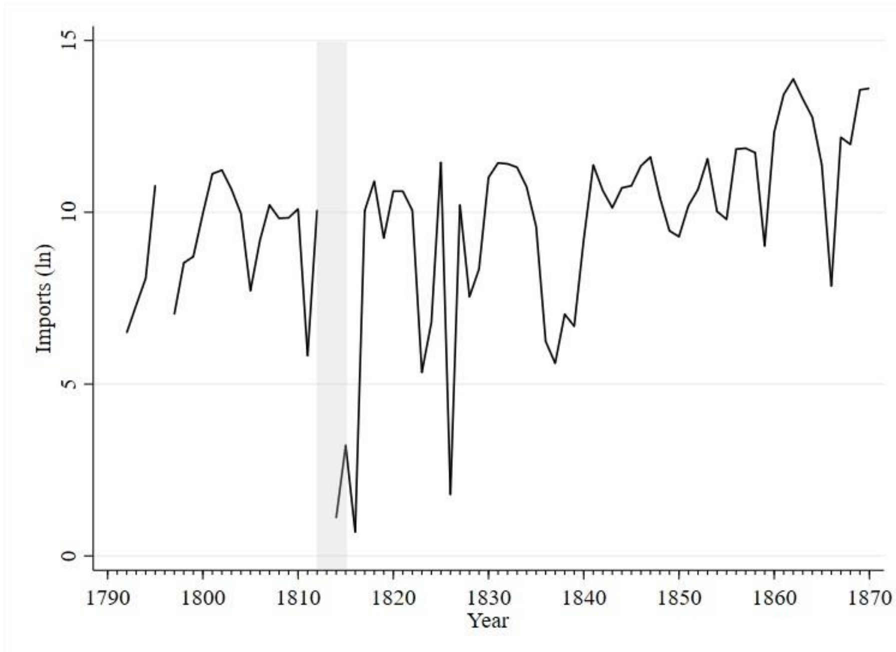

Figure 2: Imports of wheat and flour into Britain from British North America, quarters, log scale

Source: Weisdorf and Sharp (2013) from 1760 to 1839, Mitchell and Deane (1962, pp. 98-101) from 1840 to 1870.

Note: The shaded area represents the period of the War of 1812 (to 1815).

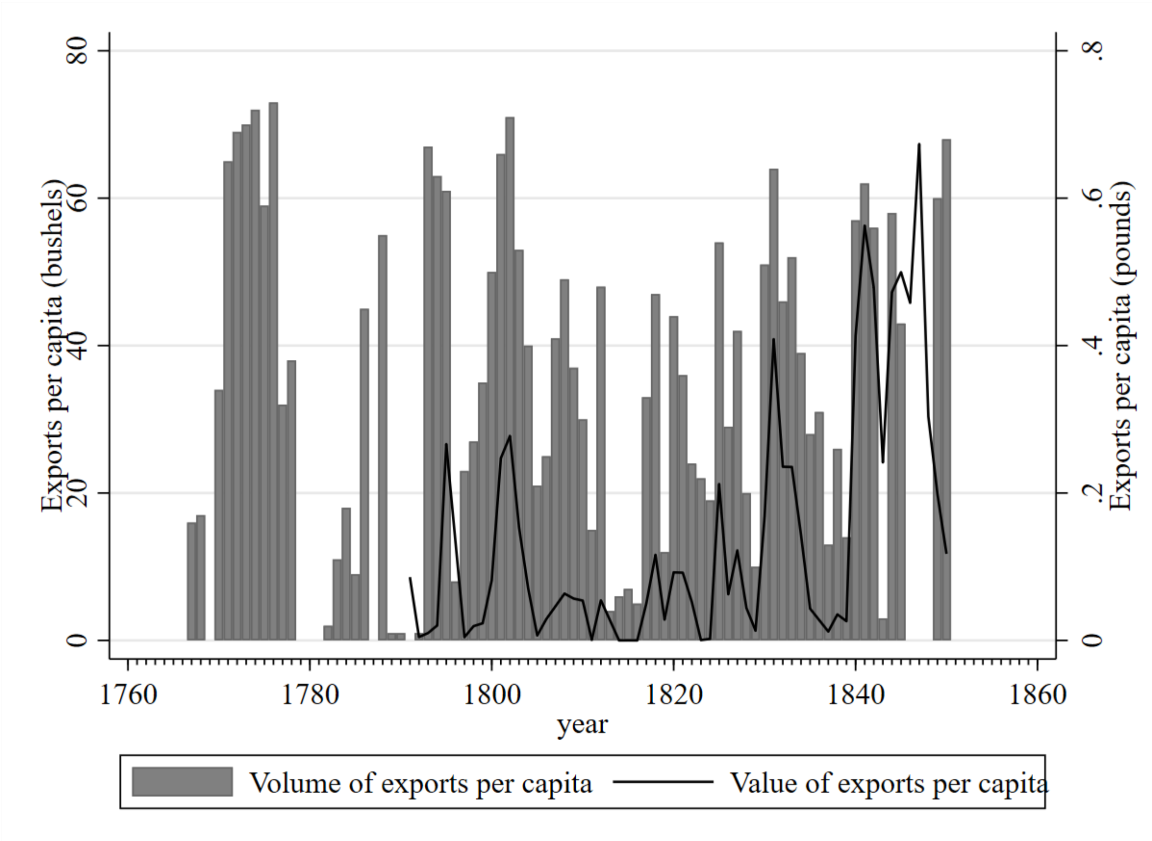

Figure 3: Exports of wheat and flour from Lower and Upper Canada, in bushels per capita (A-axis) and pounds sterling per capita (B-axis)

Source: Vallières and Desloges (2008); Geloso (2019a); Aubry (1970); Public Archives of Canada (1874). Note: The statistics on exports do no include the exports to the United States after 1784. These estimates are difficult to obtain but discussions provided by McCalla (1993) suggest that the depiction in this graph remains accurate.

Despite its inclusion within the Empire, Canada did not benefit from free access to metropolitan markets.[5] Since the beginning of the eighteenth century, the fur trade had gradually declined as a share of the overall economy (Altman 1988; Geloso 2016) while the agricultural sector – and agricultural exports as a consequence (Ouellet 1966; Aubry 1970) -- grew in importance. After 1800, while grain and flour exports rarely rivalled timber and potash exports, they had eclipsed furs (Vallières and Desloges 2008). Canadian historians, however, have long argued that wheat was never exported as much as it could have (McCallum 1980; McInnis 1982) during the first half of the

[5] This might partly have been due to the Great Lakes, which were an easy entry door into Canada and represented a problem given recently achieved American independence (Bothwell 2006, p. 549).

nineteenth century when it was more or less stagnant in spite of population growth (see Figure 2). That failure has frequently been laid at the foot of British trade policy.

This attribution of blame has to do with the nature of tariff policy towards Canadian grain. The Corn Laws permitted grain and flour imports only once prices exceeded a certain level.[6] The level at which Canadian grain and flour could enter the British market was set below that which applied to other nations.[7] In addition, there was a tariff that was modulated in function of the British price (Marr and Paterson 1980: pp.88, 90).[8] The problem that this posed is that while the Canadian colonies received preferential access compared to other foreign sources, this was not 'guaranteed' : price changes in Britain could lead to sudden closure of the British market (McInnis 1982, pp. 36-41; Russell 2012, p. 102). This caused important volatility in the ability to access the British market which some historians argue explains the stagnation -- a volatility that can be observed in Figure 3 where we expressed exports on a per capita basis. Nevertheless, by the time of full liberalization in the 1840s when the US became the dominant supplier, Canada had been able to pull its punch on British markets. In fact, Canada did manage to export greater quantities after the end of the Corn Laws (Roby and Hamelin 1971, Appendix 16).[9]

2.2 Trade between Canada and the US

Turning to the trade between Canada and the US, the Canadian colonies (Upper and Lower Canada) initially enjoyed virtual free trade during the period from 1760 to 1775. This short episode is often overlooked because of its brevity and because Canada's population was so small. However, as Figure 3 above made clear, the period was marked by high levels of exports per capita even if the absolute number of bushels was small given Canada's small population. In that period, the *Statistics of the Trade of Quebec* for 1768 to 1775 suggest that 10 percent of the exports of wheat and flour were destined to

[6] However, Canadian imports were privileged in the sense that wheat from Canada could not enter England if the price of wheat was below 67 shillings per quarter, which contrasted with 80 shillings per quarter for foreign wheat (Easterbrook and Aitken, 1988, p. 281). In 1822, the British government lowered the ceiling to 59 shillings, but with the payment of a small duty (Easterbrook and Aitken, 1988, p. 282).

[7] This preferential access explains why, in testimony given in 1816 before the House of Assembly of Lower Canada, it was pointed out that Canadian wheat and barley obtained a better price than that obtained for the same crops coming from the port of Danzig (JHALC 1816, App.E) despite the significant difference in distances.

[8] In 1828, Canadian wheat and flour could enter Britain at any price. However, if the price was below 67 shillings per quarter, a higher duty of 5 shillings per quarter was imposed and if the price was above 67 shillings, the duty was set at sixpence per quarter (Marr and Paterson 1980: p. 90).

[9] For example, in 1850, some 182,988 barrels of flour and 71,359 bushels of wheat were exported from Montreal. By 1860 and 1870, these figures had jumped to 277,567 and 975,513 for flour and 1.64 million and 5.97 million for wheat.

British North America and another 75 percent was destined to the West Indies. The proportion for biscuits made from Canadian grain was much greater: 92 percent of exports were destined to British North America.[10] Very little of the exports of grain and its by-products went to Britain between 1760 and 1775. After the American Revolutionary War, the grain trade of Lower Canada with Britain gained in importance while it faltered with the United States (Paquet and Wallot 1967; 1972). However, this coincided with the tightening of the Corn Laws which explains the pattern in Figure 4 below.

After American independence, the ability of Canadians to trade with Americans was subjected to numerous policy changes. While Quebec City had been designated a free port under the Navigation Acts (allowing the entry of foreign ships with foreign goods that did not transit through Britain), American ships were not permitted general entry until the 1820s (Marr and Paterson 1980, p. 124). Wartime events also made trade between them illegal in some key periods (1775-1795; 1807-1815). In 1822, the Canada Trade Act permitted the importation of grain and flour from the United States but duties applied and in 1828, it became possible to export flour made in Canada from American wheat to Britain on the same terms as flour made from Canadian wheat (Marr and Paterson 1980, p. 134). In 1831, there was further liberalization with the abolition of all duties on agricultural products entering British North America (Easterbrook and Aitken 1988, pp. 283, 352). However, that liberalization was not reciprocated by the United States[11] and there was a protectionist reversal in the 1840s on the eve of the end of the Corn Laws.[12]

The episodes of freer trade between the British colonies and the United States suggest that they could easily trade with each other in the absence of policy restrictions.

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[10] It is worth noting that Land and Geloso (2020) showed that, using monthly prices for wheat, prices were converging between Quebec City, Boston, Philadelphia and New York.

[11] There was a 25 cents per bushel duty on wheat imported from Canada and it was only during years of high prices (like 1835 and 1838) that wheat was imported into the United States (Easterbrook and Aitken 1988, p.284). Lawrence Officer and Lawrence Smith (1968) pointed out that prior to 1847, the price differential between the United States and Canada needed to overcome duties and transports costs had to be above 28 cents for grains to flow from Canada to the American side of the Great Lakes. As a result, grain mainly flowed into Canada but not the other way which caused a political backlash.

[12] In 1843, an import duty of 3 shillings per quarter on American wheat was implemented not for the purposes of revenue-generation but rather for the purposes of protection (Marr and Paterson, 1980, p. 135). A report by the Secretary of the Treasury in 1851 confirms this protective purpose. The report indicated that in 1840 (prior to the passing of the colonial 3 shillings duty), the exports from the United States inland ports (around the Great Lakes) to Canada for wheat and flour stood at roughly $143,277, a figure to which we must add $19,140 from other agricultural produces like butter, lard, peas and pork (Corwin 1851, p. 190). In 1851, the flow of agricultural produce from Canada to the US was virtually non-existent (Corwin 1851, p. 192).

3 Data and Variance Analysis of Wheat Prices

3.1 Data

How did the above identified episodes of protectionism and free trade impact on the level of market integration between Canada, the UK and the US? To answer this question, we turn to price information. Our data for the US and the UK are those used by Sharp and Weisdorf (2013). The price data for Canada is assembled using a combination of recent (Geloso 2019a; Geloso and Lindert 2020) and old (Dechêne 1994; Ouellet et al. 1982; McCalla 1993) price evidence regarding Québec City, Montreal and Central Ontario (which we detail in Appendix A). All prices have been converted to shillings and volumes have been converted to quarters. Figure 4 illustrates the average prices of quarters of wheat by country between 1720 and 1850.

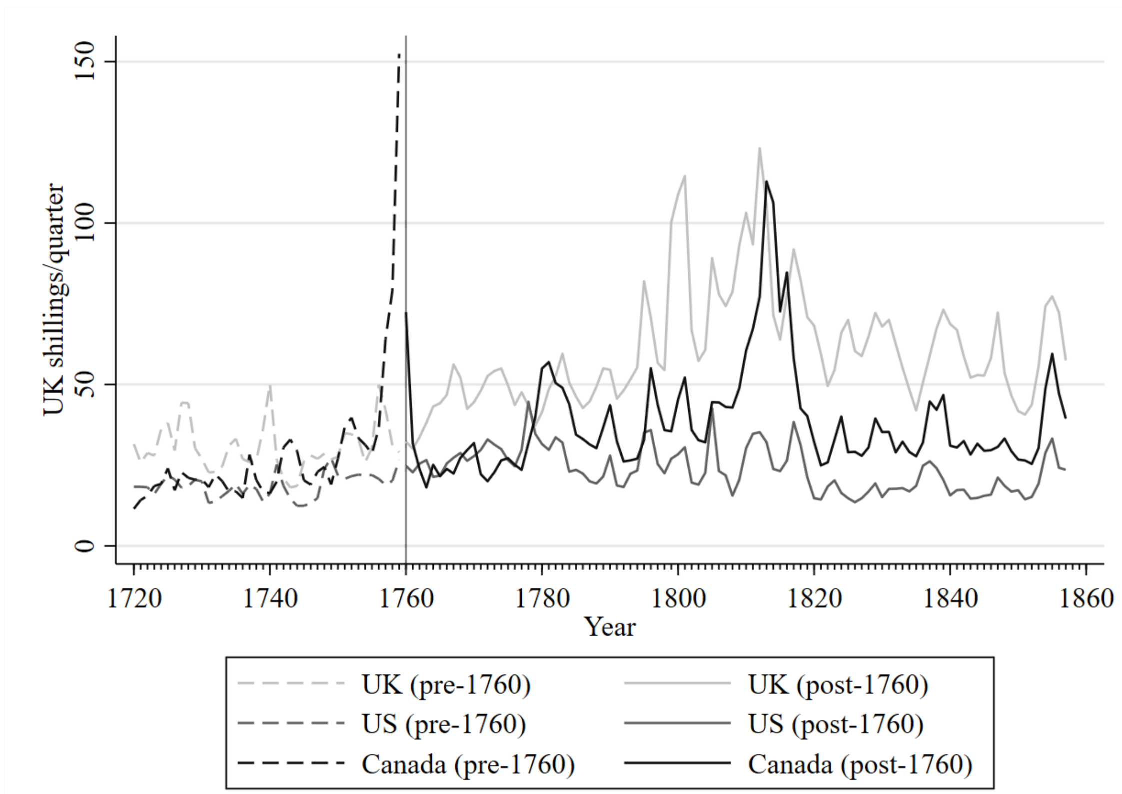

Figure 4: Average prices per quarter of wheat for Canada, UK an US, 1760-1857

Note: The graph illustrates the average prices. The dashed lines represent the period before 1760, while the solid line represents prices after 1760. In the analysis, we only make use of the data for after 1760. The sources for Canada are described in the appendix. For the US and the UK, see Sharp and Weisdorf (2013).

Our data is divided into two parts: one before 1760 and one after 1760. In our analysis we concentrate on the period after the conquest of Quebec by the British empire. Therefore, the first part of Figure 4 (the dashed lines), serves only as a visual inspection of the price trends before 1760. We choose to start our analysis in 1760 for two main reasons. The first is that, before 1760, there is no unique exchange rate between the Canadian *livre* (the unit in which prices were reported) and the British shilling, thus making it more difficult to convert to a common unit.[13] Second, we can therefore concentrate on the period where parts of Canada came under British rule which minimizes the role of political differences.

We divide our analysis of market integration into two parts: a visual inspection of price variances and a more formal analysis using cointegration. For the variance analysis, we use prices for all included markets individually, to investigate the price variance both within countries across markets, and between countries. For this part of the analysis, we rely on the same markets for the UK and the US as in Sharp and Weisdorf (2013), while for Canada we use data for all three markets mentioned beforehand, i.e. Montreal, Quebec City and Central Ontario. For the cointegration analysis, we compute the average prices for the markets in the three countries. In this part, we exclude Central Ontario from the Canadian average, because it has a shorter time series, than the two others (starting only in 1787). In Appendix D, however, we demonstrate that including it makes little difference to the results post-1787. In Figure 4, the solid lines illustrate the three price-series used for the cointegration analysis, 1760-1857.

3.2 Variance analysis of market integration

Following Federico (2011) and Sharp and Weisdorf (2012), we proceed to perform a variance analysis, and decompose total variance between the various markets in the UK, US and Canada as described above. Figure 5 thus illustrates total variance, as well as the residual variance, which is due to price dispersion within each country. A larger variance is an indication of less integrated markets.

[13] In Figure 4, we have used grams of silver per quarter of wheat, to convert the Canadian prices before 1760. The first "official" conversion ratio between the *livre* and the shilling was announced after the Conquest in 1760 (McCullough 1984).

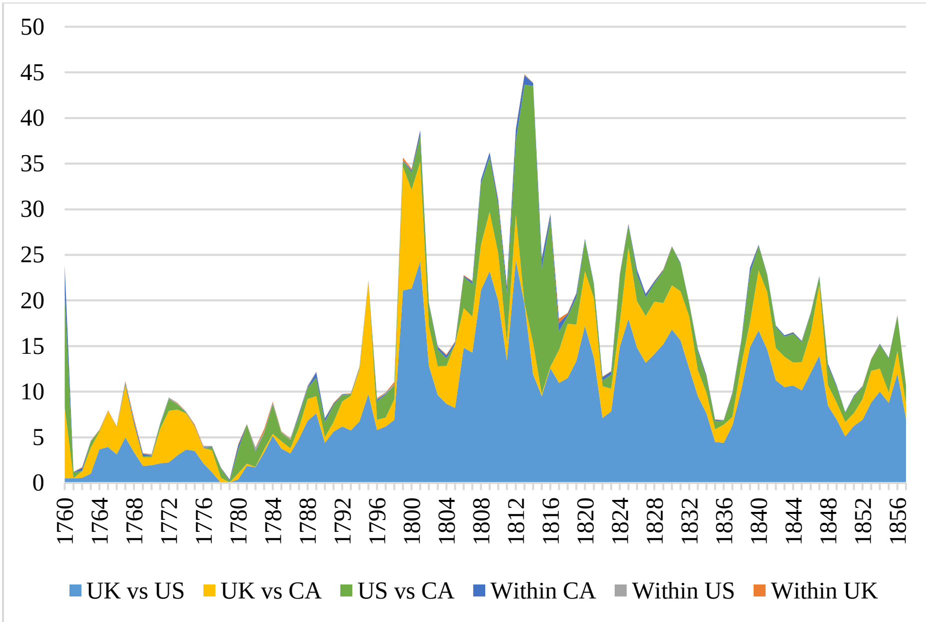

Figure 5: Price variance 1760-1857

Source: Own calculations.

The variance between the UK and the US follows of course that found by Sharp and Weisdorf (2013). As noted above, most of the literature concerning the trade between Canada and Britain agrees that although the colony benefited from a preferential access for grains, it did not benefit from guaranteed access to the British market (McInnis 1982, pp. 36-41; Russell 2012, p. 102). This is clearly confirmed by our results since most of the variance is due to between country differences and Canada was rarely well integrated with Britain's markets before the 1850s. Writings of the time tend to confirm this reality by showing that merchants very often complained about the inability to overcome government barriers to the British market whilst they seem to have been able to trade more easily within Canada. Otherwise, the results correspond well to the narrative above. Canada is relatively poorly integrated with the UK for most of the period, and integration and disintegration follows largely that for the US with the UK. Canada seems however better integrated with the UK after she received increasingly preferential treatment following the Napoleonic Wars. When it comes to integration between Canada and the US, Canada is less integrated with the US before the independence of the latter. After American independence, the Canadian and the US markets seem to integrate more and more, often better than they do with the UK market.

4 Cointegration Analysis

4.1 Econometric model and pre-estimation analysis

In the second part of the analysis we look for cointegrating relationships between the average prices. This idea builds on Cournot's division of market integration into an equilibrium concept, i.e. the law of one price, and a rapid adjustment back to equilibrium after a shock (see also Barzel 2005 and Baffes 1991). Finding cointegrating relationships (or increasing cointegration), is evidence that the law of one price holds, through co-movements of the prices.[14] By including a trend in the analysis we account for changes in transportation costs and the relative qualities of the wheat, which might vary. This gives us the following model to estimate:

$$\Delta X_t = t\alpha\beta' X_{t-1} + \Gamma \Delta X_{t-1} + \beta'_0 t + \varepsilon_t \tag{1}$$

where $X_t = (p_{us}, p_{uk}, p_{ca})'$, p_{us} is the US average price, p_{uk} is the UK average price and p_{ca} is the Canadian average price all three in logs. t is the trend and ε_t is the error term, which we will assume to be $iidN_p(0, \Omega)$ throughout the analysis.

Equation 1 assumes that that the $p = 3$ vectors in X_t are related through $r < p$ equilibrium relationships, i.e. the cointegrating relationships, where r determines the rank of the matrix $\alpha\beta'$. The parameters of interest for our analysis are in the two matrices, β' and α. The β' contains the long-run equilibrium parameters and α contains the adjustment parameters, i.e. showing how long time it takes to return to equilibrium after a shock. Gamma, Γ, represents the short run dynamics which we will ignore here.

Before we begin looking for cointegrating relationships between the prices, we investigate whether the series should be divided into smaller periods, in accordance with our data and historical events. Studying smaller periods allow for different cointegrating relationships, and estimated parameters that can change over time. This is important, if we believe that these are not constant throughout the entire period. An inspection of Figure 6 reveals that there are several breaks in the data, which gives us a first indication of the presence of structural changes.

[14] We thus do not expect prices to be the same, but only that they follow each other.

As a first step, we recursively estimate a simple unrestricted VAR model, to look for changes in the estimated parameters.[15] We do this exercise both backwards, keeping the end year fixed, and forwards, keeping the start year fixed. From the recursive graphs it appears that we should divide our data into three periods: 1760-1783, 1783-1822 and 1822-1857.[16] The recursive graphs can be seen in Appendix B, Figures B1 and B2.

The first break, 1783, is consistent with the timing of American independence and is thus a natural break point, as we can observe some important institutional changes. As mentioned in section 2, 1822 marks the start of some important events in market exchanges between the three countries. On the one hand, a period started, where Britain eased trade with Canada and on the other a Canadian law was passed imposing a duty on grain imports from the US. It is important to note here, that with the abolition of the Corn Laws in 1846, an era of greater market integration began and a break at that time is thus likely. However, longer time series would have been needed to show this picture in our analysis. As a further control we perform a Wald test for structural breaks with known break dates. The results can be seen in Table B1 and shows strong evidence for the presence of a structural break both in 1783 and 1822.

Having identified the breaks, we can proceed by identifying the number of lags, normality of the error term and the cointegrating rank in equation 1 for each of the subperiods. The results of the pre-estimation tests can be seen in Appendix B, and indicate that for the first two periods, 1760-1783 and 1784-1822, one lag is enough to avoid problems with autocorrelation while for the last period, 1822-1857, we need two lags. Tests for normality reveal no issues for all three periods.

Before proceeding with the cointegration analysis, we test the rank for each of the three periods, to know how many cointegrating relationships we are looking for. Here, we rely on two results: 1) the trace statistic along with the maximum-eigenvalue statistic and the information criteria and 2) the recursively calculated trace statistic for each of the three sub-periods. Both can be seen in Appendix B, Figures B6-B11 and show that the first period has rank 1 while the other two have rank 2. For all three periods, we proceed to look for cointegrating relationships in the data with the only initial restriction being the established rank.

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[15] For the graphs see Appendix 2.

[16] Looking at Figure 6 and the variance analysis in Figure 7 reveals similar break dates.

4.2 CVAR Results

In what follows we present the final cointegrating relationships, while the results will be discussed in section 5. For the period 1760-1783 we find the following cointegrating relationship:

$$\begin{bmatrix} \Delta p_{uk_t} \\ \Delta p_{us_t} \\ \Delta p_{ca_t} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \mathbf{-0.5093} \end{bmatrix} [\{p_{ca} - 0.5108 p_{us} - \mathbf{0.0406}\}_{t-1}] + \cdots \tag{2}$$

Equation 2 shows the results, with bold typefaces indicating coefficients significantly different from zero at the 5% level. The model is very well specified, and the imposed restrictions can be accepted with a high p-value of 85.3%. The results show that the Canadian price adjusts to the US price by 0.5108% given a 1% change in the US price, even though the parameter is not significantly different from zero. It is, however, important to recall that to be fully integrated, a 1% change in the US price should be followed by a 1% change in the Canadian price. Testing the hypothesis that the parameter is not significantly different from 1 is accepted, suggesting (weak) market integration. The adjustment parameter to p_{ca}, suggests that it took about two periods for the system to return to equilibrium after a shock.[17] The conclusion we can make for the first period is that before the American independence the US and Canada were somewhat integrated, and the Canadian prices were adjusting to the US prices. The UK was not integrated with any of the other markets in this period, given that the adjustment parameter for the UK is zero.

For the second period, 1783-1822, we find the following two cointegrating relationships:

$$\begin{bmatrix} \Delta p_{uk_t} \\ \Delta p_{us_t} \\ \Delta p_{ca_t} \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ \mathbf{-0.4735} & 0 \\ 0 & \mathbf{-0.3711} \end{bmatrix} \begin{bmatrix} \{p_{us} - \mathbf{0.4663} p_{uk}\}_{t-1} \\ \{p_{ca} - \mathbf{1.6555} p_{uk}\}_{t-1} \end{bmatrix} + \cdots \tag{3}$$

[17] Given that we use annual data, one period equals one year. The closer the adjustment parameters becomes to -1, the faster the adjustment and the greater the market integration.

The model in equation 3 is again well specified and the imposed restrictions can be accepted with a p-value of 73.69%. For this period, both the US prices and the Canadian prices are driven by the UK prices. In equation 3, the trend has been restricted to zero, given than the estimated coefficients were insignificant. The US price adjusts by 0.4663% to a 1% change in the UK price while the Canadian prices adjusts with more than 1% to a 1% change in the UK price. However, testing the hypothesis that the parameters are equal to 1, thus indicating full market integration, shows that both are not significantly different from 1 at the 1% significance level. When it comes to the adjustment parameters, the UK prices drives the others, and both the US and the Canadian prices adjust slowly after a shock, taking more than two periods to return to equilibrium.

For the last period, 1822 to 1857, equation 4 shows the following results:

$$\begin{bmatrix} \Delta p_{uk_t} \\ \Delta p_{us_t} \\ \Delta p_{ca_t} \end{bmatrix} = \begin{bmatrix} \mathbf{-0.7575} & 0 \\ 0 & 0 \\ 0 & \mathbf{-0.8876} \end{bmatrix} \begin{bmatrix} \{p_{uk} - \mathbf{0.5782} p_{ca} + \mathbf{0.0052} t\}_{t-1} \\ \{p_{ca} - \mathbf{0.7622} p_{us} + \mathbf{0.0041} t\}_{t-1} \end{bmatrix} + \cdots \tag{4}$$

The imposed restrictions can be accepted with a p-value of 8.15%, and all estimated coefficients are significantly different from zero. The UK price adjusts with 0.5782% to a 1% change in the Canadian price while the Canadian prices are driven by the US prices, adjusting 0.7622% to a 1% change in the US price. As for equation 3, testing the hypothesis of the parameters in β' being equal to 1, can again be accepted at the 1% significance level. In the last periods prices thus run from the US to Canada and from Canada to the UK. The adjustment parameters are highly significant and close to 1, indicating a quite fast return to equilibrium after a shock, also showing that markets are more integrated in the last period. Considering the event of full liberalization in 1846, this is also what we would have expected.

4.3 Recursive Analysis

As a robustness check to the chosen periods, we perform a recursive analysis of the three identified cointegrating relationships. To establish whether the end point in each period is correctly chosen, we use a forward recursive analysis while to establish whether the start points are correctly chosen, we perform a backward recursive analysis. Whenever there is an evident shift in the level of the parameters, or the p-values, in the recursive graphs, it is an indication that the analysis, using the specific restrictions, should end at that point. All the recursive graphs can be seen in Appendix C, Figures C1-C4. For the first period, 1760-1783, we need to establish whether the endpoint is correctly chosen, and thus we perform a forward recursive analysis, using the restrictions imposed in equation 2. From Figure C1 we can conclude that there is a change during the 1780s in the estimated coefficient, and thus the first break point seems plausible. For the second period, 1783-1822, we need both to look at the start point and the endpoint. Figure C2 shows the forward recursively estimated coefficients, where it clearly appears that something changes around 1822 with the p-value, while also the coefficients show a change between 1815 and 1822. Figure C3 shows the backward recursively estimated coefficients, and it is again clear that both the coefficients and the p-values change around 1883. Finally, for the last period, 1822-1857, we need to look at the choice of the start point in 1822, and we thus perform a backward recursive analysis. Figure C4 shows the result of the backward recursive analysis, and it appears again likely that there is a change around 1822.

5 Discussion and Conclusion

Looking both at the variance and the cointegration analyses, it appears clearly that there have been periods with different levels of market integration. These different periods seem to be tightly associated with different policy regimes or exogenous shocks in the form of war.

For the period between the conquest of Quebec and US independence the Canadian markets were not that well integrated with either the US or the UK markets. This result is unsurprising. The Conquest of 1760 imposed considerable destruction upon Quebec and constituted a major shock that took some years to recuperate from.[18] When trade resumed in earnest, there was only a short amount of time before the Revolutionary War would start. However, the variance analysis for this period shows large variances between both Canada and the UK and Canada and the US while the cointegration analysis shows that Canada was more integrated with the US than with the UK, which seems to be disintegrated with both Canada and the US during this period. This is consistent with trade volumes in grain that went in important proportions to the American colonies (see section 2.2).

[18] Geloso (2016) estimates that the war had caused all gains in per capita income (roughly 20%) observed between 1688 and 1739 (the last year available) to be reversed by 1762.

Thus, our finding of some tentative evidence of market integration between the US and Canada in the early period is quite telling given the problems caused by having two significant wartime shocks in proximity. The fact that we do not find evidence for integration of the British market in the period 1760-1783 can be explained by two events. Firstly, the British started to become net importers of wheat only during the 1770s with the onset of the industrial revolution combined with rapid population growth (see for example Sharp 2010). Therefore, for much of the first period, the UK did not import large amounts of wheat, thus making it less likely for markets to integrate. Secondly, we have the American War of Independence from 1775 to 1783 which brought several actions aimed at avoiding/prohibiting the export of wheat from the US.

The subsequent period sees the UK as the main determinant for wheat prices and both the US market and the Canadian market integrate with the UK from 1783 to 1822. The grain trade of Lower Canada with Britain gained in importance after American independence, explaining why we find evidence for market integration in the cointegration analysis. At the same time, we also find some evidence for integration between the UK and the US, even though the US prices only adjust by about 0.5% and the adjustment is quite slow. This is, again, unsurprising given the role that the French Wars played on grain prices. As Marr and Paterson (1980, p. 90) point out: "prior to 1815, the price of wheat in Great Britain was sufficiently high that the Corn laws seldom either taxed or excluded British North American wheat from the British market".

Finally, from 1822 to 1857 we find that the US price drives the Canadian prices, while the Canadian price drives the UK prices. As explained in section 2, the UK gradually eased the entrance of Canadian grain after 1822, and it is a period where the Canadian share of total wheat imports to Britain is quite important. In fact, the 1828 regulation that permitted easier entry had been pilot-tested temporarily between 1825 and 1828 which meant that "from 1825 on (…), Canadian exporters were at least assured that they would be able to sell their shipments at some price" (Easterbrook and Aitken 1988, p. 282). Moreover, the period also matches the beginning of gradual liberalization towards the United States even though it was unilateral. Our results are in line with these facts, given that we find that only the Canadian prices adjust to the US prices and not the other way around. Overall, we find that in the entire period 1760-1857 Canada started to integrate with both the UK and the US markets.

The fact that there were periods of increased market integration between Canada and the UK suggests that the potential was there in the absence of the 'exogenous shocks' such as wars and the effect of trade policy discussed by Sharp and Weisdorf (2013). Merchants in Canada were very aware of the conditions of the market in England and stayed on the lookout for gaps in prices that were large enough to exploit. Thus, Paquet and Wallot (2007, p. 336-347) point to several pieces of correspondence where merchants communicated with each other about arbitrage opportunities. In fact, most authors of the time recognized that Canada was awarded preferential, but not guaranteed, access to the British market precisely because merchants would eagerly supply Britain in times of deficits in UK production.

The signs of market integration suggest that barriers to trade were not essentially due to natural factors. True, while the portions of Canada that were deeper inland faced higher transportation costs that limited their access to the British market, the areas along the Saint-Lawrence River faced minimal transport costs. Citing an account from 1842, McInnis (1992, p. 29) points out that shipping grain from Montreal to Liverpool cost 7.5 pences per bushel.[19] This represents 8.3% of the British price between 1840 and 1845. In fact, from any port city in Canada, the prices differed little by ultimate destination: prices to go to Halifax, New York, Newfoundland, Liverpool and London were more or less the same (Murray 1839, pp.17-18; *Niles' National Register* 1846, p. 125; House of Assembly of Upper Canada 1836, p. 405; House of Assembly of Lower Canada 1824, Appendix E). This reflects the idea that once on the sea, the marginal cost of distance travelled does not increase by much (Shepherd and Walton 1972). Given that Canada benefits from a sea highway in the form of the Saint-Lawrence that cuts through the province of Quebec or direct access to the Atlantic in the case of the modern day Maritime provinces of Canada, this amounts to saying that more than two thirds of Canada's population pre-1850 had a potentially easy access to Britain's markets.

Moreover, other economic historians argue that McInnis was overstating the importance of transportation costs as barriers (Paterson and Shearer 2001). McInnis had shown that the effective British price in Montreal (the price minus tariffs and transportation costs) was at level that permitted profitable trade in wheat in only 15 of the 34 years to 1850 (McInnis 1992, p. 31). However, Paterson and Shearer (2001) show that these calculations were flawed because the years that should be associated with low exports to Britain – given the price differentials – are actually years of high exports. Most notably, Paterson and Shearer (2001) pointed out that freight rates were in part determined by prices for wheat for Britain and how it affected the allocation of shipping capacity.[20] When they made account for this, they find that freight rates *rose* when British demand for Canadian grain was high.

[19] Transports costs exceeded 1 shilling on the leg from cities in Upper Canada to Montreal (McInnis 1992, p. 29).
[20] In other words, there was competition for shipping capacity *between* goods to be exported to Britain.

These figures must be contrasted with the fact that British prices for wheat in the 1820s onwards were low enough to be imposed the higher duty of 5 shillings per quarter which is nearly twice as much as the transportation costs. Coupled with the role of wars that acted as exogenous shocks to trade, we are forced to consider that "non-natural" barriers to trade played a large role – if not the leading role – in deterring market integration. The results regarding the cointegration between the United States and Canada provide considerable support in this respect. In the period from 1822 to 1843, when Canada fully liberalized trade in agricultural products with the US, Canadian prices became heavily cointegrated with American prices suggesting important market integration.[21] In the same period, American wheat was limited in its ability to enter British markets by virtue of the Corn Laws while Canadians possessed a preferential (but still limited) access. As we pointed out above, the transportation costs between port cities across the North Atlantic were very similar. Essentially, this means that observing integration between Canada and the US which were liberalized from 1822 to 1843 entails that integration between Canada, the US and the UK would have been possible had it not been for the Corn Laws. More importantly, given the short episode from 1760 to 1775 when all three countries were part of the same political union shows signs that there was cointegration, the patterns of the 1822-1843 period could have been observed in the second half of the 18th century.

Thus, while there was a role for natural trade barriers especially for places deeper in the North American hinterland, we are forced to consider that the first era of globalization could have occurred much earlier had it not been for institutional trade barriers. Market integration between the US and Canada was similarly almost permanently limited by institutional barriers to trade. This has a powerful implication for students of economic history: the first era of globalization that took place in the second half of the nineteenth century could have taken place in the eighteenth century, although perhaps to a more limited extent, given the more limited technology of the time.

[21] In fact, it is worth pointing out that most wheat and flour post-1831 from Canada to Britain were from Upper Canadian wheat transiting through Quebec. Quebec's wheat and flour exports fell precipitously as it seems that they obtained wheat and flour from American and Ontarian sources while it specialized rapidly in the production and export of timber and shipbuilding (McInnis 1992). This rapid rearrangement of international trade suggests that market integration was easily possible.

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Appendix A Price Data for Canadian Markets

The main source of wheat prices for Canada is derived from the work of Geloso (2019) and Geloso and Lindert (2020) who used the accounts books of religious congregations around Quebec City from 1688 to 1858 to create a price series for wheat and flour. The prices were reported in *minots* (a French unit of volume which reflects the cultural background of the area) and in *livres* (a French monetary unit). Ouellet et al. (1982) provided the same information for wheat in Montreal from 1767 to 1858. There is also a series for flour but there are gaps in it. To complete the Montreal wheat prices pre-1767, we used the prices reported by Dechêne (1994). The prices in Montreal were reported in the same units as for Quebec City. We used the conventional conversion ratios from *minots* to bushels provided by Canadian historians (Rousseau 1983; Geloso 2019b) and the exchange rates provided by McCullough (1984) are used to convert from *livres* to shillings Sterling. This allowed us to create price series for Quebec and Montreal that cover the period from 1720 to 1858. The price data for Ontario was taken from the work of McCalla (1993). We used his prices for Central Ontario because they had the longest continuous coverage and the fewest gaps of all his series. His prices were reported in shillings of the Halifax denomination (which was below 1:1 with the Sterling) per bushels. We also used the exchanges rates McCullough (1984) provided to convert to Stirling.

Appendix B   Pre-estimation analysis

Figures B1-B2 shows the recursive analysis of an unrestricted VAR

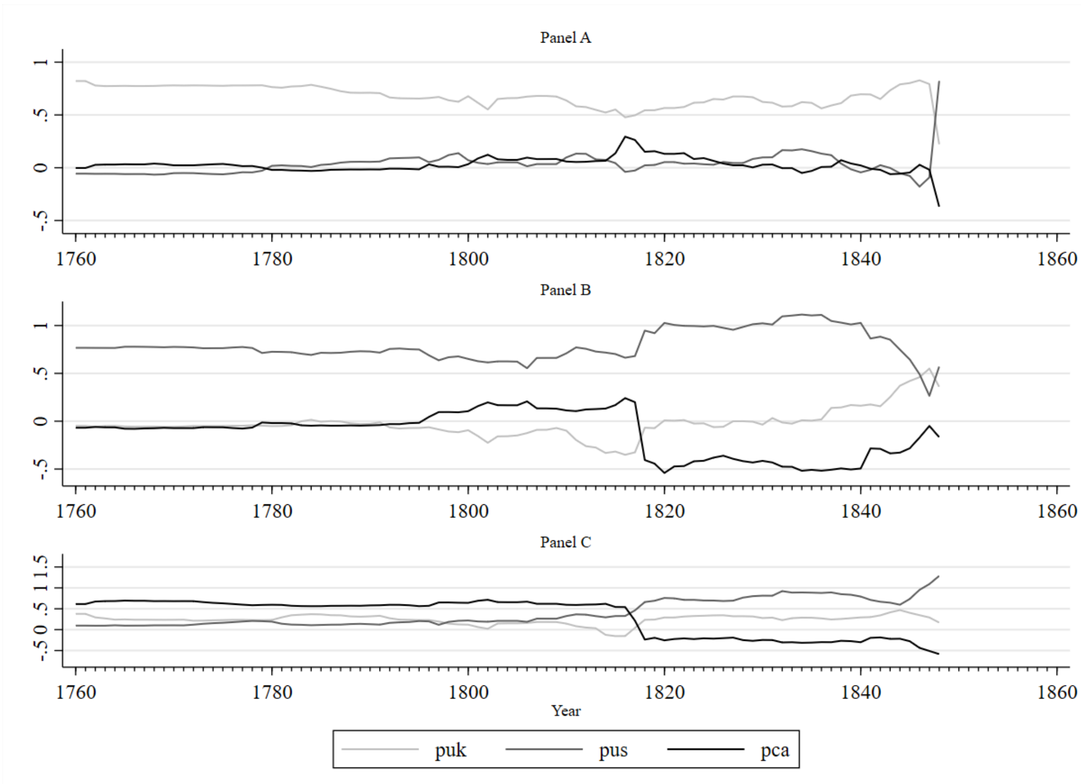

Figure B1: Backward recursively estimated VAR coefficients

Note: Backward recursively estimated coefficients with end year fixed at 1857. Panel A shows the estimated coefficients for the relationship between p_{uk} and the lagged variables p_{uk}, p_{us} and p_{ca}. Panel B shows the estimated coefficients for the relationship between p_{us} and the lagged variables p_{uk}, p_{us} and p_{ca}. Panel C shows the estimated coefficients for the relationship between p_{ca} and the lagged variables p_{uk}, p_{us} and p_{ca}.

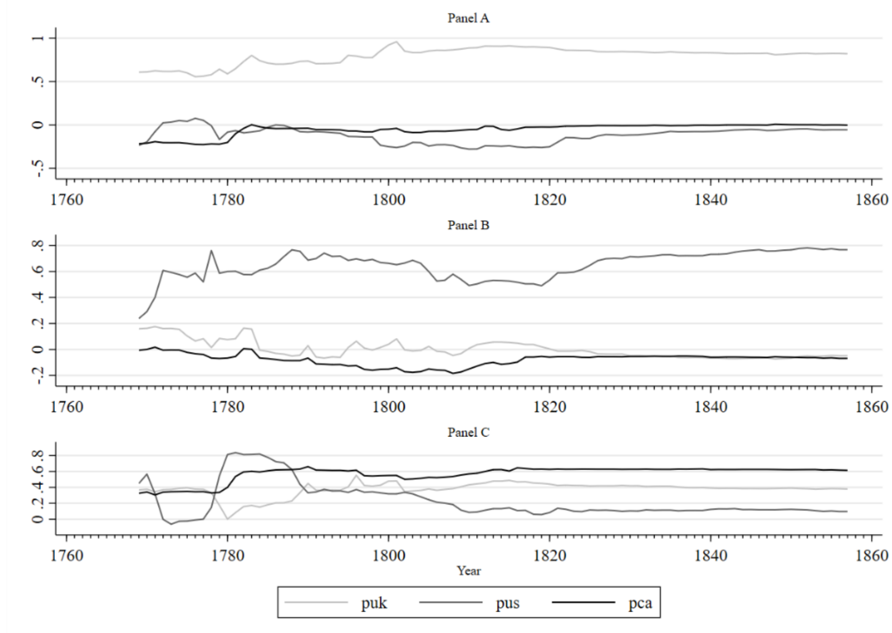

Figure B2: Forward recursively estimated VAR coefficients

Note: Backward recursively estimated coefficients with end year fixed at 1857. Panel A shows the estimated coefficients for the relationship between p_{uk} and the lagged variables p_{uk}, p_{us} and p_{ca}. Panel B shows the estimated coefficients for the relationship between p_{us} and the lagged variables p_{uk}, p_{us} and p_{ca}. Panel C shows the estimated coefficients for the relationship between p_{ca} and the lagged variables p_{uk}, p_{us} and p_{ca}.

Table B1: Wald test for structural breaks

Independent variable	Wald test	p-value
	Testing 1783 and 1822 together	
puk	13.2199	0.5093
pus	20.1936	0.1242
pca	25.8011	0.0274
	Testing 1783	
puk	1.3413	0.9873
pus	5.2600	0.6283
pca	11.6510	0.1126
	Testing 1822	
puk	12.0477	0.0990
pus	12.9318	0.0738
pca	11.8535	0.1055

Note: This table shows the test statistics for the Wald test looking for known structural break dates. H_0: no structural break. The first part shows the statistic when testing both break dates together.

The following is the analysis of the unrestricted VAR, to assure the model is well specified.

Selection-order criteria
Sample: 1764 - 1783 Number of obs = 20

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	18.7549				.000042	-1.57549	-1.54634	-1.42613
1	44.5651	51.62	9	0.000	7.9e-06*	-3.25651	-3.13988*	-2.65907*
2	51.0859	13.042	9	0.161	.000011	-3.00859	-2.80449	-1.96307
3	58.7709	15.37	9	0.081	.000015	-2.87709	-2.58552	-1.38349
4	72.5885	27.635*	9	0.001	.000015	-3.35885*	-2.97982	-1.41718

Endogenous: puk pus pca
Exogenous: _cons

Figure B3: Selection-order criteria for the period 1760-1783

Selection-order criteria
Sample: 1783 - 1822 Number of obs = 40

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-9.98735				.000384	.649368	.695166	.776033
1	39.3547	98.684*	9	0.000	.000051*	-1.36773*	-1.18454*	-.86107*
2	45.3102	11.911	9	0.218	.00006	-1.21551	-.894921	-.328849
3	50.8072	10.994	9	0.276	.000073	-1.04036	-.582375	.226301
4	58.7845	15.955	9	0.068	.00008	-.989225	-.393845	.657433

Endogenous: puk pus pca
Exogenous: _cons

Figure B4: Selection-order criteria for the period 1783-1822

Selection-order criteria
Sample: 1822 - 1857 Number of obs = 36

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	52.2073				.000013	-2.73374	-2.68768	-2.60178
1	88.3856	72.357	9	0.000	2.9e-06	-4.24364	-4.05941	-3.7158*
2	101.44	26.11*	9	0.002	2.3e-06*	-4.46891*	-4.14651*	-3.54519
3	108.582	14.283	9	0.113	2.7e-06	-4.36566	-3.90509	-3.04606
4	116.197	15.23	9	0.085	3.1e-06	-4.28872	-3.68997	-2.57324

Endogenous: puk pus pca
Exogenous: _cons

Figure B5: Selection-order criteria for the period 1822-1857

```
3 . ***** 1761-1783 *****
4 . vec puk pus pca if Year <= 1783, trend(rtrend) lags(1)
```

Vector error-correction model

```
Sample:  1761 - 1783                          Number of obs    =        23
                                              AIC              = -3.026339
Log likelihood =  43.80289                    HQIC             = -2.914592
Det(Sigma_ml)  =  4.45e-06                    SBIC             = -2.582015
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_puk	2	.110779	0.0660	1.412162	0.4936
D_pus	2	.144774	0.0118	.2379281	0.8878
D_pca	2	.158176	0.6464	36.56548	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_puk						
_ce1 L1.	.00676	.0170121	0.40	0.691	-.0265832	.0401031
_cons	.0256965	.0237575	1.08	0.279	-.0208674	.0722604
D_pus						
_ce1 L1.	-.0073537	.0222327	-0.33	0.741	-.050929	.0362215
_cons	.0119728	.031048	0.39	0.700	-.0488802	.0728258
D_pca						
_ce1 L1.	-.1463761	.0242908	-6.03	0.000	-.1939852	-.0987671
_cons	.0005852	.0339222	0.02	0.986	-.065901	.0670715

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	2	32.73851	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
puk	1	.	.	.	.	.
pus	-1.187401	1.928404	-0.62	0.538	-4.967003	2.592201
pca	3.695539	.6529566	5.66	0.000	2.415767	4.97531
_trend	-.1649068	.0487833	-3.38	0.001	-.2605202	-.0692934
_cons	-10.40306	.	.	.	.	.

```
5 . ** autocorrelation **
6 . veclmar, mlag(3)

   Lagrange-multiplier test

  ┌─────┬────────────────────────────────┐
  │ lag │      chi2    df   Prob > chi2  │
  ├─────┼────────────────────────────────┤
  │  1  │    6.2702     9     0.71260    │
  │  2  │    7.5471     9     0.58035    │
  │  3  │    7.0411     9     0.63284    │
  └─────┴────────────────────────────────┘
   H0: no autocorrelation at lag order

7 . ** normality **
8 . vecnorm, jbera skewness kurtosis dfk

   Jarque-Bera test

  ┌──────────────────┬──────────────────────────────────┐
  │         Equation │             chi2   df  Prob > chi2│
  ├──────────────────┼──────────────────────────────────┤
  │            D_puk │            3.911    2    0.14151  │
  │            D_pus │            3.439    2    0.17914  │
  │            D_pca │            3.744    2    0.15378  │
  │              ALL │           11.094    6    0.08550  │
  └──────────────────┴──────────────────────────────────┘

   Skewness test

  ┌──────────────────┬──────────────────────────────────┐
  │         Equation │ Skewness    chi2   df  Prob > chi2│
  ├──────────────────┼──────────────────────────────────┤
  │            D_puk │ -.14149    0.070    1    0.79123  │
  │            D_pus │  .00872    0.000    1    0.98698  │
  │            D_pca │  .03946    0.005    1    0.94116  │
  │              ALL │            0.076    3    0.99458  │
  └──────────────────┴──────────────────────────────────┘

   Kurtosis test

  ┌──────────────────┬──────────────────────────────────┐
  │         Equation │ Kurtosis    chi2   df  Prob > chi2│
  ├──────────────────┼──────────────────────────────────┤
  │            D_puk │  .90492    3.841    1    0.05002  │
  │            D_pus │  1.0175    3.439    1    0.06368  │
  │            D_pca │  .93285    3.739    1    0.05316  │
  │              ALL │           11.019    3    0.01163  │
  └──────────────────┴──────────────────────────────────┘
   dfk estimator used in computations


 9 .
10 . ***** 1783-1822 *****
11 . vec puk pus pca if Year >= 1783 & Year <= 1822, trend(rtrend) rank(2) lags(1)

Vector error-correction model

Sample:  1783 - 1822                              Number of obs     =         40
                                                  AIC               =  -1.252306
Log likelihood =  38.04613                        HQIC              =  -1.053846
Det(Sigma_ml)  =    .00003                        SBIC              =  -.7034204

Equation           Parms      RMSE     R-sq      chi2     P>chi2
────────────────────────────────────────────────────────────────
D_puk                 3     .209108   0.0438   1.649734   0.6482
D_pus                 3     .239269   0.2330   10.93803   0.0121
D_pca                 3     .227315   0.2216    10.2502   0.0166
────────────────────────────────────────────────────────────────
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_puk						
_ce1 L1.	-.1359562	.1898415	-0.72	0.474	-.5080388	.2361263
_ce2 L1.	-.114799	.1766584	-0.65	0.516	-.4610431	.2314451
_cons	-.0010898	.0338895	-0.03	0.974	-.067512	.0653324
D_pus						
_ce1 L1.	.2068049	.2172239	0.95	0.341	-.2189461	.6325559
_ce2 L1.	-.6559478	.2021393	-3.25	0.001	-1.052133	-.2597621
_cons	.0002616	.0387776	0.01	0.995	-.0757412	.0762643
D_pca						
_ce1 L1.	.6438478	.2063706	3.12	0.002	.2393688	1.048327
_ce2 L1.	-.1479011	.1920397	-0.77	0.441	-.524292	.2284898
_cons	-.0003141	.0368402	-0.01	0.993	-.0725196	.0718913

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	1	14.47316	0.0001
_ce2	1	6.31303	0.0120

Identification: beta is exactly identified

Johansen normalization restrictions imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
puk	1	.	.	.	.	.
pus	-5.55e-17	.	.	.	.	.
pca	-.4396558	.1155663	-3.80	0.000	-.6661616	-.21315
_trend	-.0061066	.0041884	-1.46	0.145	-.0143158	.0021026
_cons	-2.432075	.	.	.	.	.
_ce2						
puk	0	(omitted)				
pus	1	.	.	.	.	.
pca	-.3330114	.1325379	-2.51	0.012	-.592781	-.0732418
_trend	.0045001	.0048035	0.94	0.349	-.0049147	.0139148
_cons	-1.99716	.	.	.	.	.

12 . ** autocorrelation **

```
13 . veclmar, mlag(3)

   Lagrange-multiplier test
```

lag	chi2	df	Prob > chi2
1	9.4868	9	0.39361
2	8.6209	9	0.47297
3	7.8266	9	0.55171

```
   H0: no autocorrelation at lag order

14 . ** normality **
15 . vecnorm, jbera skewness kurtosis dfk

   Jarque-Bera test
```

Equation	chi2	df	Prob > chi2
D_puk	3.256	2	0.19635
D_pus	2.554	2	0.27881
D_pca	2.096	2	0.35061
ALL	7.906	6	0.24505

```
   Skewness test
```

Equation	Skewness	chi2	df	Prob > chi2
D_puk	.61962	2.560	1	0.10963
D_pus	-.15451	0.159	1	0.68993
D_pca	-.10781	0.077	1	0.78073
ALL		2.796	3	0.42412

```
   Kurtosis test
```

Equation	Kurtosis	chi2	df	Prob > chi2
D_puk	2.3537	0.696	1	0.40408
D_pus	1.8012	2.395	1	0.12170
D_pca	1.8995	2.019	1	0.15538
ALL		5.110	3	0.16391

```
   dfk estimator used in computations

16 .
17 . ***** 1822-1857 *****
18 . vec puk pus pca if Year >= 1822, trend(rtrend) rank(2) lags(2)

Vector error-correction model

Sample:  1822 - 1857                         Number of obs     =         36
                                             AIC               =  -4.350889
Log likelihood =   100.316                   HQIC              =  -4.013134
Det(Sigma_ml)  =  7.62e-07                   SBIC              =  -3.383183
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_puk	6	.100598	0.5663	37.86006	0.0000
D_pus	6	.16084	0.2225	8.299976	0.2169
D_pca	6	.109122	0.6604	56.40084	0.0000

		Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_puk							
	_ce1 L1.	-.7936675	.1805622	-4.40	0.000	-1.147563	-.439772
	_ce2 L1.	-.2615836	.1721171	-1.52	0.129	-.5989269	.0757597
	puk LD.	.7026467	.1652012	4.25	0.000	.3788583	1.026435
	pus LD.	.1878505	.2167556	0.87	0.386	-.2369827	.6126837
	pca LD.	-.1315484	.1923331	-0.68	0.494	-.5085143	.2454176
	_cons	-.0049329	.0171484	-0.29	0.774	-.0385431	.0286773
D_pus							
	_ce1 L1.	-.3387399	.2886912	-1.17	0.241	-.9045642	.2270845
	_ce2 L1.	.0076303	.2751887	0.03	0.978	-.5317297	.5469903
	puk LD.	.1934986	.2641313	0.73	0.464	-.3241892	.7111864
	pus LD.	.272077	.3465589	0.79	0.432	-.4071659	.9513199
	pca LD.	-.3779935	.307511	-1.23	0.219	-.980704	.224717
	_cons	.010386	.0274176	0.38	0.705	-.0433515	.0641236
D_pca							
	_ce1 L1.	.1931459	.195862	0.99	0.324	-.1907366	.5770284
	_ce2 L1.	.6664721	.1867013	3.57	0.000	.3005443	1.0324
	puk LD.	.333213	.1791994	1.86	0.063	-.0180113	.6844373
	pus LD.	-.0097969	.2351222	-0.04	0.967	-.470628	.4510342
	pca LD.	.1301095	.2086303	0.62	0.533	-.2787983	.5390174
	_cons	-.002055	.0186014	-0.11	0.912	-.0385132	.0344031

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	1	.2319183	0.6301
_ce2	1	53.17834	0.0000

Identification: beta is exactly identified

Johansen normalization restrictions imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
puk	1	.	.	.	.	.
pus	0	(omitted)				
pca	-.103049	.2139816	-0.48	0.630	-.5224453	.3163472
_trend	.005008	.0029602	1.69	0.091	-.0007938	.0108099
_cons	-3.793904	.	.	.	.	.
_ce2						
puk	-2.78e-17	.	.	.	.	.
pus	1	.	.	.	.	.
pca	-1.751046	.2401211	-7.29	0.000	-2.221675	-1.280418
_trend	-.0052756	.0033218	-1.59	0.112	-.0117862	.001235
_cons	3.514806	.	.	.	.	.

```
19 . ** autocorrelation **
20 . veclmar, mlag(3)
```

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	12.4225	9	0.19053
2	9.3853	9	0.40249
3	16.2816	9	0.06123

H0: no autocorrelation at lag order

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_puk	1.782	2	0.41034
D_pus	2.161	2	0.33947
D_pca	0.406	2	0.81616
ALL	4.349	6	0.62962

Skewness test

Equation	Skewness	chi2	df	Prob > chi2
D_puk	-.10064	0.061	1	0.80529
D_pus	-.13207	0.105	1	0.74632
D_pca	-.04552	0.012	1	0.91122
ALL		0.178	3	0.98108

Kurtosis test

Equation	Kurtosis	chi2	df	Prob > chi2
D_puk	1.9289	1.721	1	0.18960
D_pus	1.8292	2.056	1	0.15160
D_pca	2.4876	0.394	1	0.53028
ALL		4.171	3	0.24361

dfk estimator used in computations

Johansen tests for cointegration

Trend: rtrend — Number of obs = 23
Sample: 1761 - 1783 — Lags = 1

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	3	31.218142	.	42.5407	42.44
1	9	43.802894	0.66523	17.3712*	25.32
2	13	50.759253	0.45387	3.4585	12.25
3	15	52.488499	0.13961		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	3	31.218142	.	25.1695	25.54
1	9	43.802894	0.66523	13.9127	18.96
2	13	50.759253	0.45387	3.4585	12.52
3	15	52.488499	0.13961		

maximum rank	parms	LL	eigenvalue	SBIC	HQIC	AIC
0	3	31.218142		-2.305644	-2.416503	-2.453752
1	9	43.802894	0.66523	-2.582015	-2.914592	-3.026339
2	13	50.759253	0.45387	-2.641612*	-3.122002*	-3.283413
3	15	52.488499	0.13961	-2.51933	-3.073626	-3.259869

Figure B6: Johansen tests for cointegration 1760-1783

Johansen tests for cointegration

Trend: rtrend — Number of obs = 40
Sample: 1783 - 1822 — Lags = 1

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	3	20.090057	.	40.9774*	42.44
1	9	31.428991	0.43275	18.2995	25.32
2	13	38.046125	0.28169	5.0653	12.25
3	15	40.578753	0.11894		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	3	20.090057	.	22.6779	25.54
1	9	31.428991	0.43275	13.2343	18.96
2	13	38.046125	0.28169	5.0653	12.52
3	15	40.578753	0.11894		

maximum rank	parms	LL	eigenvalue	SBIC	HQIC	AIC
0	3	20.090057		-.7278369	-.8087045	-.8545029
1	9	31.428991	0.43275	-.7414517*	-.9840543	-1.12145
2	13	38.046125	0.28169	-.7034204	-1.053846*	-1.252306
3	15	40.578753	0.11894	-.6456079	-1.049946	-1.278938

Figure B7: Johansen tests for cointegration 1783-1822

Johansen tests for cointegration

Trend: rtrend Number of obs = 36

Sample: 1822 - 1857 Lags = 2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	12	75.148239	.	57.9590	42.44
1	18	90.852526	0.58208	26.5504	25.32
2	22	100.31601	0.40889	7.6235*	12.25
3	24	104.12775	0.19084		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	12	75.148239	.	31.4086	25.54
1	18	90.852526	0.58208	18.9270	18.96
2	22	100.31601	0.40889	7.6235	12.52
3	24	104.12775	0.19084		

maximum rank	parms	LL	eigenvalue	SBIC	HQIC	AIC
0	12	75.148239		-2.980396	-3.324005	-3.508236
1	18	90.852526	0.58208	-3.255603	-3.771017	-4.047363
2	22	100.31601	0.40889	-3.383183*	-4.013134*	-4.350889
3	24	104.12775	0.19084	-3.395862	-4.083081	-4.451542

Figure B8: Johansen tests for cointegration 1822-1857

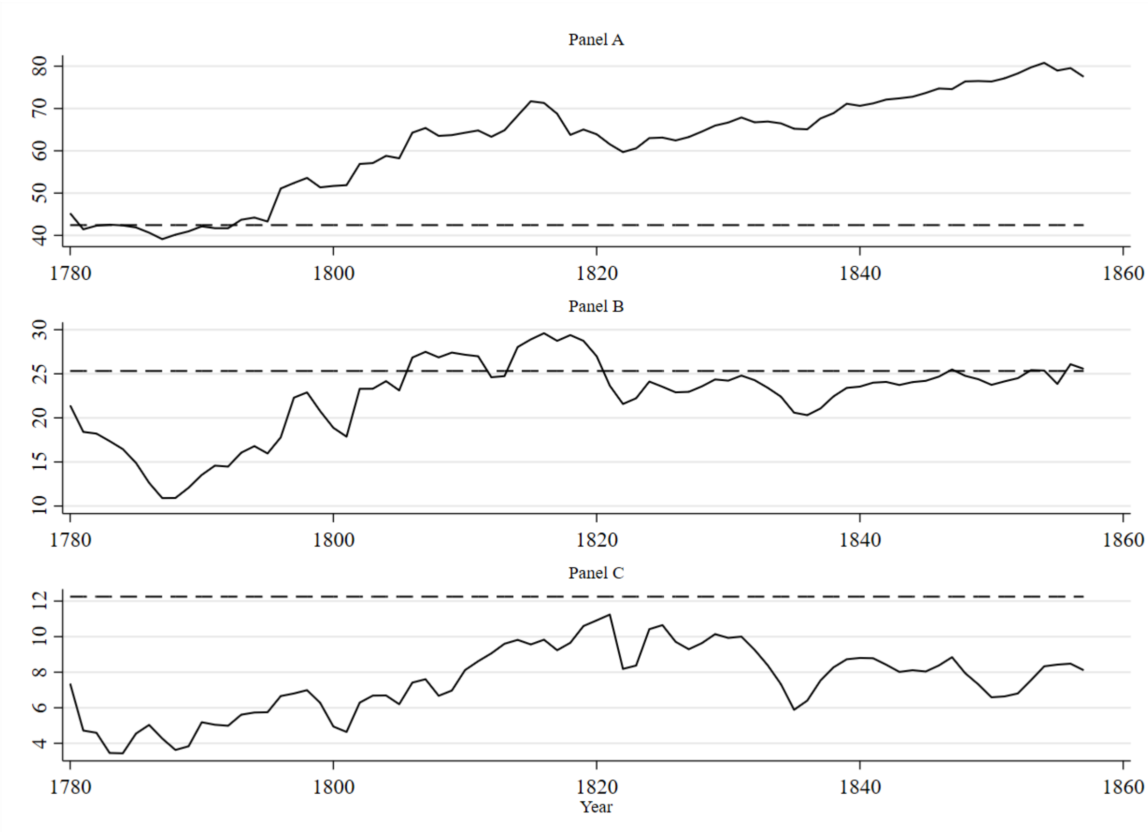

Figure B9: Recursively calculated trace statistics for cointegration rank, 1760-1783

Note: The start year is held fixed while the end year changes. Panel A represents the trace statistic for the null hypothesis $H_0\colon rank \leq 0$. Panel B represents the trace statistic for the null hypothesis $H_0\colon rank \leq 1$. Panel C represents the trace statistic for the null hypothesis $H_0\colon rank \leq 2$. The dashed lines represent the critical values at the 5% level.

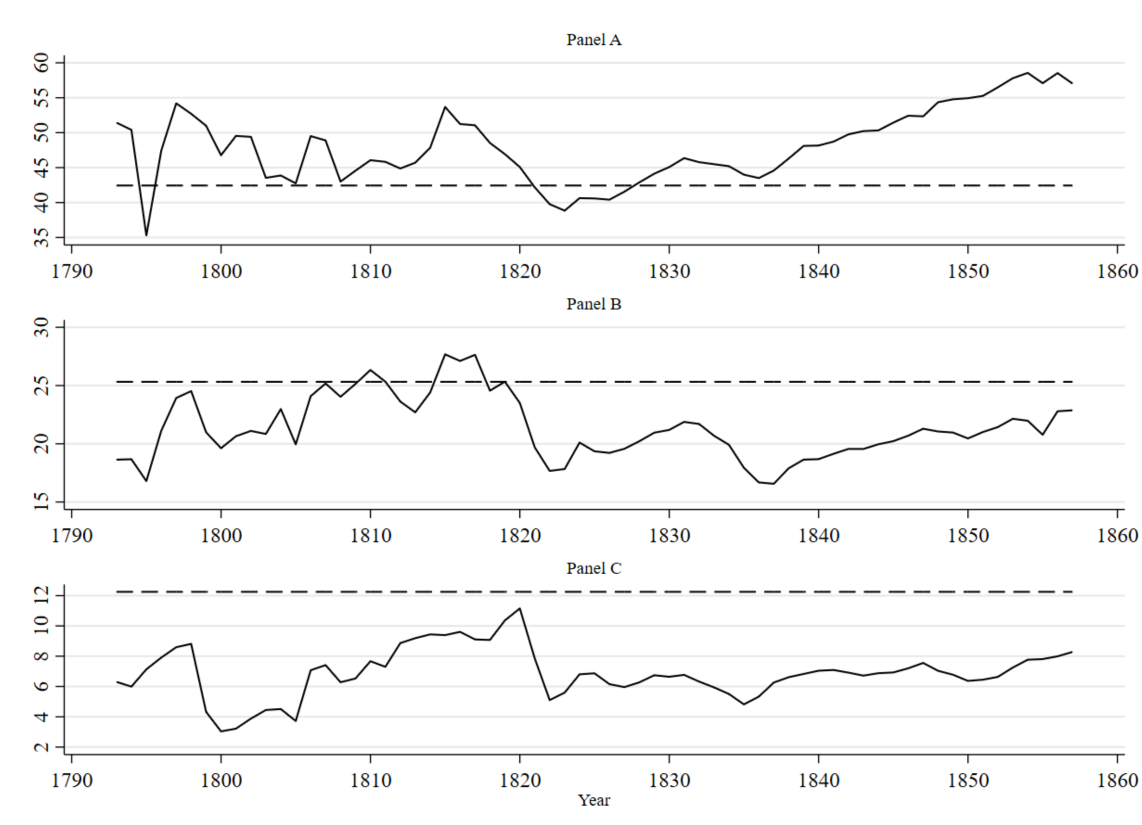

Figure B10: Recursively calculated trace statistics for cointegration rank, 1783-1822

Note: The start year is held fixed while the end year changes. Panel A represents the trace statistic for the null hypothesis $H_0: rank \leq 0$. Panel B represents the trace statistic for the null hypothesis $H_0: rank \leq 1$. Panel C represents the trace statistic for the null hypothesis $H_0: rank \leq 2$. The dashed lines represent the critical values at the 5% level.

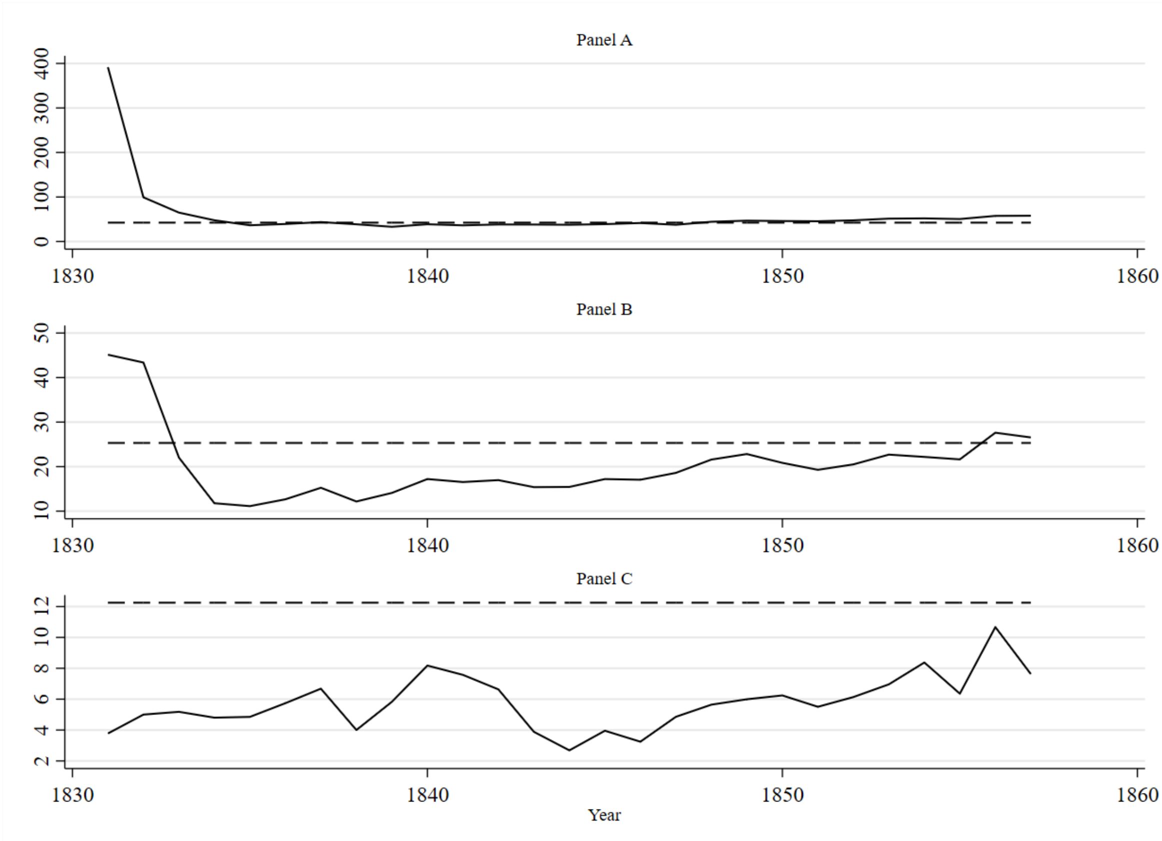

Figure B11: Recursively calculated trace statistics for cointegration rank, 1822-1857

Note: The start year is held fixed while the end year changes. Panel A represents the trace statistic for the null hypothesis $H_0: rank \leq 0$. Panel B represents the trace statistic for the null hypothesis $H_0: rank \leq 1$. Panel C represents the trace statistic for the null hypothesis $H_0: rank \leq 2$. The dashed lines represent the critical values at the 5% level.

Appendix C Recursive CVAR analysis

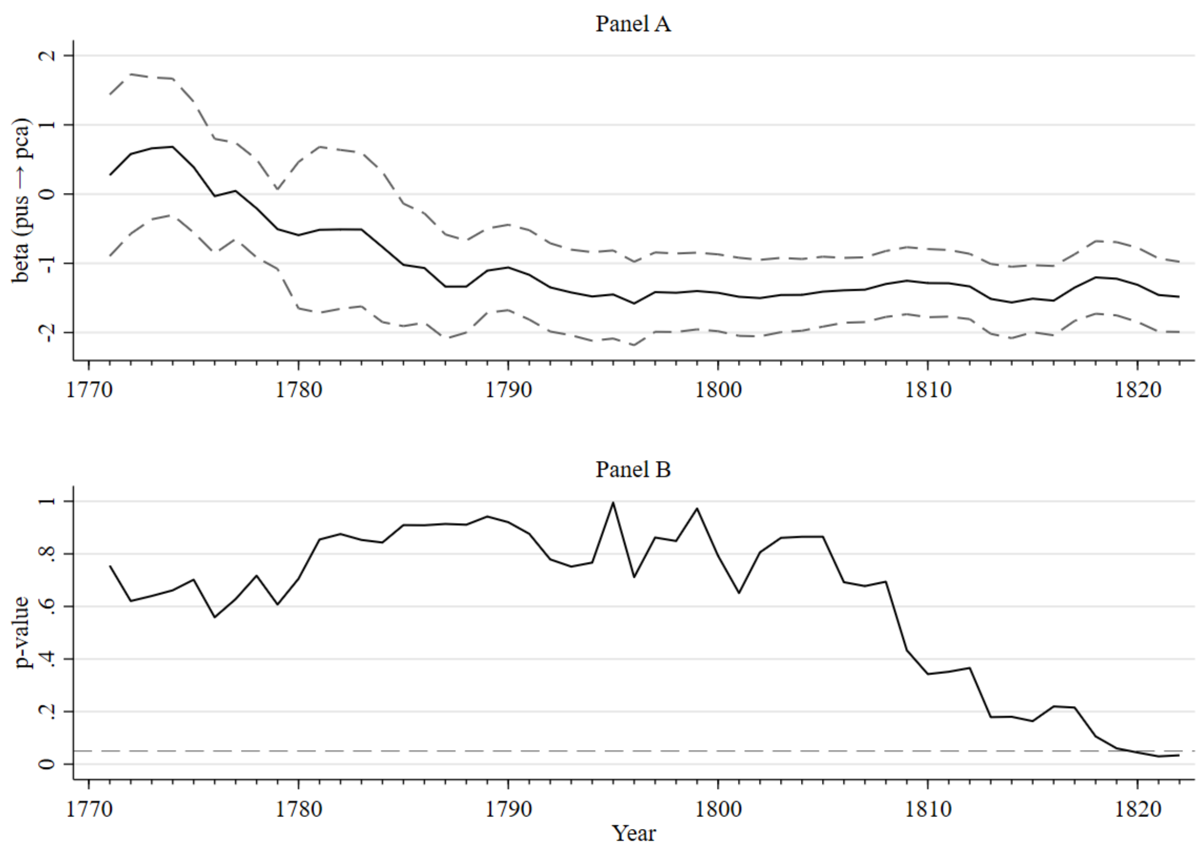

Figure C1: Forward recursively estimated coefficient and p-values for the period 1760-1783

Note: The start year is fixed at 1760 while the end year changes. Panel A illustrates the estimated beta coefficient from equation 2, while the dashed lines represent 2x standard errors. Panel B illustrates the p-value for acceptance of the imposed restrictions.

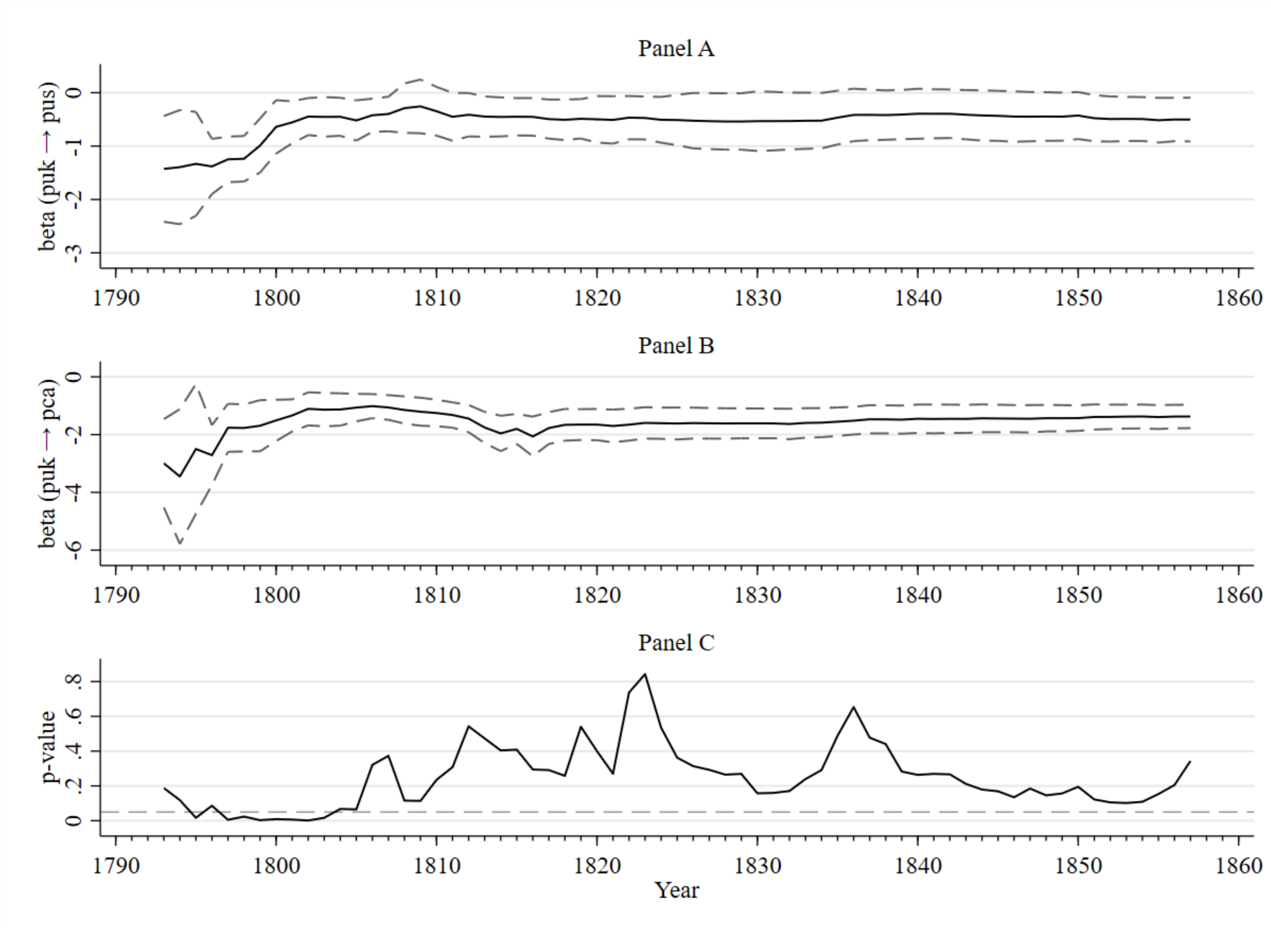

Figure C2: Forward recursively estimated coefficients and p-values for the period 1783-1822

Note: The start year is fixed at 1783 while the end year changes. Panel A illustrates the estimated beta coefficient between the UK and the US from equation 3, Panel B illustrates the estimated beta coefficient between the UK and Canada while in both, the dashed lines represent 2x standard errors. Panel C illustrates the p-value for acceptance of the imposed restrictions.

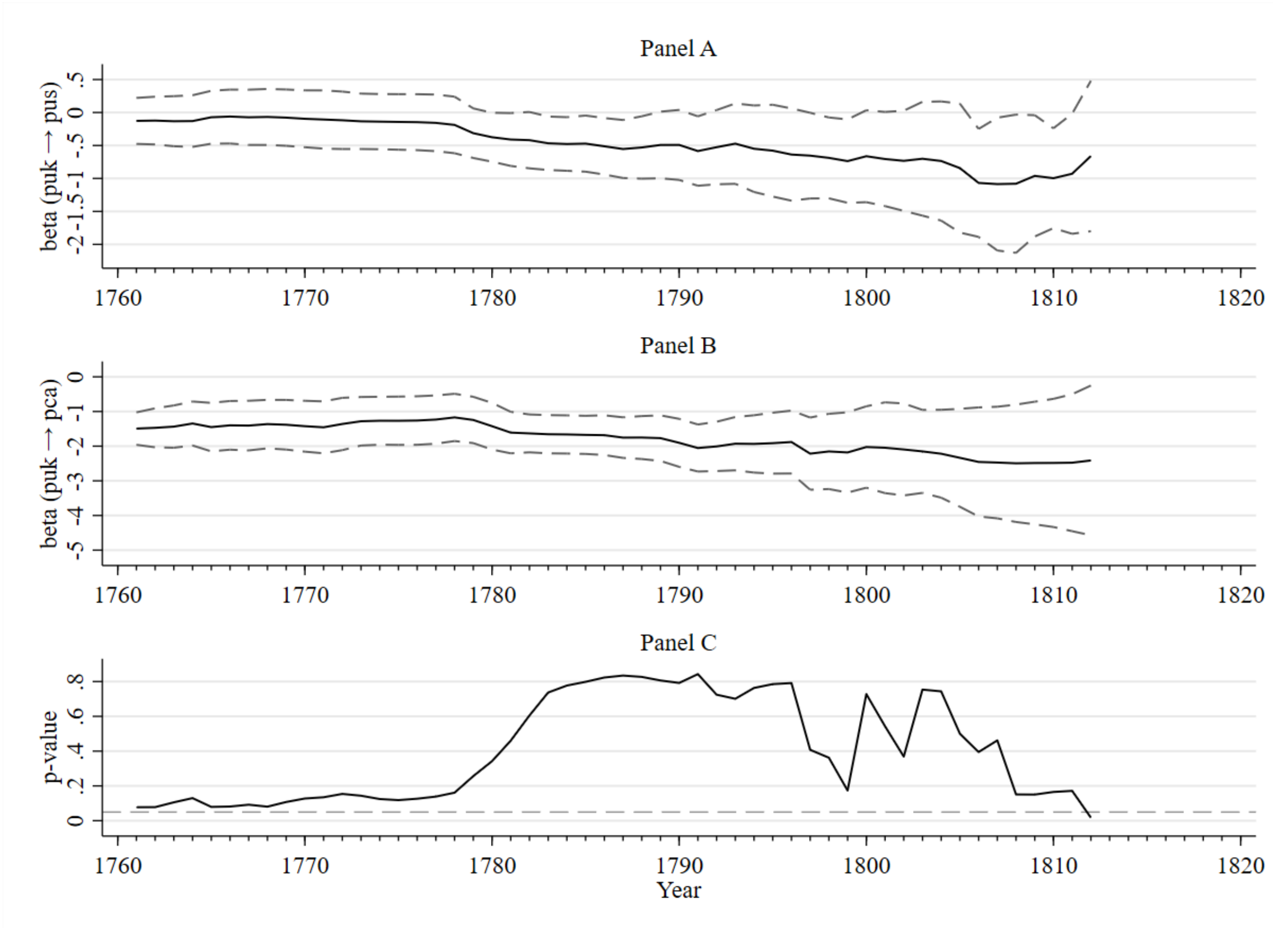

Figure C3: Backward recursively estimated coefficients and p-values for the period 1783-1822

Note: The end year is fixed at 1822 while the start year changes. Panel A illustrates the estimated beta coefficient between the UK and the US from equation 3, Panel B illustrates the estimated beta coefficient between the UK and Canada while in both, the dashed lines represent 2x standard errors. Panel C illustrates the p-value for acceptance of the imposed restrictions.

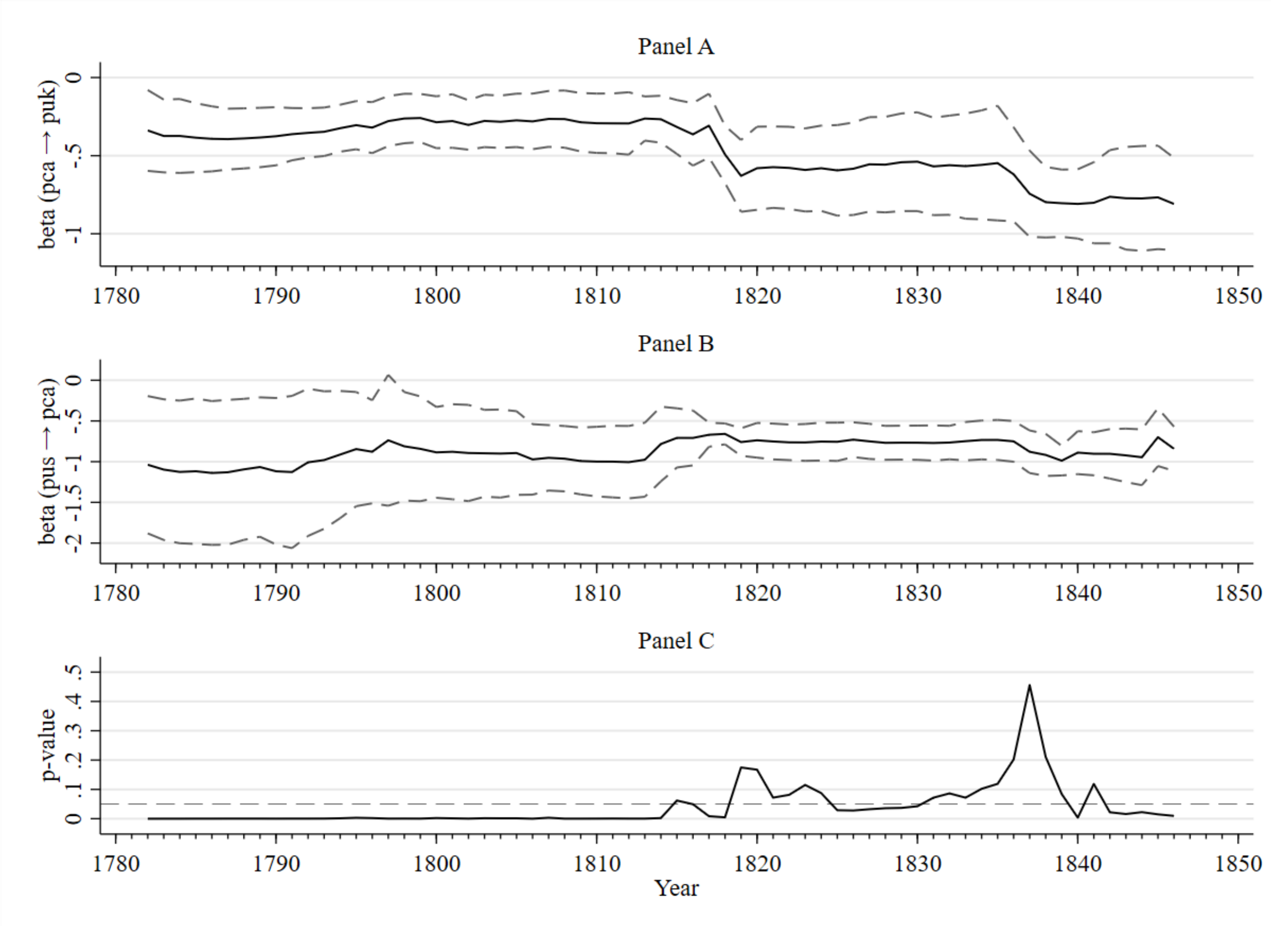

Figure C4: Backward recursively estimated coefficients and p-values for the period 1822-1857

Note: The end year is fixed at 1857 while the start year changes. Panel A illustrates the estimated beta coefficient between the Canada and UK from equation 4, Panel B illustrates the estimated beta coefficient between the US and Canada while in both, the dashed lines represent 2x standard errors. Panel C illustrates the p-value for acceptance of the imposed restrictions.

Appendix D Results including Central Ontario

The following shows the results of the CVAR analysis when including price data for Central Ontario in the Canadian average price. Observations for Central Ontario start only in 1787, so the results for the first period (1760-1783) are not affected by the inclusion of the additional observations. Figures 1D and 2D illustrate a comparison between the estimated alpha and beta coefficients from equations 3-4 and D2-D3. It can be seen that there are no statistically significant differences.

Estimated equation for the period 1760-1783

$$\begin{bmatrix} \Delta p_{uk_t} \\ \Delta p_{us_t} \\ \Delta p_{ca_t} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \mathbf{-0.5093} \end{bmatrix} [\{p_{ca} - 0.5108 p_{us} - \mathbf{0.0406}\}_{t-1}] + \cdots \qquad \text{(D1)}$$

$Chi^2(3) = 0.7849$ [0.8531]

Estimated equation for the period 1783-1822

$$\begin{bmatrix} \Delta p_{uk_t} \\ \Delta p_{us_t} \\ \Delta p_{ca_t} \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ \mathbf{-0.5059} & 0 \\ 0 & \mathbf{-0.2887} \end{bmatrix} \begin{bmatrix} \{p_{us} - \mathbf{0.4636} p_{uk}\}_{t-1} \\ \{p_{ca} - \mathbf{1.525} p_{uk}\}_{t-1} \end{bmatrix} + \cdots \qquad \text{(D2)}$$

$Chi^2(6) = 6.7040$ [0.3491]

Estimated equation for the period 1822-1857

$$\begin{bmatrix} \Delta p_{uk_t} \\ \Delta p_{us_t} \\ \Delta p_{ca_t} \end{bmatrix} = \begin{bmatrix} \mathbf{-0.7097} & 0 \\ 0 & 0 \\ 0 & \mathbf{-0.9417} \end{bmatrix} \begin{bmatrix} \{p_{uk} - \mathbf{0.5045} p_{ca} + \mathbf{0.0060} t\}_{t-1} \\ \{p_{ca} - \mathbf{0.8436} p_{us} + \mathbf{0.0023} t\}_{t-1} \end{bmatrix} + \cdots \qquad \text{(D3)}$$

$Chi^2(4) = 6.9233$ [0.1400]

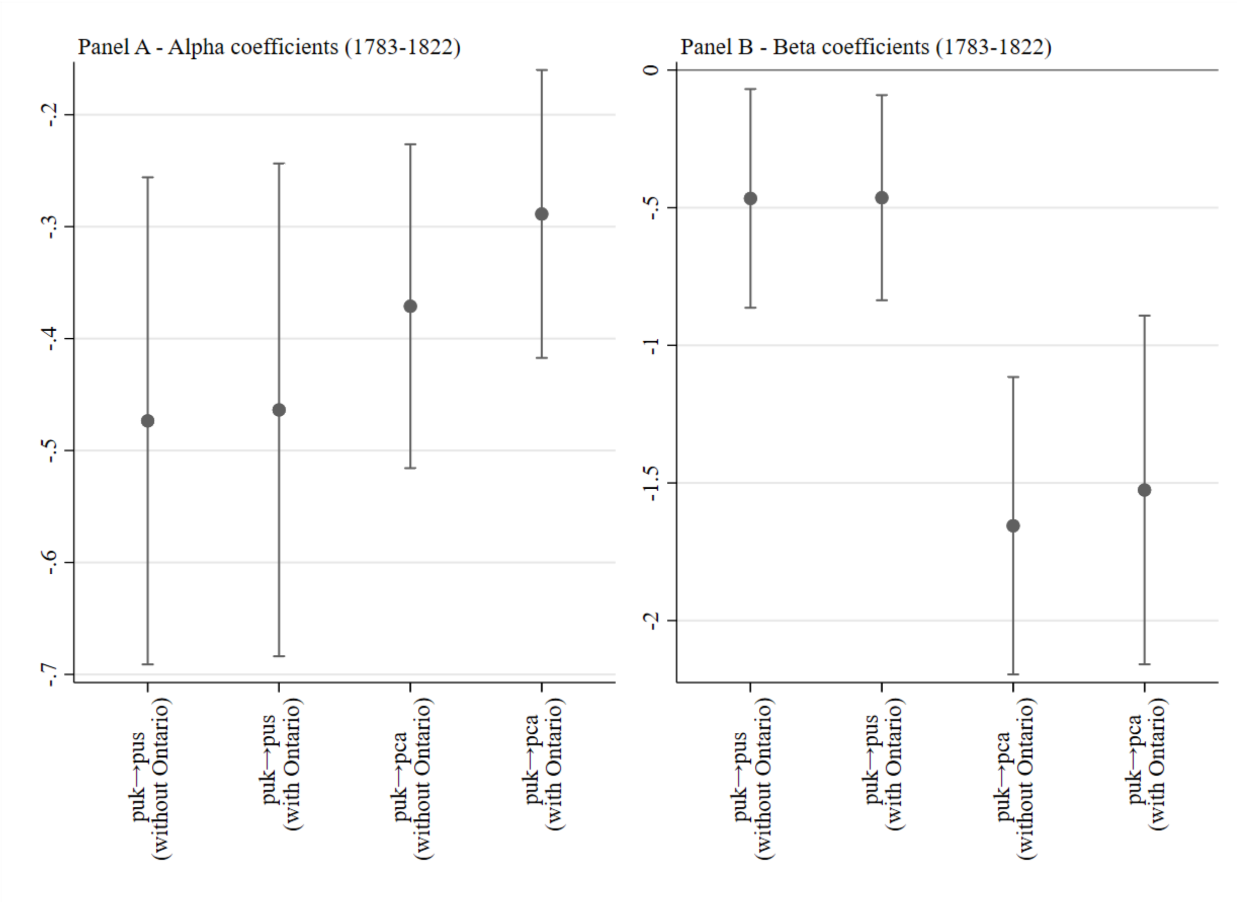

Figure D1: Comparison of point estimates with and without Central Ontario included in price data (1783-1822)

Note: Panel A illustrates the estimated alpha coefficients from equations 3 (without Ontario) and D2 (with Ontario) and Panel B illustrates the estimated beta coefficients from equations 3 (without Ontario) and D2 (with Ontario). Reported confidence intervals are at the 5% level.

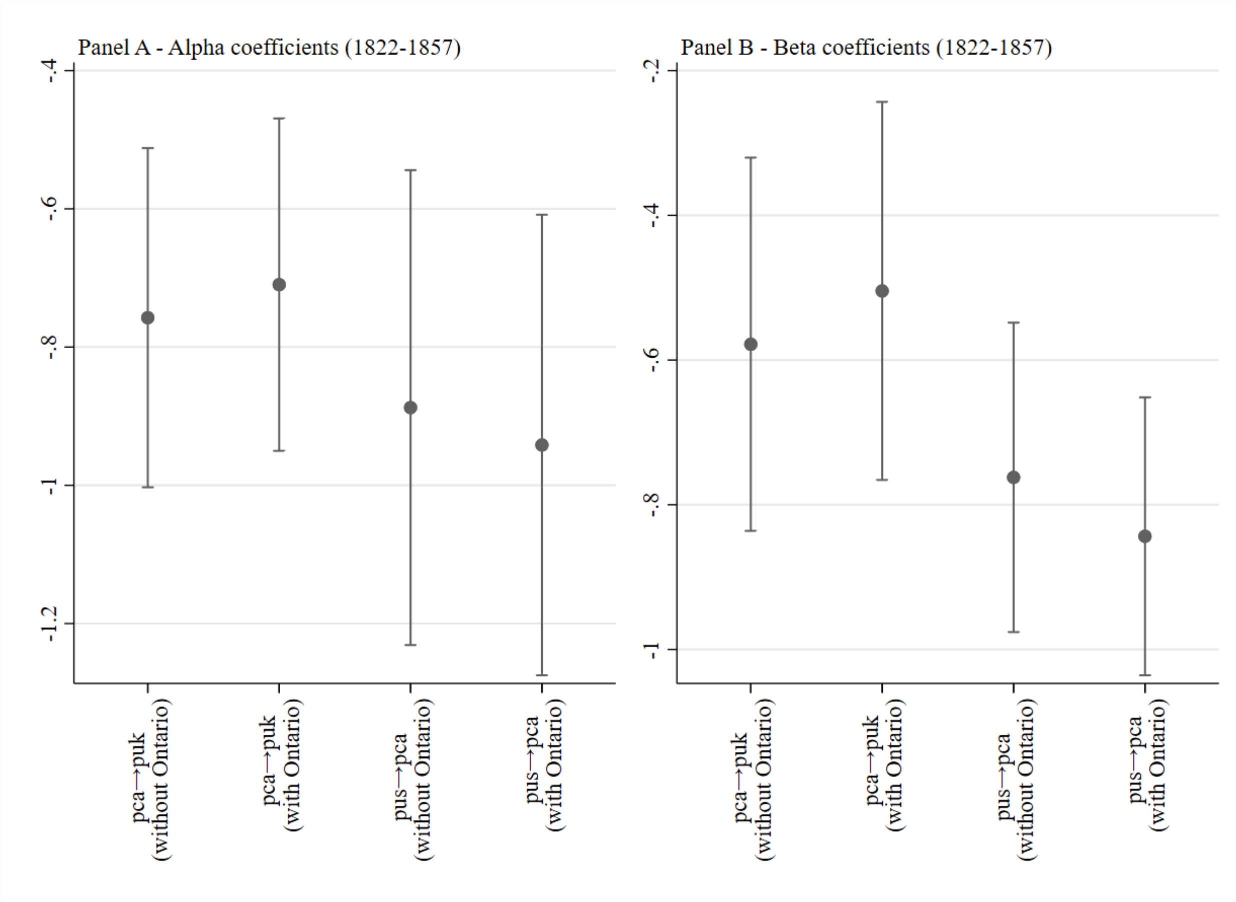

Figure D2: Comparison of point estimates with and without Central Ontario included in price data (1822-1857)

Note: Panel A illustrates the estimated alpha coefficients from equations 4 (without Ontario) and D3 (with Ontario) and Panel B illustrates the estimated beta coefficients from equations 4 (without Ontario) and D3 (with Ontario). Reported confidence intervals are at the 5% level.