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Malthusian pressures: Empirical evidence from a frontier economy

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von

Vincent Geloso und Vadim Kufenko

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Malthusian pressures: empirical evidence from a frontier economy

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Abstract

In this paper we study Malthusian pressures in a frontier economy. Using the empirical data on the real prices and demographic variables from 1688 to 1860 for Quebec and Montreal, we test for the existence of Malthusian pressures. Bearing in mind the particularities of frontier economies and the development of the Canadian economy, we conduct cointegration tests and VARs in order to identify positive and preventive checks. The cointegration test reveals absence of long-run equilibrium relationship between real wheat prices, birth and death rates. Using the Bai-Perron test we find a structural break in 1767 and divide the sample in pre- and post-conquest periods. We find that the positive checks were operating in the years prior to the conquest but that they faded during the nineteenth century. In the short-run, we find that wheat prices Granger-cause fluctuations in death rates in the pre-conquest period.

Keywords: Malthusian economy, preventive check, positive check, Canadian history, empirical analysis

JEL classification: J11, N11, E32

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1 Introduction

For most of human history, wages are fluctuated at the edge of the subsistence level, sometimes slightly above and sometimes slightly below it. Although technological innovations were not absent, most movements in living standards were determined by changes in population sizes. This reality has been labelled "Malthusian" in honour of Thomas Malthus. The key features of this model are that the supply of land is fixed and that this supply is small relative to the population. This applied very well to countries in Europe where these conditions were met, but what about New World economies from the 17th to 19th centuries which had only been recently settled.

Quebec, the modern day french-speaking province of Canada, is a good candidate to answer that question. Known as New France from 1608 to 1760 before it was taken from the French crown by the British and then known interchangeably as Quebec, Lower Canada and Canada East up to 1867, historians of this society have often portrayed it as a society rife with Malthusian pressures. The eminent Fernand Ouellet (1966) asserted that the colony lived through an "economic crisis" from 1802 to 1850 mainly because of soil erosion and overpopulation of the colony. According to Ouellet, grain price fluctuations were symptomatic of the underlying performance of the agricultural economy whose surplus fed into the other sectors of the economy.

This view is still commonly portrayed by popular historians (Bédard, 2012). This a surprising argument given that numerous authors have found that the land supply was still very large at the time specified by Ouellet (see Altman, 1983; McInnis, 1982). Moreover, the data from mortality rates and crude birth rates do not fit the Malthusian framework. The steepest increase in the mortality rate (indicative of the positive check) are found in the period of French rule when the land supply since less than 10% of the attributed estates of the colony were cleared for agricultural production in 1739. In the 1831 census, this proportion stood at 34%. But even by the mid 19th century, that claim is dubious since the 1851 census reveals that only 44% of the total lands owned were improved.

The literature on Malthusian pressures in Canada and United States is constrained by the absence of continuous data series . We try to fill in the gap. Thanks to the existence of numerous economics paper that detail operational procedures to test the existence of Malthusian pressures in economic history, filling this gap is made easier.

It is possible that this lack of testing for Lower Canada and Quebec was the result of limited statistics with regards to economic indicators. Recent work by one of the current authors Geloso (2014a,b) has generated large databases of prices in the colony from 1688 to 1858. Combined with the exhaustive data already available with regards to vital statistics (crude mortality rate, crude birth rate, nuptiality rate), it is possible to run statistical tests. We find that Malthusian pressures in the Quebec economy post-conquest were non existent - at a time when the land supply was growing scarcer. In fact, we find evidence of Malthusian pressures in the pre-conquest - at a time when land was more easily available.

2 The Malthusian Economy

Under Malthusian theory, real wages are not determined by the marginal product of labor but rather by the population sizes relative to the pool of available resources in a technologically stagnant environment (see Wrigley and Schofield, 1981). Under the constraint of slow technological improvements, the first equation of the Malthusian model sets wages as a function of population. However, in the short-run population is endogenous to real wages. Births (the rate of population increase) are respondent to wages. Deaths, are also respondent to wages. When real wages increase (decrease), births increase (decrease) while deaths decrease (increase). In the long-run, the equilibrium rate of population is equal to zero. In the short run, an increase in real wages (reflected by a one-time technological shock) which increases productivity brings demographic behaviour out of equilibrium and population increases. However, the marginal product of labor will decline as more individuals compete for a fixed stock of capital - leading to lower real wages (mostly through higher prices). Two forces will act to restore equilibrium : preventive check and positive check. The preventive check refers to households delaying family formation. This may be expressed through later marriage ages, planned sexual activities, contraception, longer stays in a parent's household, greater distancing between childbirths. The positive refers to the impact of mortality increasing to force the population back to equilibrium level (Guinnane and Ogilvie, 2008).

It is these two checks that have been the topic of discussion amongst economic historians. More precisely, the discussion has centered on when the two checks disappeared. In England, Nicolini (2007) and Craft and Mills (2009) have argued that the two checks disappeared somewhere between the 16th and 18th century with the positive check disappearing earlier than the preventive check. However, in 18th century Germany, Fertig and Pfister (2012) found that the positive check was stronger and weakened slightly past 1815 and that the preventive check was equally strong throughout the period. According to these two authors, the weakening of the positive check was caused by greater market integration. Most of the research has concentrated on economies that were already densely populated.

3 Malthusian framework in the New World and Quebec

However, this theoretical framework works differently if there are large quantities of unused inputs. The concept behind Malthusian equilibrium is that inputs are being used more intensively for diminishing marginal returns. However, if there are unused resources to be cheaply introduced into the production, an increase in population will not have these effects. In fact, in the short run, the larger population would increase prospects for specialization and would increase output very rapidly relative to inputs. One example of this is provided by Alvarez-Nogal and Escosura (2013) in the case of Spain after the Black Death. Since Spain was at that time a frontier economy with more abundant land, the Black Death did not reduce pressures on scarce land resources, it merely eradicated commercial networks, isolated scarce populations and led to a decline in specialization. This Spanish case shares

similarities with North America prior to the first half of the 19th century. These were economies where land was a cheap input that could easily be introduced into production and an increase in population would not lead to falling real wages. Quebec qualifies as such an economy in our opinion. Yet numerous are the authors who would disagree (Ouellet, 1972, 1980; Russell, 2012; Greer, 1985). These authors have tended to explain the poor economic performance of Quebec up to the 1850s in great part upon Malthusian pressure. Ouellet has made this claim in a different manner pointing out that overpopulation was caused by a "shortage of fertile, easily accessible land" (see Ouellet, 1980, p. 144). Ouellet argued that this shortage was localized in some long-settled areas and individuals resettled in other parishes and townships in the colony (Ibid: 156). These new parishes would have been on marginally less productive lands. Along these lines, and although he never uses the term, Ouellet is arguing for the existence of a preventive check. According to this framework, the pressures materialized thanks to inputs that were costly to introduce into production and whose productivity was marginally lower than previously settled lands. Haines (2000, pp. 168-169) defended his claim that there existed evidence of a preventive check in New England in the form of high costs of household formation. More broadly, the claim of economic distress in Quebec is attributed to the rapid increase in the rural population whose effects were amplified by exogenous shocks like the Hessian Fly and the Wheat Midge as well as a supposed innate conservatism amongst the French-Canadians that made them less efficient than English-Canadian households Le Goff (1974).

Paquet and Wallot (2007) countered this line of argument by denying that the economy was performing poorly. In doing so, they negated the existence of any significant pressures along the lines proposed by Malthus. They pointed out that the economy of Lower Canada was diversifying into products like timber, potash and pearl ash. Bédard and Geloso (2014) have advanced evidence supporting this view that economic growth was positive in the first half of the 19th century. McInnis (1982) also feeds such a line of argument by pointing out colonists in Quebec exported timber to England, imported wheat from Upper Canada which places the performance of the agricultural economy (whose decline is central to the claim of Malthusian pressure) in a more positive light. Serge Courville also noted a distinct trend in favour of diversification in the form of larger urban centers (1990, 1995, 2008). Increased urbanization is contradictory to the Malthusian model as Becker and Murphy (1999) pointed out. Greater population density promotes specialization and greater investment in human capital. These "increasing returns from specialization would raise *per capita* incomes as population grew and are likely to be far more important than diminishing returns in resource-constrained sectors" (see Becker and Murphy, 1999, p. 146). However, this is a question of degree. It is possible, under the Malthusian model, for both population and economic growth to be positive if there are improvements in productivity and technological settings. Hence, observing positive growth as Paquet and Wallot do, does not invalidate the existence of Malthusian pressures. Haines (2000) makes the claim that the United States did manage to generate fast economic growth on a *per capita* basis in the Antebellum era while there was a preventive check operating. All of the facts highlighted above suggests that the literature is in an impasse which could only be settled through empirical testing.

4 Data

Wheat prices were selected because of their importance in the diets of the French Canadians. According to Fyson (1992, p. 74), 56% of the diets of workers in Lower Canada came from starches. But this is a conservative estimate since Vallieres and Desloges (2008) put this proportion above 60% in urban areas during the New France area and close to 70% in rural areas during the same era. Given this great importance of wheat, it should be seen as a good measure of the variation in the standard of living. "From one year to the next, fluctuations in the price of grain were the primary determinants of variations in the real wage" (Galloway, 1988, p. 276) since nominal wages were relatively stable (which is the case as can be seen in Geloso 2014b for New France) from year to year. The prices collected for wheat stem in part from Geloso (2014) for the pre-conquest era and from Ouellet et al. (1982) for the post-conquest era. Both these price series should be seen as wholesale prices collected from the account books of religious congregations. Market exchanges were thus always an open option the *habitant* farmer. Even if he chose not to trade his labor on the market, he could always do so at the prevailing price. Most peasants in Quebec produced for themselves, but they always tried to sell part of their crop to the fifth of the population in urban areas in exchange for money that would allow them to acquire imported goods like cloth, sugar, pepper and salt. For the Montreal area prior to the conquest, we have used the price series produced by Dechene (1994) which is also illustrative of wholesale prices. Prices were deflated over the broad price index produced by Geloso (2014a) which was combination of his own price index for the pre-conquest era with that of Paquet and Wallot (2007).

The vital statistics we have used have been drawn from multiple sources. The raw numbers of births and deaths have been drawn from the work of George Langlois Langlois (1935) and concerns only the Catholic population. In order to provide births and deaths relative to population, we have relied on the Catholic population estimates from Henripin and Péron Henripin and Péron (2000). We do not believe that the focus on the Catholic population is problematic. The Catholic population of Quebec was predominantly French while the non-Catholic population tended to be English-speaking. According to the 1851 census of Canada East (as Quebec was then known), the mortality rate observed in predominantly English-settled areas were equal to those of French-settled areas Public Arcives of Canada (1873). Moreover, the focus on Catholic is warranted in order to solve the impasse discussed above. The tenants of the position that there were population pressures have largely focused on the Catholic population which was believed to be poorer than the Protestant population. Since poorer populations tend to be more susceptible to suffer from Malthusian pressures (through poorer nutrition, poor diets and a lesser ability to withstand shocks), the focus on the Catholic population is warranted. Normally, we would have opted for the inclusion of a variable for infant mortality. If there was a positive check with regards to the population through higher mortality, it would have been felt more strongly for younger individuals whose immune systems were not fully developed - namely children. The problem is that the dataset we use does not differentiate mortality on the basis of age, it is merely the crude mortality rate. However, there is a mortality quotient

provided by Gentil (2009). In her work, Marilyn Gentil estimates infant mortality in Quebec up to 1779 and even has regional breakdowns (Quebec city, Montreal, Trois-Rivières and rural areas). While it is tempting to evaluate how to use her estimates to refine our estimates, her data is not suited for any such attempts. Her mortality quotients do not cover the full population and concentrates on a segment of the population that did not suffer from high mortality rates relative to other groups - namely the illegitimate births. Gentil's data is concentrated on the mortality of legitimate children whose mortality rate was considerably below that of illegitimate children. Hence, using this data could lead to some bias. However, papers like those of Nicolini (2007) and Craft and Mills (2009) have relied on the broader crude mortality and crude birth rates with sufficiently robust results.

Wars and climate in this economy would have been very problematic and could potentially disrupt any statistical attempt if no control is attempted. Consequently, we have included a war dummy variable throughout the sample which we combined with the climate dataset provided by Mann and Hughes (1998). The war dummy is pretty straightforward and includes also the rebellions of 1837-38 in Lower Canada as well as the international wars the colony was brought into from 1688 to 1860. The climate variable is expressed in deviation from the average temperature observed between 1961-1990. Although other climate datasets exist (McIntyre and McKittrick, 2003), we have opted for the more often cited dataset by Mann and Hughes (1998).

5 Empirical strategy, methods and results

We begin with testing the key variables, real wheat prices, birth and death rates on stationarity. We apply the Augmented Dickey-Fuller test with Generalized Least Squares (further ADF GLS) estimation as in Elliott et al. (1996) which performs better in small samples comparing to the original version of the test using the Order of the Least Squares (OLS) estimation. The optimal lag length of the test is selected according to the Akaike Information Criteria (further AIC) as in Akaike (1974)¹. Thus, we report the test statistics at the optimal lag² in Table 1. As it follows from the test, all of the levels of the three key variables are not stationary. This test result implies, that prices and population in Canada during 1688-1860 were unstable. Strategically this means that we can tests the data on cointegration.

¹In order to preserve methodological consistency we will apply the AIC lag selection method for further estimations in the paper. We double check the lag length with the Wald lag-exclusion test.

²In the ADF GLS test for wheat prices the AIC determined optimal lag is 8; for birth rates it is 2 and for death rates the optimal lag length is 10.

Figure 1: Original data



Table 1: Augmented Dickey-Fuller test, GLS version

Variables	Test statistic	Critical value (5%)
Wheat price	-2.258	-2.874
Birth rate	-1.271	-2.943
Death rate	-2.121	-2.846

In order to verify the existence of a long-run equilibrium between real wheat prices, birth and death rates, we have decided to apply a cointegration test. We have given preference to the Johansen cointegration (Johansen, 1988; Hamilton, 1994, see Chpt. 14) test due to its multivariate framework and a good performance on finite samples, as stated in Dhrymes and Dimitrios (1997). The optimal number of lags³ is determined by the AIC, as in the ADF GLS test. As we observe from Table 2, the trace statistic exceeds the critical value dramatically and therefore we reject the null hypothesis of a cointegrated system of prices, birth and death rates. The implication of these results is the absence of a long-run equilibrium relationship between the key variables.

Even though, that the long-run equilibrium between prices, birth and death rates was not confirmed by the cointegration test, we need to investigate the interaction between the short-run fluctuations. The time frames of our analysis are 1688-1860. As we have noted before, during this period a number of historical events took place and the economy of Canada and its structure have changed dramatically. Therefore, we would like to test our data on structural breaks with the

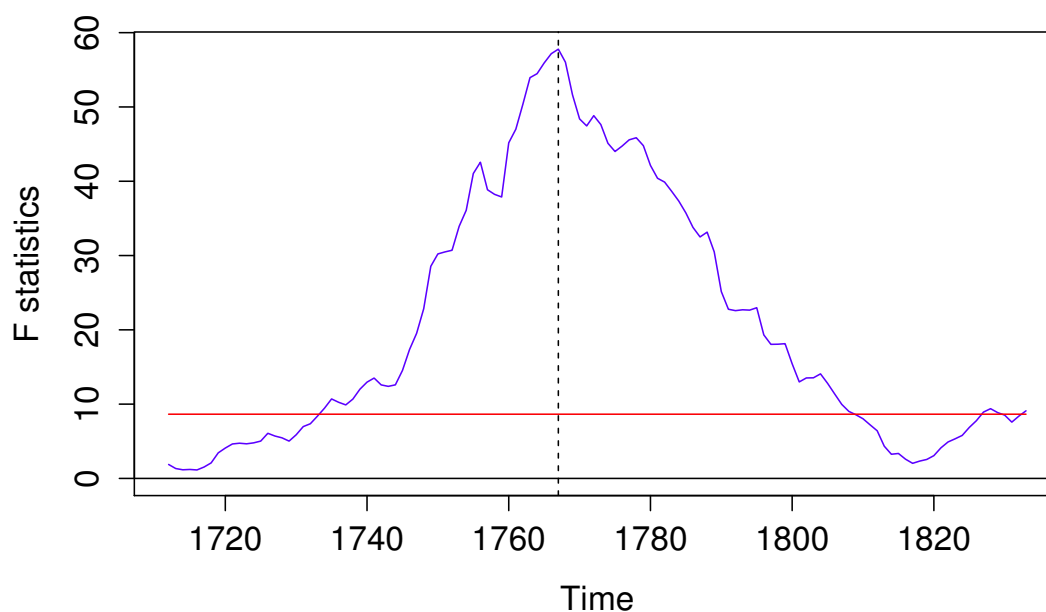
³In the Johansen cointegration the AIC determined optimal lag length is 2.

Table 2: Johansen Cointegration test

Rank	Trace statistics (2nd Rank)	Critical value (5%)
0	107.5706	29.68
1	46.8626	15.41
2	12.5723	3.76

help of the Bai and Perron (2003) test. The results of the structural break test considering wheat prices are depicted on Figure 2⁴. The F statistics suggests that the break-point occurred in 1767, which is roughly seven years after the British conquest. This allows us to divide the sample into two periods for the short-run analysis according to historical events: we treat the data according to two periods, the pre-conquest or 1688-1767 and the post-conquest or 1768-1860.

Figure 2: Bai-Perron structural break test



First of all, let us examine the descriptive statistics of our key variables: real wheat prices, birth and death rates. According to the results from Table 1, we required a transformation to achieve stationarity. In order to perform detrending and obtain cyclical fluctuations we apply filtering with the Hodrick-Prescott filter (further HP) to remove the trend and achieve stationarity. Below is the minimization problem of the HP filter. For demonstration we choose 6.25 for λ as in Ravn and Uhlig (2002, p. 374). The HP filter penalizes the series up to the second order

⁴The Bai-Perron test applied to birth and death rates yields different results: at the end and beginning of our time frames, which would not allow us to divide the time-series into sub-samples.

and all of our series are $I(1)$, which should not cause any distortions.

$$\min_{\tau} = \left(\sum_{t=1}^T (y_t - \tau_t)^2 + \lambda \sum_{t=1}^T [(\tau_t - \tau_{t-1}) - (\tau_{t-1} - \tau_{t-2})]^2 \right) \quad (1)$$

We obtain detrended data which represent cyclical fluctuations in prices, birth and death rates. Further we use the detrended cyclical data for the descriptive statistics and for the time-series Granger-causality analysis. let us first examine the descriptive statistics of the filtered cycles.

Table 3: Descriptive statistics for I (1688-1767) and II (1768-1860)

Variable	Obs.		Std. Dev.	
	I	II	I	II
Wheat prices (cycles)	80	91	0.15688	0.12515
Birth rate (cycles)	80	93	0.0524	0.01963
Death rate (cycles)	80	93	0.2147	0.12566

Let us consider descriptive statistics from Table 3 for the main variables of interest. It appears that in the second period prices, birth and death rates have become less volatile: the standard deviation of prices decreased by 20.3%, of birth rates - by 62.5% and of death rates - by 41.5%. We observe narrower cyclical price fluctuations which implies a decrease in volatility of all variables. Indeed, the period after 1767 appears to be less volatile in terms of demographics; however, one has to question whether this was a smooth change or a discontinuous change.

Figure 3 depicts rolling standard deviation of birth and death rates. From Figure 2 we can tell that there was a structural break in wheat prices after 1767; however, the demographic variables did not display such obvious structural breaks and therefore we depict rolling standard deviations⁵ of the related series on Figure 3. There are two important points to highlight: firstly, the standard deviation of birth and death rates gradually decrease after 1740-1760, exhibiting occasional humps. Secondly, the decrease in demographic volatility was gradual; however, we should note that most of this decrease took place in period II (1768-1860). The latter fact is confirmed by the descriptive statistics from Table 3.

⁵In order to obtain smooth results we use a window of 20 observations and set the smallest step of 1.

Figure 3: Rolling standard deviation of cyclical fluctuations



Descriptive methods allowed us to capture changes in the fundamental time-series characteristics: decreasing volatility. Decrease of volatility of real wheat prices, birth and death rates in period II of our analysis requires a thorough investigation of the causal interaction between these variables. In order to perform such an analysis, we have selected the well established VAR framework, as in Hamilton (1994, Chpt. 11) and the Granger-causality test, as in Granger (1969). The cyclical fluctuations, obtained with the help of the HP filter, are stationary and can be used for the VAR analysis and Granger-causality testing with the help of the following model⁶:

$$\begin{pmatrix} y_{1,t} \\ y_{2,t} \\ y_{3,t} \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} + \begin{pmatrix} \pi_{11}^1 \pi_{12}^1 \pi_{13}^1 \\ \pi_{21}^1 \pi_{22}^1 \pi_{23}^1 \\ \pi_{31}^1 \pi_{32}^1 \pi_{33}^1 \end{pmatrix} + \begin{pmatrix} y_{1,t-1} \\ y_{2,t-1} \\ y_{3,t-1} \end{pmatrix} + \begin{pmatrix} e_{1,t-1} \\ e_{2,t-1} \\ e_{3,t-1} \end{pmatrix} \quad (2)$$

Where $y_{1,t-1}$ denotes cyclical fluctuations in the real wheat prices; $y_{2,t-1}$ denotes cyclical fluctuations in birth rates; $y_{3,t-1}$ denotes cyclical fluctuations in death rates; c denotes a constant, whereas π denotes coefficients; e is an error. In addition, we include exogenous controls into the model: dummies for war periods and temperature change.

Let us investigate the results in Table 4 for period I (1688 to 1767). Using temperature change and war dummies for periods of war clashes as exogenous

⁶For the simplicity a one-lag model is described. The number of lags to be included is determined by the AIC and the Wald lag-exclusion test. We have tested specifications up to the 10th lag and the Wald lag-exclusion test showed no substantial benefits from including lags further than 6. The latter specification with 6 lags outperformed specifications with fewer lags according to the Likelihood Ratio test and the AIC. Therefore, the optimal specification used for our estimations includes 6 lags.

controls, we have obtained the following result: the first lag of the change of the real wheat prices has a positive impact on the death rates with 0.286%. This effect of a positive check is significant on 5% level. Naturally, this is confirmed by the Granger-causality test in Table 6 for specifications 1, 2 and 3. From the test it follows, that cyclical fluctuations of the real wheat prices Granger-cause cyclical fluctuations in death rates. For period I this effect is valid on the 5% level. The second effect is related to lagged birth rates Granger-causing death rates. This effect is also positive and significant on 5% level. We associate this effect with infant mortality and note that in period II it vanishes. The preventive check was not discovered.

Period II results from Table 5 seem to be different: the lags of the cyclical fluctuations of the wheat prices is insignificant for the death rates. The causal effect vanishes which is confirmed by the Granger-causality test in Table 7. The results suggest no preventive or positive check in period II. However, we note significant impact of wars and temperature change, as exogenous controls, on the birth rates (see Table 5). Therefore, we can conclude that the causal effect of real wheat prices on demographic variables vanishes in period II, after 1767. This is consistent with the decreases in demographic volatility after 1740-1760, depicted on Graph 3.

Table 4: Pre-conquest period, 1688-1767

VARIABLES	(1) Wheat rice	(2) Birth rate	(3) Death rate
Wheat price, lag 1	-0.384*** (0.102)	0.00686 (0.0375)	0.286** (0.120)
Wheat price, lag 2	-0.599*** (0.104)	-0.0279 (0.0383)	-0.229* (0.123)
Wheat price, lag 3	-0.769*** (0.114)	1.58e-06 (0.0418)	0.225* (0.134)
Wheat price, lag 4	-0.549*** (0.107)	-0.00441 (0.0394)	0.0606 (0.127)
Wheat price, lag 5	-0.417*** (0.104)	0.0101 (0.0381)	-0.192 (0.122)
Wheat price, lag 6	-0.462*** (0.107)	-0.00777 (0.0392)	0.186 (0.126)
Birth rate, lag 1	0.149 (0.353)	-0.752*** (0.130)	1.777*** (0.416)
Birth rate, lag 2	0.312 (0.426)	-0.422*** (0.157)	0.586 (0.503)
Birth rate, lag 3	0.0547 (0.415)	-0.533*** (0.153)	1.656*** (0.489)
Birth rate, lag 4	-0.152 (0.419)	-0.600*** (0.154)	1.750*** (0.494)
Birth rate, lag 5	-0.0406 (0.461)	-0.453** (0.170)	1.064* (0.544)
Birth rate, lag 6	-0.286 (0.370)	-0.192 (0.136)	-0.0197 (0.437)
Death rate, lag 1	0.0164 (0.0988)	0.0376 (0.0363)	-0.131 (0.117)
Death rate, lag 2	0.208** (0.101)	0.0116 (0.0370)	-1.029*** (0.119)
Death rate, lag 3	0.0621 (0.115)	-0.0114 (0.0421)	-0.0952 (0.135)
Death rate, lag 4	0.115 (0.119)	-0.0612 (0.0437)	-0.543*** (0.140)
Death rate, lag 5	0.0688 (0.0913)	-0.00982 (0.0336)	0.00159 (0.108)
Death rate, lag 6	-0.00574 (0.0888)	-0.0209 (0.0326)	-0.273** (0.105)
diff_temp_mann	2.861** (1.304)	-0.0257 (0.479)	-2.423 (1.538)
war	0.0427 (0.0265)	-0.00378 (0.00976)	-0.0345 (0.0313)
Constant	-0.0318* (0.0175)	0.00134 (0.00644)	0.0235 (0.0207)
Observations	74	74	74

Standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Table 5: Post-conquest period, 1768-1860

VARIABLES	(4) Wheat price	(5) Birth rate	(6) Death rate
Wheat price, lag 1	-0.129 (0.116)	-0.0450** (0.0204)	0.0593 (0.122)
Wheat price, lag 2	-0.732*** (0.114)	0.0267 (0.0201)	-0.114 (0.120)
Wheat price, lag 3	-0.516*** (0.132)	-0.0259 (0.0231)	0.129 (0.138)
Wheat price, lag 4	-0.469*** (0.133)	-0.00427 (0.0234)	0.0970 (0.139)
Wheat price, lag 5	-0.182 (0.119)	0.000289 (0.0208)	-0.0585 (0.124)
Wheat price, lag 6	-0.156 (0.118)	-0.00526 (0.0206)	0.143 (0.123)
Birth rate, lag 1	0.857 (0.603)	-0.406*** (0.106)	0.879 (0.630)
Birth rate, lag 2	-0.407 (0.591)	-0.339*** (0.103)	0.759 (0.617)
Birth rate, lag 3	-0.573 (0.603)	-0.286*** (0.106)	0.597 (0.629)
Birth rate, lag 4	-0.183 (0.572)	-0.223** (0.100)	0.475 (0.597)
Birth rate, lag 5	0.709 (0.552)	-0.270*** (0.0967)	-0.0312 (0.576)
Birth rate, lag 6	-0.242 (0.551)	-0.139 (0.0965)	1.757*** (0.575)
Death rate, lag 1	0.0374 (0.0941)	0.0244 (0.0165)	-0.538*** (0.0983)
Death rate, lag 2	-0.121 (0.101)	0.00809 (0.0177)	-0.586*** (0.106)
Death rate, lag 3	0.0276 (0.105)	0.0160 (0.0184)	-0.714*** (0.110)
Death rate, lag 4	-0.0740 (0.105)	0.0196 (0.0183)	-0.577*** (0.109)
Death rate, lag 5	0.0179 (0.0999)	0.00552 (0.0175)	-0.430*** (0.104)
Death rate, lag 6	0.0877 (0.0936)	-0.00683 (0.0164)	-0.169* (0.0977)
diff_temp_mann	-0.708 (0.997)	0.636*** (0.175)	-0.893 (1.041)
war	-0.0199 (0.0206)	0.00723** (0.00361)	0.00221 (0.0215)
Constant	0.00785 (0.0124)	-0.00209 (0.00217)	-0.00304 (0.0130)
Observations	88	88	88

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Granger causality test for 1, 2 and 3

Equation	Excluded	P > chi2
Wheat price	Birth rate	0.8710
Wheat price	Death rate	0.4300
Birth rate	Wheat price	0.9811
Birth rate	Death rate	0.1999
Death rate	Wheat price	0.0107
Death rate	Birth rate	0.0000

Table 7: Granger causality test for 4, 5 and 6

Equation	Excluded	P > chi2
Wheat price	Birth rate	0.2881
Wheat price	Death rate	0.4233
Birth rate	Wheat price	0.2358
Birth rate	Death rate	0.6513
Death rate	Wheat price	0.5717
Death rate	Birth rate	0.1037

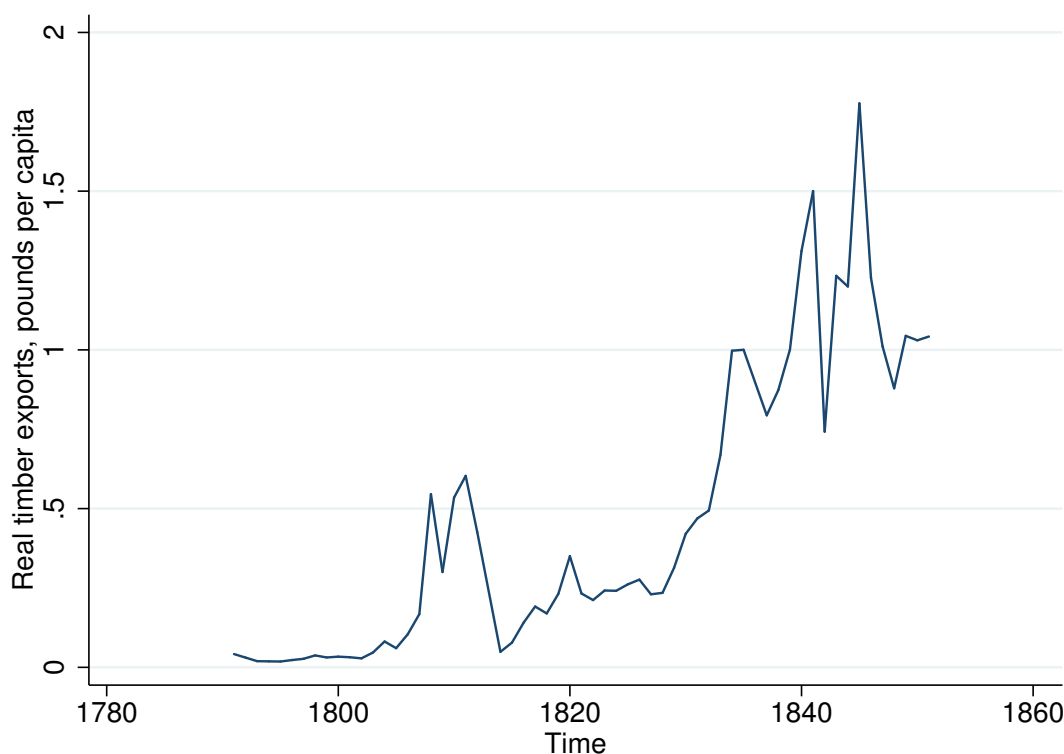
6 Discussion and conclusion

Our cointegration tests reveal the absence of any long-run equilibrium relationship between real wheat prices, birth and death rates. Furthermore, we found that when it was under French rule, Quebec did seem to exhibit signs of population pressures in the form of the positive check. We found that fluctuations in wheat prices Granger-cause fluctuations in death rates in the pre-conquest period. However, after the conquest of Quebec by the British, the positive check disappeared. These are surprising results given that the literature which argues for population pressures locates them in the era of British rule.

We believe that our results can be explained through two possible channels: migration and market efficiency. Throughout our studied period, migration was mostly possible past the conquest. It is quite possible that French-Canadians mitigated demographic pressures through migration to the United States. Paquet and Smith (1983) provide evidence for such an argument, pointing out that there was a large migration flux of French-Canadians. Unfortunately, their data is not annualized and we only possess conjectural estimates that, on average, roughly 9000 French-Canadians left Lower Canada for other colonies between 1831 and 1851 (see Paquet and Smith, 1983, p. 440). However, their own analysis suggests that the bulk of the migration occurred in the 1830s - a decade of poor economic performance. Indeed, those years were marked by the wheat midge, epidemics and political rebellion. Yet, the 1840s exports and imports data (Vallieres and Desloges, 2008) suggest a recovery of economic activity which compensated for the unfortunate decade of the 1830s. Furthermore, the rate of population growth did

not seem to have decelerated considerably between population estimates. While the compound rate of population growth was 1.8 % between 1831 and 1844, it bounced back to 3.56 % between 1844 and 1851 and to 2.76 % between 1851 and 1861. Moreover, there was also a steady positive flow of British settlers to Canada and Quebec - which also went through a lull in the 1830s before picking up in the 1840s and 1850s (see McNinnis, 2000, p. 386). Anyhow, the reversal of population movements away from Canada is more relevant in the second half of the 19th century - a period beyond the focus of this paper (see McNinnis, 2000, p. 416). As a result, we are not convinced that emigration - although a relevant factor - was sufficient to distort the impact of Malthusian pressures in the latter period.

Figure 4: Timber exports

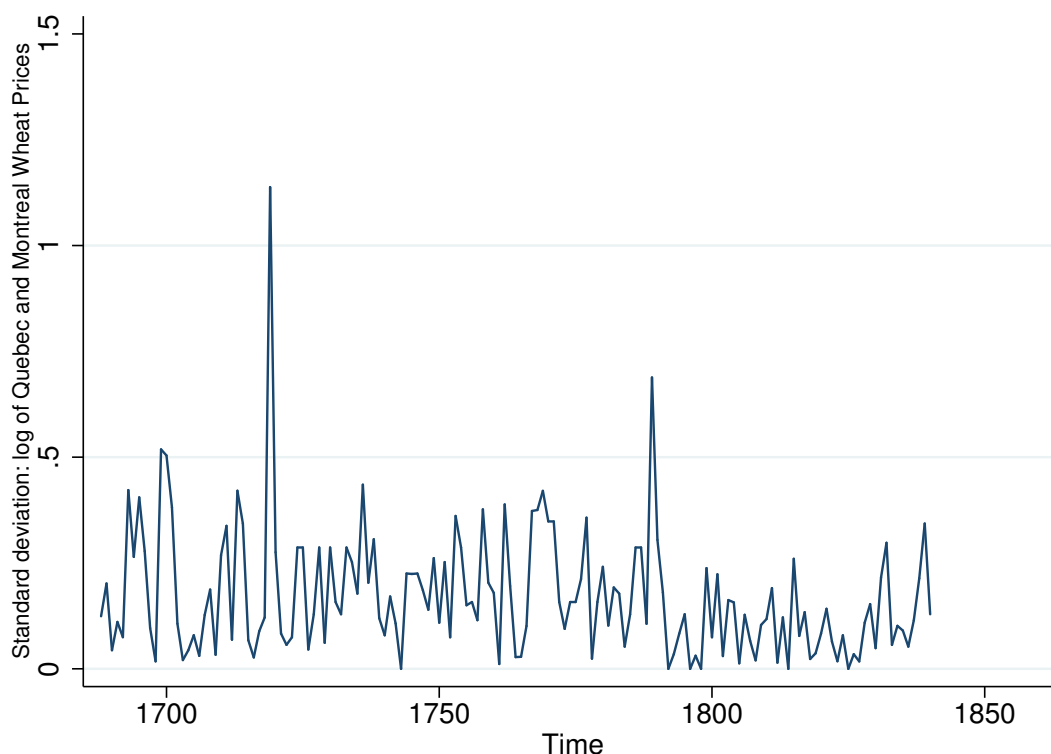


The other explanation that we find more convincing is that of institutions which made markets more efficient. At this point, the logic presented by Boserup (2005) can be useful. Instead of population growth slowing down to equilibrium level associated with the given technologies, population growth leads to the adoption of new methods of production. Cultivators have a wide set of production possibilities via different mixtures of capital and labour inputs. They choose the mixture that reflects best the relative scarcities of these inputs. As population increases, they shift to new techniques that prevent output from falling. According to Boserup, this implies a decline in productivity. However, her model is concerned only with a one sector economy (agriculture). If productivity increases in agriculture, households could decide to shift labor inputs to other non-agricultural sectors. Moreover, if productivity increased in other sectors, households could be tempted to sacrifice

on leisure and use the freed labour inputs on other markets. These latter two forms of development would still appear to us as close to the Malthusian ceiling of production and yet, there would still be an increase in living standards if they occurred. Such developments are well illustrated in the work of De Vries (2008) regarding the "industrious revolution". Reduction in transaction costs allowed the labor market to better coordinate employers and employees, leading to greater allocative efficiency and to greater incentives to intensification.

This logic of greater market efficiency explains the absence of the Malthusian checks after the conquest. First of all, the larger population of Quebec allowed for thicker markets to be formed which means more trade opportunities. As trade opportunities become more easily available, arbitrage opportunities also become exploitable. This implies that local supply shocks are eased thanks to the ability of merchants to ship grain around leading to some price equalization in the colony. In our case, the data supports the idea that markets grew increasingly integrated after the conquest and they begin to move closely together after 1790 as can be seen with the diminishing price gap between the different cities of the colony (see figures 5 and 6). This is a first channel by which increased population might not have led to the operation of either the preventive or the positive check. Secondly, households would have shifted inputs away from agriculture as they could now rely on providers outside their local markets (or even outside the household). In this case, they could work in other areas in order to acquire a monetized income and then complement this income with a small sized farm. Such a channel could have easily materialized through the emergence of the timber trade. Households in Quebec would have allocated inputs to the timber trade (or even the winter shipyards on the banks of the St-Lawrence river - (Dufour, 1981), sold the timber on British markets and bought wheat from the neighbouring colony of Upper Canada. Up to the early 19th century, furs had been the main exports of Quebec, but this trade occupied only a small share of the population. However, once the timber trade progressively replaced the fur trade, it occupied a much larger share of the population. Households would have shifted inputs away from agriculture to harvest wood which they could sell to merchants who would then resell it in England. Figure 4 illustrates the importance - on a per person basis - of the increase in the timber trade throughout the 19th century. This specialization would have allowed households to better tolerate higher wheat prices because income were substantially higher. This argument is strengthened by the fact that throughout the early 19th century, trade with the United States was also progressively liberalized. This is well exemplified by the 1831 Colonial Trade Act which allowed American grains and flour to enter freely into Canada - allowing Canadians to sell timber to Britain and buy wheat from the Americans.

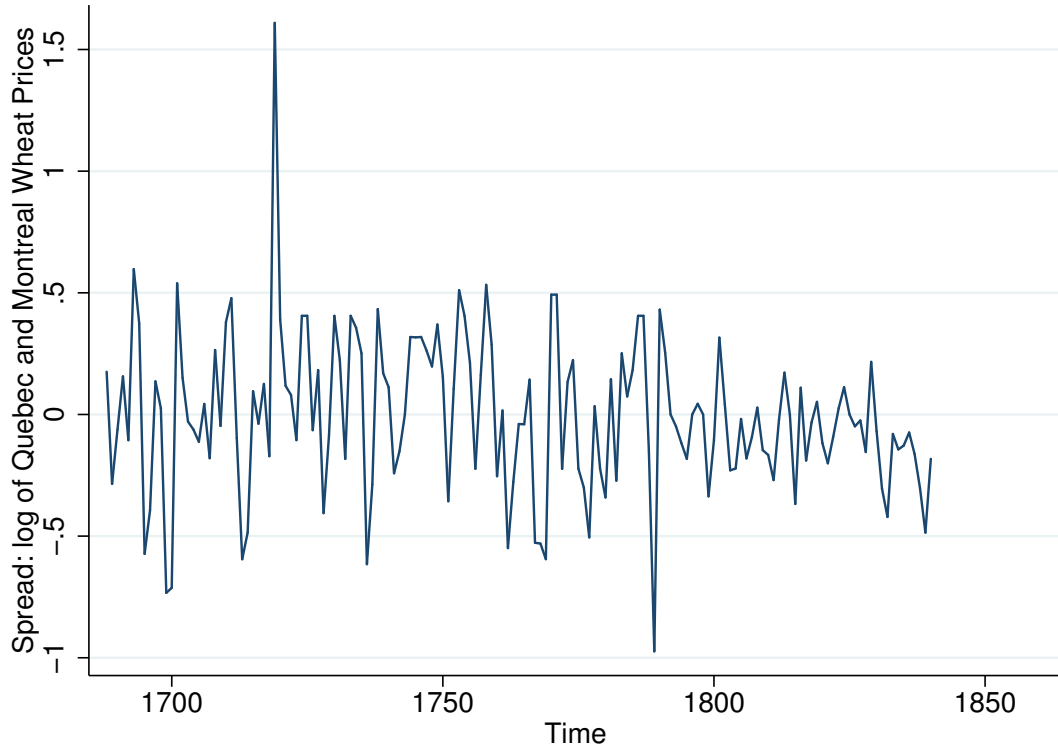
Figure 5: Decrease in price deviations between Quebec and Montreal



This greater level of market efficiency is well supported by many forms of secondary evidence. First of all, as Bédard and Geloso (2014) underlined, the rise of banking in Quebec which was allowed by the local legislatures allowed the emergence of a network of private bank notes which eased denominational shortages of small currency. Secondly, the British domination over the seas allowed for safer trade and hence allowed the timber trade to expand in the colony to previously unseen levels. Thirdly, trade policy with the United States and other areas was progressively eased allowing for trade to become relatively freer than it had been under French rule. Combined with greater populations within the colony (allowing trade networks to form), this would have also played in favor of increased specialization and hence in favor of the diminution of the preventive and positive checks. Finally, the British also allowed land settlement past 1791 to be outside the realms of seigniorial tenure - whereby the person who farmed the land never owned it - and rather under the British law whereby one owned his farm plot. This would have allowed greater investments in agricultural techniques. Taken together, these factors would have mitigated Malthusian pressures. One important sign in our results that support this claim is the disappearance of the relation between birth rates and death rates during the post-conquest era. The disappearance of this link means that some form of demographic transition had been initiated in Lower Canada through lower mortality. Although it is beyond the scope of this paper to study the demographic transition, we believe that the presence of early signs of its beginning support our claim that the population pressures were disappearing. This is because demographic transition are associated with industrialization - something

that goes against Malthusian theory.

Figure 6: Spread of wheat prices between Quebec and Montreal



These explanations we propose are merely suggestions at present times. However, they are plausible and can be easily tested in future papers - something which we plan on doing. But at present, we can only postulate. However, we hope at the very least that this new presentation of the Malthusian pressures will lead to further research by historians and economists.

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