PhD Thesis

Wheat, Globalization and Economic History

Paul Sharp

Department of Economics

Faculty of Social Sciences

University of Copenhagen

May 2009

Supervisors: Karl Gunnar Persson and Heino Bohn Nielsen

Contents

Summary

This thesis is composed of four in many ways quite separate papers, which nevertheless have the common theme that they concern the role of wheat in economic history, in particular with reference to historical market integration and the "globalization" of trade.

Soon after starting my PhD studies, which were to concern the role of wheat for the globalization of the nineteenth century, I discovered that existing estimates of the incidence of the British Corn Laws were unsatisfactory. Chapter 1 addresses this. By documenting the legislative history of the Corn Laws from 1670 and using previously unused data to calculate annual Ad Valorem Equivalents for most years from 1814, it is possible to establish several important facts about British wheat protection. Statutory protection was only significant for a few years after 1815, the decline starting in the 1820s and continuing beyond the famous "repeal" in 1846. The level of protection prior to 1846 was, for many years, much lower than previous accounts have suggested. The annual time series of Ad Valorem Equivalents will allow for UK trade policy to play the important role it deserves in econometric analyses of the nineteenth century.

Chapter 2 represents the main thrust of my research: the causes and consequences of what became known as the "grain invasion" – a massive increase of in particular wheat exports from the US to Europe. The usual explanation for the American grain invasion of Britain in the last decades of the nineteenth century is that falling transportation costs caused the price gap between the US and the UK to fall, causing US prices to rise, UK prices to fall, and thus causing US export supply and UK import demand to increase. This chapter documents that this story is flawed. Falling per mile transportation costs simply permitted an expansion of frontier farming in the US, while the price received by the average American farmer remained constant. What this process did allow, however, was a massive increase in US output, which was then available to supply the booming demand in the UK. The grain invasion was therefore not a response to increasing prices by American farmers, who in reality offered a perfectly elastic supply at the going price as practically unlimited supplies of land in the West were populated by immigrants.

My research also led me to question when this importance of America's grain supply for Britain started. Chapter 3 provides evidence that transatlantic commodity market integration began prior to the "first era of globalization" at the end of the nineteenth century. It does so by giving a long term perspective to the story of the development of an Atlantic Economy in wheat between the United States and Britain. Both trade statistics and contemporary comment reveal the importance of this trade from the middle to late eighteenth century, long before the so-called grain invasion of the late nineteenth century. Using price data for wheat in America and Britain, evidence is found that markets were integrated, but this process was continuously being interrupted by "exogenous" events, such as trade policy, war and politics. Transportation costs cannot be seen to be the driving force behind periods of increased trade, which are more attributable to the absence of these exogenous events. Whether the observed market integration is evidence of "globalization", however, is questioned.

Chapter 4, co-authored with Jacob Weisdorf, represents another area of research interest for me: the question of whether pre-industrial societies functioned as the eighteenth century economist T. Robert Malthus suggested they did. Although this might not obviously seem to relate to wheat, the Malthusian "preventive check" mechanism has in fact been well documented for pre-industrial England through evidence for a negative correlation between the marriage rate and the price of wheat. Other literature, however, speculates that the correlation was in fact positive from the early nineteenth century. This paper uses the cointegrated VAR model and recursive estimation techniques to document the changing relationship between nuptiality and the price of wheat from 1541 to 1965. The relationship is indeed positive from the early nineteenth century to the First World War. A simple theoretical model shows that this result is not in fact inconsistent with a stylised Malthusian mechanism, and can be understood within the context of an increasing dominance of shocks to aggregate demand rather than to aggregate supply.

Acknowledgments

During my time as a PhD student I have benefitted from the help and advice of a large number of people. I would like to thank Bob Allen for my time at Nuffield College, Oxford, Greg Clark for my time at the University of California, Davis, and Giovanni Federico, in particular for my time at the European University Institute in Florence, but also for his encouragement and interest in my work throughout my time as a PhD student. Ingrid Henriksen, Katarina Juselius, Markus Lampe, Niels Framroze Møller, Alan Olmstead, Kevin O'Rourke, Peter Solar and Jeffrey Williamson have all read through early drafts of one or more chapters. I have co-authored one chapter with Jacob Weisdorf and have enjoyed his enthusiasm and company at many conferences abroad. In addition, I have benefitted from a large number of helpful comments from seminar and conference participants, both in Denmark and abroad. I must also thank my second supervisor, Heino Bohn Nielsen, without whom I would certainly have made many embarrassing econometric mistakes, and of course my main supervisor, Karl Gunnar Persson. I could not have wished for someone more encouraging and supportive. Lastly, I would like to thank my children and my wife, Claudia Riani, for their patience and understanding, in particular over the last months. If I have forgotten to name anyone, it is not because their help has not been appreciated. And of course it goes without saying that none of these people bear any responsibility for any remaining mistakes and omissions in this work.

Copenhagen, May 2009 *Paul Sharp*

Chapter 1

1846 and All That: The Rise and Fall of British Wheat Protection in the Nineteenth Century[1]

Abstract: By documenting the legislative history of the Corn Laws from 1670 and using previously unused data to calculate annual *Ad Valorem* Equivalents for most years from 1814, it is possible to establish several important facts about British wheat protection. Statutory protection was only significant for a few years after 1815, the decline starting in the 1820s and continuing beyond the famous "repeal" in 1846. The level of protection prior to 1846 was, for many years, much lower than previous accounts have suggested. The annual time series of *Ad Valorem* Equivalents will allow for UK trade policy to play the important role it deserves in econometric analyses of the nineteenth century.

1. Introduction

It is now three-quarters of a century since the publication of *1066 and All That*. The authors ridiculed the historian's fixation with "memorable dates", although this enthusiasm even now seems little diminished. For the economic historian few dates in the nineteenth century are more memorable than 1846.

The repeal of the British Corn Laws is one of the nineteenth century's most famous political episodes concerning economic policy. As such it has attracted the attention of historians of British politics, who have revelled in the cut and thrust of the political debate of the time,

[1] I would like to thank Karl Gunnar Persson, Giovanni Federico, Jeffrey Williamson, Kevin O'Rourke, Peter Solar, Markus Lampe, Heino Bohn Nielsen and seminar and conference participants for their suggestions and assistance.

and that of economic historians: see for example the articles in Harley (1996) and Schonhardt-Bailey (1997).

Recently, there has been renewed interest in the Corn Laws. The late twentieth century phenomenon of "globalization" has led economic historians to demonstrate that this process actually occurred in two phases. The beginning of globalization has been placed in the late nineteenth century, the process being interrupted and severely set back during the interwar years, only to experience a second wave after the Second World War (O'Rourke & Williamson, 1999). The trade liberalization exemplified by the repeal of the Corn Laws was of course a necessary precursor for this.

The true economic significance of the nineteenth century Corn Laws has not been satisfactorily assessed, however. Two strands are discernable in the literature. The first presents the day to day functioning of the Corn Laws and/or the politics surrounding them; see for example Fay (1932), Barnes (1965) and Vamplew (1980). The second attempts to quantify the economic impact of the Corn Laws, for example through estimates of their *ad valorem* incidence. These, however, differ widely. For example, estimates for the pre-1842 system have ranged from 5.6 per cent in McCloskey (1980) to 54 per cent in Williamson (1990). The reason for these discrepancies is their complexity: the Corn Laws were by no means a simple *ad valorem* tariff and it is easy to oversimplify when interpreting them as such.

The workings of the Corn Laws are in fact recorded in great detail in British parliamentary papers. This information can be used to lay to rest some of the conventional historical wisdom about the Corn Laws. Traditionalist accounts even today[2] suggest that 1846 was a dramatic break with the past, repealing age-old tariffs, inspiring other European countries and paving the way for an age of free trade in Europe and the first era of globalization, as exemplified by the American "grain invasion". None of this is true. British grain protection was significant for just a few years after 1815 and the movement to free trade was a gradual

[2] See for example Schonhardt-Bailey (2006).

process, starting in the 1820s, but only ending in 1869. 1846 was just one stage, albeit an important one, in this.

The paper is structured as follows. Section 2 documents the legislative history of the Corn Laws from the seventeenth century. Section 3 first gives a critical summary of previous attempts to assess the incidence of the Corn Laws in the nineteenth century, and then utilizes previously unused data from British parliamentary papers to provide an alternative account. In particular, this is done by compiling an annual time series of *Ad Valorem* Equivalents (AVEs) from 1828, which give an impression of the rise and fall of British wheat protection after this date. Section 4 tests the robustness of these findings, and suggests some implications of them. Section 5 concludes.

2. The Legislative History

2.1 The Rise and Fall of British Protection

The general history of the Corn Laws is adequately covered by existing literature (for example Nicholson 1904, Fay 1932 and Barnes 1965), but a short overview is helpful here.

After the repeal of an old and inoperative law of 1463 there was no statutory restriction on importation until the Corn Law of 1660. (Barnes 1965, p. 6) From 1670 until 1815 there was little change in the basic format of the laws governing imports. Price bands were specified within which certain duties would be payable. A common feature after 1670 is a very small "nominal" duty payable when the price of wheat was high (normally about 1 shilling per quarter), and a "pivot level" below which duties were very high. These bands and duties were adjusted at various times, and extra levels, above and below the aforementioned were sometimes in effect, but in practice they had little impact on imports which were very low, and at times of scarcity they were suspended. The importance of the duties was as a counterpart to the system of export bounties[3]. Without the wheat duty, it would have been profitable to import in order to re-export and collect the bounty. (Fay 1932, p. 15)

[3] Although these were rarely payable after 1773 (Fay 1932, p. 31), and they were abolished in 1814.

Although the import restrictions began to have a larger practical relevance from the late 1780s, when a combination of the effects of the industrial revolution and population growth led to England becoming a net importer of wheat on a permanent basis (Fay 1932, p. 28), almost constant wars with France from 1792 until Waterloo in 1815 meant that the Corn Laws became irrelevant, as prices rose to such a level that only the (very small) lowest rate of duty was payable for most of the time. In sum, the period to 1815 was one of "practically free" trade in corn, as stated in the report of an 1821 select committee. (Fay 1932, p. 80)

With peace in 1815 a new law was passed which prohibited wheat imports when prices were under 82.5s./quarter and admitted wheat free of duty above this level. This was a radical departure from previous Corn Laws. Fay has described the 1815 Law as "the one and only serious breach in corn-law policy from beginning to end" and "defiantly protective" (Fay 1932, p. 35) Barnes (1965) has suggested that it reflected a new antagonism between the classes after the French Revolution. With one notable exception from November 1816 to November 1817, ports were almost permanently closed from the passing of the Act until 1825[4]. (Fay 1932, p. 79)

However, although the UK turned protectionist in 1815, this was immediately met by protests, including a formal Protest in the House of Lords, signed by eleven peers including two royal dukes, and this opposition continued, amongst other things resulting in the famous "Petition of the London Merchants" in 1820 drafted by Tooke (McCord 1970).

New legislation followed the protests. Protection was ostensibly relaxed by a new Act in 1822, but this was only to come into operation "as soon as wheat should be again admissible for consumption, under the Act of 1815" (BPP 1843). Since these terms were never met (except for colonial corn), this Act never came into force. However, in 1825, 1826 and 1827 a series of temporary Acts allowed some wheat to be released from bond for a short period of the year, although these applied only to grain that had been imported prior to the passing of

[4] Ports were also open for a few months in 1818 and 1819.

each Act[5]. The 1815 Act was permanently repealed in 1828 when the import prohibition was dropped in favour of the Duke of Wellington's "sliding scale" of import duties.

For most of the 1830s domestic harvests were plentiful, prices were low and discussion of the Corn Laws was muted. However, from 1837 prices began to rise and in 1838 the famous Anti-Corn Law League[6], led by Richard Cobden and John Bright, began to campaign for free trade in grain[7]. In 1842 an attempt was made to ease the degree of protection, but poor harvests and the Irish Potato Famine caused political disarray which finally led to the repeal of 1846, when duties were greatly reduced together with a promise that only a "nominal" registration duty would be payable from 1849. (Tracy 1989, pp. 39-40)[8]

The Acts from 1828 are complicated and scholars have contradicted each other when documenting them. The account below is based on contemporary parliamentary papers and for simplicity only documents the measures concerning foreign wheat; colonial wheat was given favourable rates until 1849, but was a very small proportion of imports.

Again, it is important to emphasise that the Corn Laws were not a simple *ad valorem* tariff. From 1828 to 1849, they involved a complicated "sliding scale", whereby certain price ranges would imply a particular duty on "wheat entered for home consumption". This was a throw back to the years prior to 1815, when duties were also payable according to what can be seen as a miniature sliding scale. The rate of duty payable was recalculated on a weekly basis. Until 1849 there was no import duty on wheat as such; grain could be imported freely, and then placed in "bonded warehouses". It was only on release from "bond", i.e. "entered for home consumption", that the duty was payable.

---

[5] Schlote (1952, p. 112) states that "imports" (i.e. releasing wheat from bond) were prohibited from May 15, 1825 to July 14, 1828. This is not strictly true.

[6] It has been suggested that the League's motives were wider than a simple reaction to the rise in prices. See McCord (1968).

[7] This raises the question as to whether Williamson (1990, p. 130) seeks to answer the wrong question: "What was the impact of the Corn Laws in the mid-1830s when the Corn Law debates rose to a crescendo?" The mid-1840s are far more interesting in this respect.

[8] For a more detailed account of the politics of repeal, see Barnes (1965).

The price determining the duty was an average of wheat prices recorded for a varying number of "inspected markets" (varying depending on the current Act governing the Laws). An average was taken of these prices: this is the famous "*Gazette*" price – so called because it was (and still is) recorded weekly in the *Gazette* newspaper. In determining the price relevant for the duty for each week, the average of the last six weeks' *Gazette* prices was calculated.

The duties payable under the various tariff regimes are shown in table 1.

Table 1: The Corn Laws 1828-1869

All prices in shillings per imperial quarter

When the *Gazette* price was…	**… the duty payable was…**			
	From 15 July 1828 to 29 April 1842	*From 29 April 1842 to 26 June 1846*	*From 26 June 1846 to 1 February 1849*	*From 1 February 1849 to 1 June 1869*
73+	1	1	4	1
72+	2.67	2	4	1
71+	6.67	3	4	1
70+	10.67	4	4	1
69+	13.67	5	4	1
68+	16.67	6	4	1
67+	18.67	7	4	1
66+	20.67	8	4	1
65+	21.67	9	4	1
64+	22.67	10	4	1
63+	23.67	11	4	1
62+	24.67	12	4	1
61+	25.67	13	4	1
60+	26.67	14	4	1
59+	27.67	15	4	1
58+	28.67	16	4	1
57+	29.67	17	4	1
56+	30.67	18	4	1
55+	31.67	19	4	1
54+	32.67	20	4	1
53+	33.67	20	4	1
52+	34.67	20	5	1
51+	35.67	20	6	1
50+	36.67	20	7	1
49+	37.67	20	8	1
48+	38.67	20	9	1
47+	39.67	20	10	1
	+1 for every shilling decrease in price	20 was the maximum payable	10 was the maximum payable	Fixed rate of duty

A point to note about the 1828 Law is the non-linearity. Above 66 s./quarter the duty fell away very rapidly. The table demonstrates clearly the legislative progress towards free trade from 1828. Duties were decreased in 1842, 1846 and 1849.

Interestingly, although 1846 is popularly considered to mark the "repeal" of the Corn Laws, duties on grain survived for many years afterwards. From June 26, 1846 to January 31, 1849 the sliding scale was to continue in a truncated state, although duties were suspended from January 26, 1847 to March 1, 1848[9]. Shortly afterwards under the terms of the 1846 Act, the sliding scale was abolished altogether: from February 1, 1849 a fixed "nominal registration duty" of 1s./quarter was in effect[10]. In addition, an Act of August 1, 1849 ended the practice of "warehousing" by making the duty payable on import. (Prest 1996, p. 474) With the growing realization, documented by Prest, that the registration duty amounted to a significant tax on the poorest in society, it was finally repealed on June 1, 1869, leading to true free trade in grain, although it was briefly re-imposed in order to pay for the Boer War from April 15, 1902 to June 30, 1903. (*Annual Statement*, 1903) Wheat then remained duty free until the Wheat Act of May 1932. (Malembaum 1953, p. 35)

2.2 Some preliminary conclusions

It is surprising how much can be learned from a simple account of the legislative process leading to repeal. The movement away from the protection of 1815 was gradual, starting with the temporary laws from 1825-7, and it was most importantly and permanently reversed in 1828. There is a long running debate about whether or not Britain led the way to free trade (see the contributions in Dormois & Lains 2006). Although this paper cannot attempt to resolve this, since this would require a far more general survey, it does provide some interesting evidence as far as the important trade in wheat is concerned. Here Britain's example was set in the 1820s, not the 1840s[11]. In the context of previous history, the

[9] Schlote (1952) gives the last date as September 1, 1847, but contemporary sources (for example *Tables of Revenue* (1847) give the date as March 1, 1848. This also seems more likely, given the very small level of tariff revenue reported for 1847, see table 3, below.

[10] From September 1, 1864 duties were calculated and imports measured based on weight (cwt.) rather than volume (quarters). So technically from this date the registration duty was 3d. per cwt., but this is approximately the same as 1s. per quarter. (*Annual Statement*, 1864)

[11] This was not only in terms of grain. Britain's nineteenth century commitment to a process of trade liberalization can be dated to at least 1820, when parliament, which at that time included David Ricardo as an

"repeal" in 1846 seems less important, and simply another step in a progress towards free trade after the reversal of 1815. Indeed, 1846 did not even mark the end of British wheat protection, which only finally gave way to true free trade in 1869. The "traditional" argument[12] about Britain's leading role in the movement to free trade and thus potentially serving as inspiration for other countries might therefore have more validity than recent accounts suggest.

What a simple history of the tariff legislation does not answer, however, is how important the statutory protection after 1828 was. At the extremes of the sliding scales, the UK market was either practically closed or as open as under the nominal duty of 1849. Several attempts have been made to assess this question as will be discussed in the next section. All rely on the calculation of so-called "*Ad Valorem* Equivalents".

3. The incidence of the Corn Laws in the nineteenth century

3.1 Ad Valorem Equivalents

In order to compare the impact of the various Corn Law regimes, it can be helpful to convert the statutory tariffs to so-called *Ad Valorem* Equivalents (AVEs). An *ad valorem* tariff is one that is a fixed percentage of the value of the imported commodity. So $P = (1+t)\bar{P}$, where $t \geq 0$ is the tariff rate, *P* is the price payable by the domestic consumer and $\bar{P}$ is the value of the imported commodity. The Corn Laws were, however, a specific, rather than an *ad valorem* tariff.

MP, declared that future commercial policy should be guided by the principle of free trade (Grampp 1987). In fact, by the 1840s "the Corn Laws stood out as the major remaining bastion of Protection, while tariffs on other imports had been very substantially diminished" (McCord 1970, p. 10).

[12] I call this the traditional argument after Irwin, who characterizes it as such. However, many so-called traditionalists would not subscribe to the idea that repeal sparked an international following, so in this sense Irwin characterizes the traditionalist argument rather too crudely. I am grateful to an anonymous referee for this point.

A specific tariff is one which charges a specific duty per non-monetary unit of a good. The Corn Laws first charged per unit of volume (quarter) and from 1864 per unit of weight (hundredweight). Obviously the information requirements for imposing a specific duty are rather less from those for an *ad valorem* duty – the good only needs to be weighed, measured or counted to determine the duty. For an *ad valorem* tariff, the good also needs to be valued.

When converting specific tariffs it is thus necessary to value the product. This could be based on the domestic price, the world price, or something in between. There is no standard way of calculating these so-called AVEs and in fact the recent WTO Doha round broke down over this very issue, although "Draft guidelines" were accepted by negotiators on May 4, 2005[13]. (*Economist*, May 5, 2005)

There are two generally accepted approaches. The first is the "unit price" method, whereby a specific duty is compared to a reference price. The other is the "revenue method": total tariff revenue over a period compared to the total value of imports over the same period. The two methods are actually equivalent, since

$$AVE = \frac{D}{P} = \frac{D*Q}{P*Q}, \tag{1}$$

where *D* is the monetary value of the duty collected per unit of imports and *P* is the import unit value. So D/P is the unit value expression of the AVE. Multiplying by *Q*, the quantity of imports, in the numerator and the denominator gives the revenue method expression of the AVE, since *D*Q* is total duty revenue and *P*Q* is the total value of imports.

The problem remains of how to value the imports and this matter will be returned to later in this paper. Ideally, given the definition of an *ad valorem* duty, imports should be valued at the counterfactual price that would apply under free trade, which would be the c.i.f. price of imports. This is, however, not normally known and previous attempts at calculating the *ad*

[13] AVEs would allow countries to "tier" their tariffs and thus allow for a "progressive" reduction in tariffs, i.e. high tariffs should be reduced more.

valorem equivalent of the Corn Laws can be seen as ways of trying to get around this problem.

One popular solution is to calculate estimates based on the price differential between UK wheat and a representative foreign exporting country (Prussia). This approach relies on the efficient operation of the Law of One Price and thus the strong assumption of perfect market integration. The former states that the price of a traded good, adjusted for trading costs, such as transportation and tariffs, will be equal in two markets due to the possibility of arbitrage:

$$P = (1+t)\left(P^{*}+\tau\right), \tag{2}$$

where P is the price of the good in the home importing market, which is a mark-up on the foreign price, P^{*}, including the cost of the tariff (expressed as an AVE), t, and other non-tariff barriers, τ, such as transportation costs. From this we can calculate the home price with free trade as

$$P^{FT} = P^{*}+\tau \tag{3}$$

since $t = 0$.

Using this, we can solve for the extent of the *ad valorem* equivalent of a tariff, t, as follows:

$$AVE = t = \frac{P-\left(P^{*}+\tau\right)}{P^{*}+\tau} = \frac{P-P^{FT}}{P^{FT}}, \tag{4}$$

where the numerator is the part of the price differential due to the tariff and the denominator is the free trade domestic price. The *ad valorem* tariff is simply the proportion of the price attributable to the tariff. However, although P is observable, P^{FT} is not, because normally we do not know how much of the price differential $P - P^{*}$ is due to non-tariff barriers.

3.2 Previous estimates

An obvious and simple way of estimating the impact of the Corn Laws on an annual basis is to use the unit price method employed by Schlote (1953, p.61). He takes the average yearly

Gazette price of wheat and uses the sliding scale to calculate what the tariff would have been at that price. That is

$$AVE_t = \frac{D_t(P_t)}{P_t}, \tag{5}$$

where $D_t(P_t)$ is the duty payable from the relevant sliding scale at time *t*, which is a function of the price at time *t*.

He then reports the tariff as a percentage of the price for selected years from 1829 to 1848. Completing his time series gives the picture in figure 3.[14] However, although Schlote's method seems intuitively correct, it tends to hide the true variation in the *ad valorem* incidence of the Corn Laws between the years. This is due to the workings of the Corn Laws under the sliding scale, as touched on above. Vamplew (1980) has shown that wheat was only normally released from the bonded warehouses when tariffs were at their lowest level during a year. Indeed, in most cases over 95 per cent of wheat was released at the lowest level of duty in each period of an up- or downswing in duties.

Thus, to take one example, during the downswing in duties from week 5 to week 38 in 1838, 1,306 quarters of wheat were released for home consumption, 96.6 per cent of this at a rate of 1s./quarter. From week 39 to week 45 there was an upswing in duties, during which only 166 quarters were released. In the downswing from week 46 to week 13 in 1839 100 per cent of the 996 quarters released for home consumption paid a duty of just 1s./quarter. Just looking at the average price for 1838 (64s.), as Schlote did, would imply a duty of 22.67s, or 35 per cent of the *Gazette* price. In reality, most wheat paid a duty of just 1s./quarter: less than 2 per cent of the price.

Thus it is that Schlote's method yields unreliable estimates: very little grain was subject to duty at the highest rates and any estimate using the average price for the year to determine the implied duty will upwardly bias the estimates of the *ad valorem* incidence.

[14] The duty for 1828-41 is calculated using the 1828 sliding scale. The duty for 1842-5 is calculated using the 1842 sliding scale. The duty for 1846-48 is calculated using the 1846 sliding scale. From 1849 the duty used is 1s. per quarter.

The most widely cited estimates for the *ad valorem* incidence of the Corn Laws are those of Williamson (1990), given again by him again in O'Rourke & Williamson (1999, p. 38 and pp. 83-4)[15] and O'Rourke & Williamson (2005, p. 10).

Williamson (1990) attempts to assess the *ad valorem* impact of the Corn Laws after 1815 by first testing whether there is market integration between the UK and Prussia. If markets are well integrated "it would be a simple matter to infer the impact of the Corn Laws on home prices by measuring price differentials between British and foreign markets, adjusting for transport costs". (p. 126)

Williamson draws inspiration from Fairlie (1969), who divides the period 1815-68 into five periods: 1815-27, 1828-41, 1842-8, 1849-59 and 1860-8. She has a time series with an average yearly price of wheat in England and Wales and an average yearly price of wheat in Prussia. Both are taken from Fairlie (1965). She provides estimates of the "amount by which English prices would have been lower had there been free trade" by making seemingly *ad hoc* assumptions about the level of transport costs and terms of trade effects, i.e. she corrects for the fact that with free trade the Prussian price would have risen, thus offsetting some of the gains in England. This number can then be used (see Williamson 1990, p. 128) to give an estimate of the *ad valorem* impact of the tariff in each period. Williamson (1990, p.128n) suggests that Fairlie's calculations assume too strong a terms of trade assumption (thus implying smaller potential price changes in Britain and a implied tariff that is too low), although Ward (2004, p. 254) finds support for Fairlie's assumption.

Williamson's solution is to run a simple regression of the English prices of wheat from 1815-61 on the Prussian prices given in Fairlie (1965). Dummies are introduced for the three protectionist regimes, 1815-27, 1828-41 and 1842-45 and finally a trend is introduced "to reflect the possibility of changing transport costs or changing market efficiency". (Williamson 1990, p. 127) Since the dummy coefficients represent the mark-up of English over Prussian prices due to each regime, they can be used to calculate an estimate of the *ad valorem* protection afforded by the various Corn Law regimes.

[15] Here the figure for the 1842 regime is given incorrectly and should read 22 per cent rather than 7 per cent.

Comparing these with Fairlie's calculations without the terms of trade effect ("Using Williamson's assumption"), Williamson concludes that "[t]he preferred estimates… are quite close. They imply that the *ad valorem* equivalent tariff rate was about 71% between 1815 and 1827, about 54% between 1828 and 1841, and about 22%[16] between 1842 and 1845." (Williamson 1990, p. 128)

There are a number of problems with Williamson's analysis; for example, there are some minor questions about the data.[17] More importantly, however, interpreting his results presents difficulties. Williamson finds the constant to be insignificant. This means that it is difficult to accept his interpretation as any meaningful "estimate of transport costs and expenses". Moreover, the trend is also insignificant, which using Williamson's interpretation suggests that "there is no evidence of significant combined changes in market efficiency and transport costs over time", but the three dummies act much like a trend, and it is surely difficult to separate the effects.

However, there is no escaping the main conclusion from Williamson's regression: that the price gap was narrowing over time, and that successive tariff reductions almost certainly played a large part in this. The main criticism has to be, however, that it fails to provide any information on the swings in the protection from year to year. In fact, of course, the protection varied from week to week, so to state that the 1828 sliding scale was equivalent to a 54 per cent *ad valorem* tariff provides about as much information as quoting the

[16] This is incorrectly cited as seven per cent in O'Rourke & Williamson (1999, p. 38).

[17] There is an error in the Prussian series. From 1816-27 this is taken from a contemporary article, Rawson (1842). The price for 1816 appears to have been transcribed incorrectly by Fairlie (58s. instead of 48s.) and no source is given for 1815. However, even correcting for this, it has not been able to reproduce Williamson's estimates using the data he cites. Using the regression the figures, for 1815-27, 1828-41 and 1842-45 respectively, are 74.8%, 59% and 24.8%. Using "Williamson's assumption", the figures are 63%, 50% and 23%. Even using Williamson's regression coefficient for 1815-27, the estimate is 74.8% rather than 72.8%. This difference, as well as the reported average Prussian price of 34.47s. in his footnote 2, suggests that the differences between my results and his stem from discrepancies between his Prussian data for 1815-27 and that given in Fairlie (1965). The difference is of little importance for the results, however.

average price for the period. As Capie (1983) notes, average rates for long periods must "be a great simplification".

Is it then possible to use price differentials to create annual estimates? As before, this will only be possible if markets are perfectly integrated and although Williamson's regression provides evidence that this was fulfilled on average for the periods he looks at, there is evidence that for some years the tariff was so high that this was not the case.

O'Rourke (1994)[18] makes the point that the Corn Laws could have influenced UK grain prices in two ways. Either the tariff was so high that imports were excluded and prices were determined by domestic demand and supply, or grain entered Britain, and the Law of One Price held[19].

O'Rourke determines which scenario was relevant for each year by noting that both the Prussian price plus transport costs and the British price minus the tariff should both be equal to the free trade price of wheat in the UK if the law of one price holds, i.e. $P^{FT} = P^* + \tau = P - t$. He finds this not to be the case from 1832 to 1837, and this in itself presents difficulties if the Law of One Price is to be used as the basis for calculating annual AVEs.

However, there are a couple of problems with his method which if corrected for would reinforce this conclusion. The main problem with his approach is that he uses Schlote's method to calculate the average tariff payable for each year. This will overemphasize the tariffs with the implication that markets would appear more integrated than they would if a more representative tariff was used.

In addition, the assumption of constant transportation costs is unlikely to be correct – cycles in transport costs are a well documented phenomenon (see for example North (1958) and Persson (2004)). Persson's data show that the barrier to trade due to transportation costs could easily fluctuate by a factor of two or three from year to year. This could be the reason

[18] See also O'Rourke & Williamson (1999, p. 83)

[19] In fact, there was grain imported and released from bond in every year, but the level was very low, especially in the mid-1830s.

why Williamson's constant is insignificant in his aforementioned econometric analysis. Even ignoring this, there is still the problem, as suggested in section 3.1, that any estimates based on the Law of One Price must assume *perfect* market integration, i.e. that *all other costs*, except transportation costs, have been arbitraged away. There is nothing to suggest that markets were so efficient at this time.

The conclusion must be that annual estimates based on the assumption that the Law of One Price held are not appropriate for every year. Another method is necessary.

3.3 Annual estimates based on the revenue method

The revenue method, i.e. ratios of tariff revenue to import values, has the advantage that it does not rely on an assumption of market integration or on trade with specific countries. It is also possible to use this method to create annual estimates which more accurately reflect the proportion of the price paid in duty than Schlote's method.

The revenue method is a commonly used approach, for example by Imlah (1958) and more recently by Nye (1991) for more general studies of this period. It is also the method recommended by Capie (1983, p. 7), who states that "[d]uties as a percentage of total imports overcome the serious problem of the conversion of specific duties… to *ad valorem* equivalents. And… since this was a time when prices of many commodities were falling sharply, they are therefore clearly an improvement on simply looking at legislative changes in protection." In relation to the Corn Laws, we should therefore not necessarily expect to see a fall in the *ad valorem* incidence between the 1828 and 1842 regimes, since prices were falling and this would make it more likely that wheat was paying higher rates of duty.

This approach has been extensively criticised, see for example Irwin (1993) and Estevadeordal (1997) and a detailed criticism is given in Board of Trade (1904, pp. 287-292). However, this is mostly directed towards its applicability as a comparative measure of protection between various countries and particularly when it is used as an average over many commodities. As a way of comparing the protection offered between different years for one commodity, it seems reasonable enough. Another common criticism is that it cannot

account for prohibitive tariffs (Capie 1983, p. 7) – however, wheat was released from bond and imported in every year after 1828.

McCloskey (1980) uses the revenue method to present three estimates: for 1841 (5.6%), for 1854 (1.5%) and for 1881 (0%). Her estimates have been dismissed by Williamson (1990, p. 128n), who notes the sizeable difference between McCloskey's estimate of the average tariff for 1841 (35 per cent) and, for example, that given for wheat – just 5.6 per cent. He explains that since "the fact that duties on wheat were at their lowest in 1841… the atypical low rates in 1841 can be ignored". This is not, however, a general criticism of the method, but rather of taking 1841 as representative of the pre-1842 incidence. If it were possible to extend McCloskey's analysis beyond her three data points, then a fuller picture would emerge.

With data from British parliamentary papers this is in fact possible. The formula is simple enough:

$$AVE_t = \frac{(Duties\ collected)_t}{(Value\ of\ imports)_t} \tag{6}$$

The duties collected in each year are available in official publications. "Value of imports", however, presents some special difficulties.

Until 1849 "imports" should be taken to mean foreign wheat released from bond, since colonial wheat was subject to different duties and the duty was only payable when the wheat was released from the warehouse. From 1850, imports can be taken to mean total imports of wheat, both foreign and colonial, since the duty was payable on import, and colonial wheat no-longer enjoyed preferential rates of duty.

Data is available on volumes of the above for every year. The difficulty is then how to value it. McCloskey notes that the value of wheat imports is not reported prior to 1854[20], but this is not entirely accurate. From 1696 records of overseas trade began to be systematically collected. Goods were valued using "official values" which were based on the average prices in 1694 – but these are obviously of little use here since prices were undoubtedly rather

[20] She has one observation prior to this for 1841, which seems to have been taken from secondary literature.

different by the nineteenth century[21]. However, from 1854 the method was changed, so that actual current prices[22], compiled by experts, were used each year. (For more detail, see Schlote 1952, section A).

The best method for valuing wheat released from bond in the UK is the average domestic price, i.e. the *Gazette* price. This valuation has some other advantages. First, it allows the estimates to be directly comparable with Schlote's, who also used the *Gazette* price in the denominator when calculating his AVEs. Second, this appears to have been the method used for valuing wheat after 1854 and thus makes my estimates consistent with those based on later valuations, as can be seen by comparing the result of multiplying quantities with the *Gazette* price, and the official valuations from 1854.

This may or may not be an appropriate valuation from 1850 when the duty was payable on import. However, an alternative measure will make little difference when calculating the value of the imported wheat relative to duties collected, since the difference between the two alternative evaluations will be relatively small in comparison to the volume of imports and the relatively small amount of revenue collected. Besides, with virtual free trade after 1849 and market integration, the *Gazette* price could be expected to be equal to the c.i.f. price of imported wheat, which is presumably the basis for the official valuations.

The revenue method is unfortunately not particularly helpful before 1828. The amount of duty received for years prior to 1828 is only given on wheat and flour combined in official statistics, and is entirely absent prior to 1814, since the records were destroyed in the Custom House fire of 1814. The information that does survive, and the AVE for each year, is however given in table 2.

[21] Schumpeter (1938, p. 32) disputes this common explanation of the official value, and argues that it varied until 1725. This has little importance in the current context, however!

[22] These were, confusingly for the modern economist, referred to as "real values".

Table 2: AVEs 1814-1828 for Wheat and Wheat Flour

	[A]	[B]	[A*B]	[C]	[C/(A*B)]
	Gazette Price (s./qr.)	Quantity admitted (quarters)	Value of "imports" (£)	Duty collected (£)	AVE
1814	74.33	623086	2315803	31140	1%
1815	65.58	116382	381636	9411	2%
1816	78.50	225260	884146	0	N/A
1817	96.92	1023862	4961465	0	N/A
1818	86.25	1550606	6686988	0	N/A
1819	74.50	115697	430971	0	N/A
1820	67.83	1056	3582	0	N/A
1821	56.08	0	0	0	N/A
1822	44.58	0	0	0	N/A
1823	53.33	51	136	0	N/A
1824	63.92	914	2921	0	N/A
1825	68.50	399297	1367592	197519	14%
1826	58.67	287338	842858	170017	20%
1827	56.67	519268	1471259	591821	40%
1828	60.42	821794	2482503	67925	3%

Source: BPP (1849)

The duty collected in 1815 is presumably for the months prior to the passing of the new Law on March 23. The figures for 1814 and 1815 thus give a flavour of the low level of protection afforded by the Corn Laws during the Napoleonic Wars. From 1815 until the temporary Acts of 1825-7 no duty was collected. Wheat was either entered free of duty or prohibited. It is thus impossible to calculate AVEs for these years. The AVEs for 1825-7 are only applicable for the few months covered by the temporary Acts. Finally, the dramatic impact of 1828 is all too clear. For this period it seems more reasonable to use methods based on price differentials to gain some idea of the level of protection afforded.

From 1828, the estimates of the annual *ad valorem* equivalents of the duties on wheat are constructed as below, where P_t is as usual the *Gazette* price in year *t*.

1828-1849:

$$AVE_t = \frac{(Duties\ collected)_t}{(Quantity\ released\ \ from\ bond)_t * P_t}, \tag{7}$$

where all values are for *foreign wheat only*.

1850- :

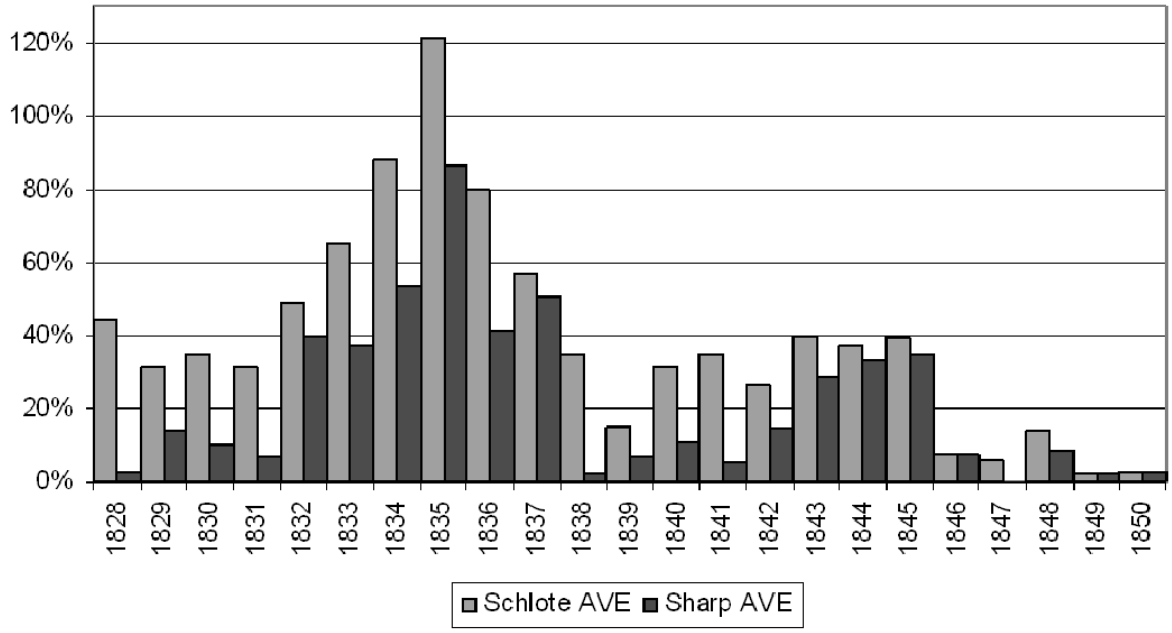
$$AVE_t = \frac{(Duties\ collected)_t}{(Quantity\ imported)_t * P_t}, \tag{8}$$

where all values are for *both foreign and colonial wheat*.

As admitted in the aforementioned WTO draft guidelines, “calculation of AVEs is not an exact science” and these estimates are no exception. They are, however, certainly an improvement on previous attempts and must accurately capture the annual variation in the protection afforded.

The results of these calculations are given in figure 1, where they are compared to the Schlote estimates. The periods of highest tariffs are unsurprisingly similar in both series. However, my estimates are of course consistently lower (since Schlote does not allow for the fact that grain was normally only released during the weeks of the year with lowest duty payable – see section 3.2), and the difference between the highest and lowest *ad valorem* rates is exaggerated. It should be noted that the figure for 1828 is only for the period after the introduction of the Duke of Wellington’s sliding scale, i.e. from July 15. Note also that the years of least protection before “repeal” were in 1828, 1838 and 1841 as stated in contemporary sources (Williamson 1990, p. 128n).

Figure 1: Comparison of Schlote's and Sharp's AVEs



Source: See appendix

4. What can be learned from the new estimates

The discussion of the legislative history in section 2 has demonstrated the movement away from protection after 1828. The annual AVEs can also be used to illustrate this, but present a rather different picture than the estimates of other scholars. This is demonstrated in the following table, where the averages for each of the three sliding scale regimes are given:

	Fairlie[23]	Williamson	Schlote	Sharp
1828/9-41	20%	54%	51%	28%[24]
1842-45	10%[25]	22%	36%	28%
1846-48	4%	N/A	9%	6%

Initially, the most striking fact about these numbers is the variation between them. The differences between Schlote's and Sharp's estimates have already been explained. These are also directly comparable. Fairlie's and Williamson's estimates are also directly comparable, and the difference is of course due to Fairlie's large terms of trade effect.

The difference between Sharp's and Williamson's estimates will be accounted for by non-tariff barriers. Indeed, the workings of the Corn Laws themselves acted as a sort of non-tariff barrier, since the uncertainty surrounding the duties payable on wheat in the medium term and the costs of warehousing wheat in bond would certainly have added to the direct measures of protection detailed above.

An interesting conclusion to be drawn from the regime averages of the annual AVEs is that, even excluding 1828, it turns out that the average *ad valorem* impact of the Corn Laws did not fall after 1842 and in fact remained constant. Although scholars have hitherto assumed that the reduction in the duties payable must have given rise to a fall in protection, a fall in the domestic price of wheat meant that 1842 actually inaugurated a short period of high protection, compared to other years since 1838. This previously undocumented fact has

[23] These are recalculated using the relevant periods.

[24] The average for the first regime for Sharp's AVE is calculated without the level for 1828, since this was only for part of a year.

[25] The sizeable difference between this estimate and that reported by Williamson (1990) of 7.4 per cent is due to him having used the figures reported in Fairlie (1969) for the period 1842-48, which includes years after the "Repeal".

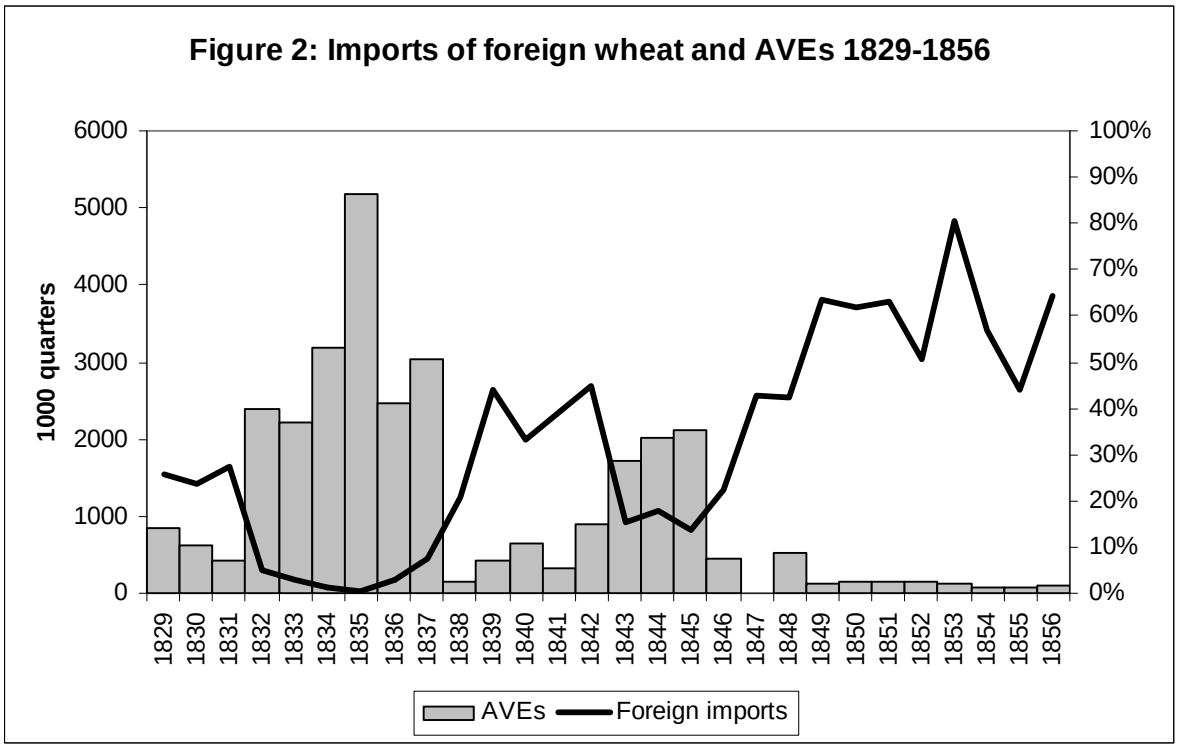
important implications for historians of British politics: it sheds light on the urgency surrounding the debate on the repeal of the Corn Laws after 1842, despite the reform of the sliding scale. Contemporaries were clearly aware of the high level of protection at the time, despite the reform.

For the true value of the annual AVEs, however, it is necessary to look beyond the regime averages. For the first time, the variation in the protection afforded by the Corn Laws from year to year, as recognized by Vamplew, has been documented. It turns out that the statutory protection varied quite substantially from year to year, reinforcing the point that any attempt to give an estimate for the whole period of a tariff regime is a gross oversimplification. For the same reason, a case could be made for saying that estimates based on yearly averages are also unsatisfactory, since duties varied on a weekly basis. However, for economic variables which were less important to the nineteenth century state, i.e. those not involved in raising revenue, the data is at most available in annual aggregates. So if import duties are to play the important role they deserve in empirical analyses of the nineteenth century, then they must be reported on an annual basis.

In addition, an annual series is perhaps the most frequent that has practical relevance when estimating the impact on imports. Traders might be able to respond to the weekly level of the tariff (or at least the expected level), but they could not necessarily rely on a supply: farmers need much longer to form supply decisions. The only real test of the relevance of the annual AVEs is to compare them to the volume of foreign imports for each year. Vamplew noted that “imports did not respond as strongly as bonded corn to either domestic prices or duties. Although imports peaked at the times of lowest duties, there was a flow of wheat into the bonded warehouses throughout the year” (Vamplew 1980, p. 385). However, the new estimates fit in remarkably well with the data on levels of foreign imports[26] after 1828. These are shown in figure 2.

[26] I.e. not wheat released from bond.

Figure 2: Imports of foreign wheat and AVEs 1829-1856



Source: See appendix

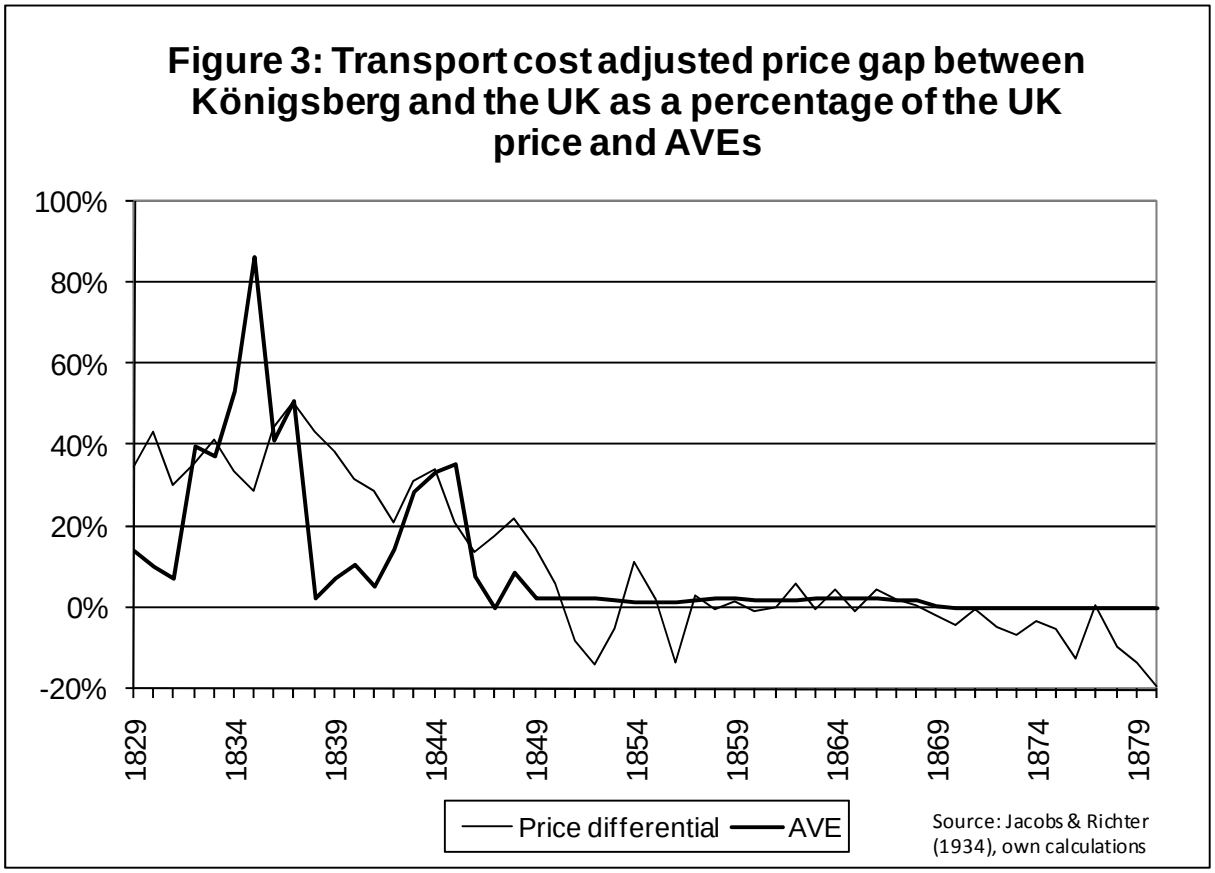
The causality can only be satisfactorily established by more formal econometric testing, but this would be the subject of a separate paper (although see appendix 1). However, the evidence for the importance of the AVEs for import decisions is striking. First, it is difficult to imagine, had the 1828 regime really been equivalent to e.g. a flat 54 per cent tariff rate, that imports would have reached the levels they did in the late 1830s and early 1840s (and to a lesser extent from 1829-31) – levels comparable to those in the years immediately following repeal. Also, if we are prepared to accept Vamplew's well-documented assertion that grain merchants waited for periods of low duties before releasing their grain from bond, then it is not such a great leap of faith to believe that foreign grain exporters waited for years of low protection before sending grain to Britain. In fact, Vamplew noted that the official six-week average, together with time-lags in the regulatory process, meant that the duty was predictable: "A knowledge of market trends, which those involved in the corn trade should have had, ought to have made the prediction of the duty a fairly straightforward task. Holders and potential holders of foreign corn would thus be in a position to take action, if

necessary, before the duty actually changed." (Vamplew 1980, p. 384) It would thus be possible to arrange shipments of wheat to the UK in anticipation of a period of low duties.

The graph also seems to present a solution to the seeming puzzle as to why O'Rourke & Williamson (2005, p. 14), when assessing the importance of trade policy for the timing of a structural break in the relationship between English commodity prices and English endowments, i.e. England's change from a closed to an open economy, find 1838 to be the most likely candidate. Figure 4 makes clear that this year marks the end of significant wheat protection due to the Corn Laws, except for three years. Indeed, it is possible to see the tariff protection as prohibitive from 1815 until 1837 (with the exception of half of 1828, 1829, 1830 and 1831) and low from 1838 (with the exception of just three years – 1843, 1844 and 1845). O'Rourke & Williamson note that 1838 also saw the start of the decline in the Harley freight index and the UK-US grain price gap. Of course the 1846 repeal was important, since it meant that the level of protection stayed permanently low, but the real break came in 1838 and imports clearly responded to that.

Emphasising this point should not, however, detract from the larger political and social significance of repeal, which went far beyond the actual levels of protection. This event certainly had a lasting impact on the politics and Constitution of Britain. Moreover, without repeal and thus a continuation of the sliding scale in some form, and even perhaps with adjustments to take account of deflation, the movement of English prices towards the lower levels enjoyed by continental Europe during the late nineteenth century, in particular with the Grain Invasion from America, and the consequent high tariffs would have muted the increases in real wages and boosted the rents to landowners with potentially considerable distributional effects (see the analysis in O'Rourke 1997).

The AVEs would, of course, also be expected to have an impact on price gaps between the UK and export markets. As discussed above, price gaps are not a reliable measure of protectionism, and in addition price gaps can disguise many factors, such as quality differences, which might also change over time. Nevertheless, figure 3 presents price gaps between the UK (*Gazette* price) and Königsberg (present day Kaliningrad), at this time a major export port for Prussian grain.



The Königsberg prices are taken from Jacobs & Richter (1934, pp. 52-53) and are converted from marks per 1000 kg to shillings per quarter using the assumption that 1 quarter of wheat equals 4.4 cwt and the exchange rates in Schneider & Schwarzer (1990) and Schneider, Schwarzer & Zellfelder (1991). The usual estimate of 7.5 shillings has been subtracted from the price gaps to allow for transportation costs, and the price gap is expressed as a percentage of the UK price in order to allow comparison with the AVE measure.

The similarities between the two series are remarkable. Importantly, the fall in protectionism after 1837 is apparent, as is the spike in protection despite the 1842 reform – the two most important conclusions from above. There is some evidence to suggest that the price gap does not respond immediately to a fall in protection. This could well be to do with transportation costs, which might be expected to increase with booms in trade. In reality, 7.5 shillings is probably an underestimate for such periods. This seems to be confirmed by looking at the price gap between Hamburg and Königsberg using the data in Jacobs & Richter

(1934, pp. 52-53). This might be expected to be a good indicator of Baltic transportation costs, and does indeed spike in 1839 and 1847.

As is to be expected, the near prohibitive tariffs of the mid-1830s are not reflected in the price gap. At this time, local supply and demand would have determined English prices. Moreover, of the small amounts of wheat imported at this time, only a relatively small amount came from Prussia, with a larger proportion coming from Colonial suppliers (BPP, various). Germany ceased being a major supplier of the UK market and became progressively more protectionist from 1879, thus accounting for the late divergence of prices. Otherwise, the correspondence between the AVEs and the price gap is clear.

In summary, it seems that the AVEs accurately reflect the rise and fall of wheat protection after 1828. They thus have an important role to play in analyses of the nineteenth century. The famous contention that the nineteenth century political debate about the Corn Laws was "much ado about nothing" (Kemp 1962, p. 189), a claim largely based on the fact that the "repeal" did not immediately lead to reduced cereal acreage in Britain[27] can now be tested using annual data. Looking at imports, it seems that the level of protection was very important. At times of low duties imports reached levels not unlike those seen immediately after repeal, although numerous other factors certainly also played a role. The impact of the Corn Laws on market integration can perhaps also now be analyzed. Definitive answers must await formal econometric testing. My estimates support the work of Capie (1983, p. 9), who concludes for a more general survey of protection and import ratios, that "protection was not as high or not as effective as usually supposed", which is also the natural conclusion to be drawn from the work of Vamplew.

5. Conclusion

By focussing on 1846, historians have tended to ignore the legislative progress towards free trade before and after that date. This is mirrored by a fascination with the Anti-Corn Law League, an organization which was first founded in 1838 by which time the British market was already open! We should not forget that, amongst the peaceful protestors

[27] See the discussion in Williamson (1990), p. 129.

demonstrating for parliamentary reform attacked by the British military in the famous Peterloo Massacre of 1819, were some holding banners proclaiming “No Corn Laws”. At this time Cobden was just a boy of 15.

Through an analysis of the legislation and estimates of the *ad valorem* incidence, it is possible to establish several facts about British wheat protection under the Corn Laws. First, prohibitive tariffs were a nineteenth century phenomenon, and statutory protection was in fact only significant for about twenty years after Waterloo. Second, the incidence of the Corn Laws after 1828 was, for most years, not as high as has previously been suggested. However, some of the years of highest protection occurred after the passing of the reformed sliding scale in 1842, a point that has not previously been understood. Third, Britain’s legislative movement towards free trade in wheat should be dated from the 1820s rather than the 1840s. Fourth, and related to the previous point, the famous repeal of 1846 marked neither the beginning nor the end of Britain’s progress towards free trade in grain.

As previously noted, none of this tells us whether Britain really led the European movement towards free trade. However, before 1815 Britain had been very open and, in an interesting parallel to later years, she was importing substantial amounts of grain and flour from the United States. Thus it was that Napoleon’s Continental System failed to starve Britain into submission (Galpin 1922 and 1925). This must surely have been a death blow to the traditional argument for European agricultural protection: that it was necessary in order to secure a home-grown supply of food in case of war. Britain’s example should have been a powerful and convincing one. The lesson took a while to sink in, even for the British, but once it did it would help change the world for ever.

References

BARNES, D.G. (1965). *A History of the English Corn Laws from 1660-1846.* New York: Sentry Press

BLACK, J. & WINTERS, L.A. (eds.) (1983). *Policy and Performance in International Trade.* London: The MacMillan Press Ltd.

CAPIE, F. (1983). Tariff Protection and Economic Performance in the Nineteenth Century in Black & Winters (1983)

DAVIDSON, R. & MACKINNON, J.G. (1993). *Estimation and inference in econometrics.* Oxford University Press

DOORNIK, J. A., and HANSEN, H. (1994). *A practical test for univariate and multivariate normality.* Discussion paper, Nuffield College.

DORMOIS, J. & LAINS, P. (2006). *Classical Trade Protectionism 1815-1914.* Abingdon: Routledge

ECONOMIST (May 5, 2005). Progress at last.

ESTEVADEORDAL, A. (1997). Measuring protection in the early twentieth century. *European Review of Economic History* **1**, pp. 89-125

FAIRLIE, S. (1965). The Nineteenth-Century Corn Law Reconsidered. *The Economic History Review* **18:3**, pp. 562-575

FAIRLIE, S. (1969). The Corn Laws and British Wheat Production, 1829-76. *The Economic History Review* **22:1**, pp. 88-116

FAY, C.R. (1932). *The Corn Laws and Social England.* Cambridge: Cambridge University Press

GALPIN, W.F. (1922). The American Grain Trade to the Spanish Peninsula, 1810-1814. *The American Historical Review* **28:1**, pp. 24-44

GALPIN, W.F. (1925). *The Grain Supply of England During the Napoleonic Period.* New York: Macmillan

GRAMPP, W.D. (1987). How Britain Turned to Free Trade. *The Business History Review* **61:1**, pp. 86-112

HARLEY, C.K. (1996). *The Integration of the World Economy II.* Cheltenham: Edward Elgar

IMLAH, A.H. (1958). *Economic Elements in the Pax Britannica.* Cambridge, MA: Harvard University Press

IRWIN, D.A. (1993). Free Trade and Protection in Nineteenth-Century Britain and France Revisited: A Comment on Nye. *The Journal of Economic History* **53:1**, pp. 146-152

JACOBS, A. & RICHTER, H. (1935). *Die Großhandelspreise in Deutschland von 1792 bis 1934 (Sonderhefte des Instituts für Konjunkturforschung. Nr. 37.).* Hamburg: Hanseatische Verlagsanstalt

KEMP, B. (1962). Reflections on the Repeal of the Corn Laws. *Victorian Studies* **5:3**, pp. 189-204

MALEMBAUM, W. (1953). *The World Wheat Economy 1885-1939.* Cambridge, MA: Harvard University Press

MCCLOSKEY, D.N. (1980). Magnanimous Albion: Free Trade and British National Income, 1841-1881. *Explorations in Economic History* **17**, pp. 303-320

MCCORD, N. (1968). *The Anti-Corn Law League.* London: Unwin University Books

MCCORD, N. (1970). *Free Trade.* Newton Abbot: David & Charles

NICHOLSON, J.S. (1904). *The History of the English Corn Laws.* London: Swan Sonnenschein & Co. Ltd.

NORTH, D. (1958). Ocean Freight Rates and Economic Development 1750-1913. *The Journal of Economic History* **18:4**, pp. 537-555

NYE, J.V. (1991). The Myth of Free-Trade Britain and Fortress France: Tariffs and Trade in the Nineteenth Century. *The Journal of Economic History* **51:1**, pp. 23-46

NYE, J.V. (2007). *War, Wine, and Taxes: The Political Economy of Anglo-French Trade, 1689-1900.* Princeton: Princeton University Press

O'ROURKE, K.H. (1994). The Repeal of the Corn Laws and Irish Emigration. *Explorations in Economic History* **31**, pp. 120-138

O'ROURKE, K.H. (1997). The European Grain Invasion, 1870-1913. *The Journal of Economic History* **57:4**, pp. 775-801

O'ROURKE, K.H. & WILLIAMSON, J.G. (1999). *Globalization and History.* London: The MIT Press

O'ROURKE, K.H. & WILLIAMSON, J.G. (2005). From Malthus to Ohlin: Trade, Industrialisation and Distribution Since 1500. *Journal of Economic Growth* **10**, pp. 5-34

PERSSON, K.G. (2004). Mind the Gap! Transport costs and price convergence in the nineteenth century Atlantic economy. *European Review of Economic History* **8:2**, pp. 125-147

PREST, J. (1996). A Large amount or a Small? Revenue and the Nineteenth-Century Corn Laws. *The Historical Journal* **39:2**, pp. 467-478

RAWSON, R.W. (1842). On the Prices and Fluctuations of Grain in Prussia and England, from 1816 to 1841. *Journal of the Statistical Society of London* **5:1**, pp. 32-46

RICH, S. (2004). *Integration af kornmarkeder i 1800-tallet – med Danmark og Storbritannien som eksempel.* Masters thesis, Department of Economics, University of Copenhagen

SCHLOTE, W. (1952). *British overseas trade from 1700 to the 1930s.* Oxford: Blackwell

SCHNEIDER, J. & SCHWARZER, O. (1990). *Quellen und Forschungen zur Historischen Statistik von Deutschland, vol. XI, Statistik der Geld- und Wechselkurse in Deutschland (1815-1913).* St. Katharinen: Scripta Mercaturae

SCHNEIDER, J. & SCHWARZER, O. & ZELLFELDER F. (eds.) (1991). *Währungen der Welt. Vol. 1, Europäische und nordamerikanische Devisenkurse 1777-1914, part 3*. Stuttgart: Franz Steiner

SCHONHARDT-BAILEY, C. (ed.) (1997). *The Rise of Free Trade Volume IV: Free Trade Reappraised: The New Secondary Literature.* London: Routledge

SCHONHARDT-BAILEY, C. (2006). *From the Corn Laws to Free Trade.* London: The MIT Press

SCHUMPETER, E.B. (1938). English Prices and Public Finance, 1660-1822. *The Review of Economic Statistics* **20:1**, pp. 21-37

TRACY, M. (1989). *Government and Agriculture in Western Europe 1880-1988.* Hemel Hempstead: Harvester Wheatsheaf

VAMPLEW, W. (1980). The Protection of English Cereal Producers: The Corn Laws Reassessed. *The Economic History Review* **33:3**, pp. 382-295

WARD, T. (2004). The Corn Laws and English Wheat Prices, 1815-1846. *Atlantic Economic Journal* **32:3**, pp. 245-255

WILLIAMSON, J.G. (1990). The Impact of the Corn Laws Just Prior to Repeal. *Explorations in Economic History* **27**, pp. 123-156

WORLD TRADE ORGANIZATION. After the framework: technical work on market access. (Agriculture negotiations: backgrounder)

WORLD TRADE ORGANIZATION (10 May 2005). Draft Guidelines for the Conversion of Final Bound *Non-Ad Valorem* Duties into *Ad Valorem* Equivalents. *Committee on Agriculture, Special Session Informal technical work* UU2601

Appendix 1: Testing for cointegration and the long run effect of the AVEs on imports

The following is a cointegration analysis based on an unrestricted ADL or ECM (dynamic) model. The following equation is estimated using PcGive[28]:

$$\log(import)_t = \beta_0 + \beta_1 \log(import)_{t-1} + \beta_2 \log(import)_{t-2} + \beta_3 AVE_t + \beta_4 AVE_{t-1} + \beta_5 AVE_{t-2} + \beta_6 t + \varepsilon_t$$

where *t* is a trend and ε_t is the error term.

The results are given in column 1 in the following table. After removal of the least significant terms, the results are as in column 2:

	(1)	(2)
constant	7.259*	7.551**
$\log(import)_{t-1}$	0.499**	0.462**
$\log(import)_{t-2}$	-0.018	-
AVE_t	-3.674**	-3.691**
AVE_{t-1}	0.168	-
AVE_{t-2}	1.360	1.413**
t	0.026*	0.027**

* - significant at the 10% level; ** - significant at the 5% level

[28] OxPack 3.40 for GiveWin 2, copyright Jurgen A. Doornik 1998-2004.

For model (2), the LM test for no autoregressive residuals is accepted with a p-value of 0.73 and the Doornik and Hansen (1994) test for normally distributed residuals is accepted with a p-value of 0.69. The model thus appears well specified.

Solving for the static long-run solution yields the following equation (t-values in parentheses):

$$ECM = \log(imports) - \underset{(29.4)}{14.033} + \underset{(-4.82)}{4.235}AVE - \underset{(2.29)}{0.049}t \,,$$

Given the variables are cointegrated, then the t-ratios constructed from the estimated standard errors follow normal distributions under the null. The standard errors thus imply that all variables are significant at the 5% level, given that the PcGive test for no cointegration is rejected with a t-value of -5.101, which should be compared to a 5% critical value of -3.69 (critical value from Davidson & MacKinnon 1993).[29]

[29] It should be noted that this is only a preliminary investigation of the relationship between these variables. A fuller investigation should take account of the fact that these are bounded unit root processes. They have a lower limit of zero, and are often close to zero. I am grateful to Heino Bohn Nielsen for making this point.

Appendix 2: Data sources

BPP (1843). *Returns Relative to Importation and Exportation of Corn.* HCPP

BPP (1843 to 1852). *Tables of Revenue, Population and Commerce of United Kingdom and Dependencies and of some Foreign Countries.* HCPP

BPP (1849). *Grain, Flour and Meal.* HCPP

BPP (1853 to 1903). *Annual Statement of Trade and Navigation of United Kingdom with Foreign Countries and British Possessions.* HCPP

Board of Trade (1904). *Second Series of Memoranda, Statistical Tables and Charts.* London: HMSO

MITCHELL, B.R. & DEANE, P. (1953). *Abstract of British Historical Statistics.* Cambridge: Cambridge University Press

Measures in hundredweight have been converted to quarters where necessary at the rate of 4.4 cwt. to the quarter.

Table 3: Schlote and Sharp AVEs

	[A]	[B]	[B/A]	[C]	[A*C]	[D]	[D/(A*C)]
	Gazette Price (s./qr.)	Implied Duty Payable (s.)	Schlote AVE	Wheat imports (quarters)	Value of imports (£)	Duty collected (£)	Sharp AVE
1828	60.42	26.67	44%	748750	2261849	66269	3%
1829	66.25	20.67	31%	1260683	4176013	587645	14%
1830	64.25	22.67	35%	1494382	4800702	493146	10%
1831	66.33	20.67	31%	1088797	3611178	260498	7%
1832	58.67	28.67	49%	166128	487308	193249	40%
1833	52.92	34.67	66%	1144	3027	1124	37%
1834	46.17	40.67	88%	264	609	324	53%
1835	39.33	47.67	121%	48	94	81	86%
1836	48.50	38.67	80%	972	2356	969	41%
1837	55.83	31.67	57%	210254	586959	297545	51%
1838	64.58	22.67	35%	1728453	5581462	134924	2%
1839	70.67	10.67	15%	2521494	8909280	631697	7%
1840	66.33	20.67	31%	2020215	6700379	724106	11%
1841	64.33	22.67	35%	2236153	7192959	384294	5%
1842	57.25	15	26%	2625491	7515467	1107700	15%
1843	50.08	20	40%	843739	2112864	601173	28%
1844	51.25	19	37%	781036	2001405	671033	34%
1845	50.83	20	39%	87701	222908	78344	35%
1846	54.67	4	7%	1903853	5203866	398550	8%
1847	69.75	4	6%	2622086	9144525	2047	0%
1848	50.50	7	14%	1818912	4592752	406935	9%
1849	44.25	1	2%	4450043	9845719	221441	2%
1850	40.25	1	2%	3682273	7410574	187712	3%
1851	38.50	1	3%	3754318	7227063	190714	3%
1852	40.75	1	2%	3013864	6140747	153002	2%
1853	53.25	1	2%	4840909	12888920	247569	2%
1854	72.42	1	1%	3379318	12235948	173140	1%
1855	74.67	1	1%	2627273	9808485	134312	1%
1856	69.17	1	1%	4011136	13871847	205401	1%
1857	56.33	1	2%	3385909	9536977	173770	2%
1858	44.17	1	2%	4177500	9225313	212091	2%
1859	43.75	1	2%	3940227	8619247	199814	2%
1860	53.25	1	2%	5791818	15420716	294178	2%
1861	55.33	1	2%	6808182	18835970	344886	2%
1862	55.42	1	2%	9325909	25840540	472998	2%
1863	44.75	1	2%	5537273	12389648	280870	2%
1864	40.17	1	2%	5272045	10588025	274973	3%
1865	41.83	1	2%	4764318	9965366	262098	3%
1866	49.92	1	2%	5262727	13134890	289340	2%
1867	64.42	1	2%	7874091	25361134	433056	2%
1868	63.75	1	2%	7418182	23645455	407548	2%
1869	48.17	0	0%	8567273	20632848	133059	1%
1870-1901			0%				0%
1902	28.08	1	4%	18409545	25850070	789763	3%
1903	26.75	0	0%	20029773	26789821	456424	2%
1904-1931			0%				0%

Notes:

For data sources see appendix.

1828 is from July 15.

Until 1849 all figures are based on foreign wheat released from bond.

From 1850 all figures are based on total imports.

Chapter 2

Frontier Farmers and the Atlantic Economy: Another look at the causes and consequences of the American grain invasion of Britain in the nineteenth century[30]

Abstract: The usual explanation for the American grain invasion of Britain in the last decades of the nineteenth century is that falling transportation costs caused the price gap between the US and the UK to fall, causing US prices to rise, UK prices to fall, and thus causing US export supply and UK import demand to increase. This paper documents that this story is flawed. Falling per mile transportation costs simply permitted an expansion of frontier farming in the US, while the price received by the average American farmer remained constant. What this process did allow, however, was a massive increase in US output, which was then available to supply the booming demand in the UK. The grain invasion was therefore not a response to increasing prices by American farmers, who in reality offered a perfectly elastic supply at the going price as practically unlimited supplies of land in the West were populated by immigrants.

[30] I am indebted to Giovanni Federico, Markus Lampe, Niels Framroze Møller, Heino Bohn Nielsen, Alan Olmstead, Karl Gunnar Persson and seminar and conference participants for assistance and suggestions.

1. Introduction

The dominant explanation for the growth of an Atlantic Economy at the end of the nineteenth century, associated in particular with C. Knick Harley and Jeffrey G. Williamson, has stressed the importance of falling transportation costs, both across the Atlantic and within the United States. Improvements in transportation technology – with the movement from sail to steam and the extension of the rail network – allowed wheat in particular to flood into Europe from grain producers in America. Prices fell in Europe, stimulating demand, and increased in America, stimulating supply.

This paper, whilst accepting that falling transportation costs were crucial for this "grain invasion" (ca. 1870-1900), disputes some of the key assumptions routinely made about their consequences. Crucially, it questions the Panglossian interpretation of the grain invasion, in which both UK consumers and US producers won. In fact, the price received by the average American farmer did not increase in real terms.

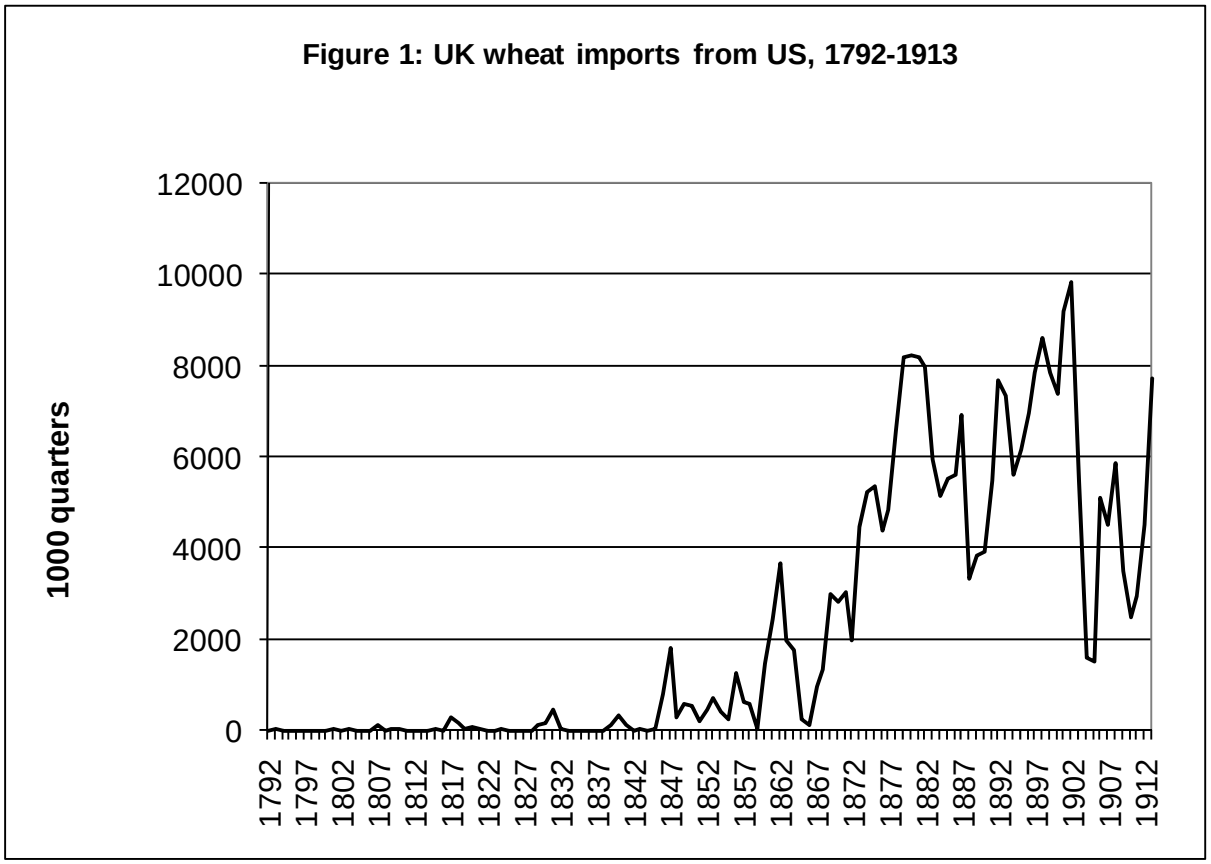
Falling per mile transportation costs did, however, permit an expansion of frontier farming in the US. This process thus allowed a massive increase in US output as the centre of production moved west, which was then available to supply the booming demand in the UK. The grain invasion was therefore not a response to increasing prices by American farmers, who in reality offered a perfectly elastic supply at the going price as practically unlimited supplies of land in the west were populated by immigrants, an argument inspired by that famously put forward by Lewis (1954).

2. The grain invasion of Britain and the expansion of the American frontier

In common with much of the literature on the grain invasion, this paper focuses on the wheat trade between the US and the UK. This is not to say that other trading pairs were unimportant, but Britain was by far the most important export market for US wheat, taking about one half of her exports from 1870 to 1914 (Williamson 1980, p. 195n), at least in part because other European countries protected their agriculture for most of this period.

Before attempting to explain the grain invasion as an historical phenomenon, it is worth standing back for a moment and reflect on what it actually entailed. As figure 1 demonstrates, this was a truly dramatic event. Although America had been an important supplier of wheat since colonial times, and was to play a significant role during the Napoleonic Wars (Galpin 1922, 1925) and periodically thereafter, it was not until after the Civil War that UK imports of American wheat were to reach a more permanently high and significant level.

Figure 1: UK wheat imports from US, 1792-1913



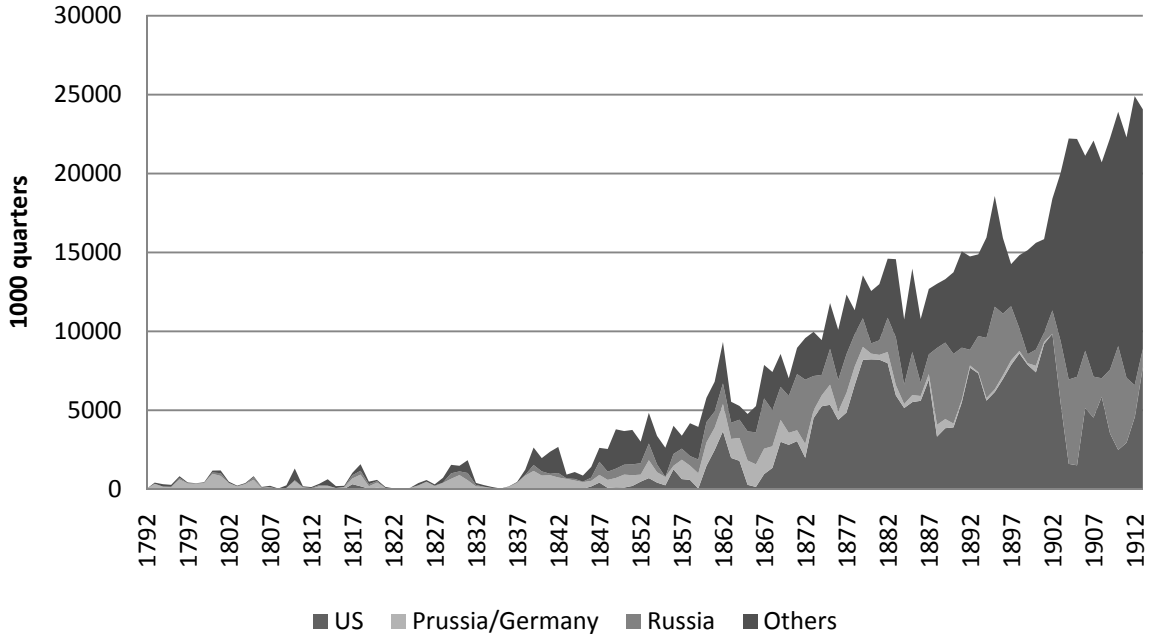
Sources: BPP (various), Mitchell & Deane (1953)

Prior to this, trade fluctuated wildly. The rise and fall of wheat imports after 1815 was determined by trade policy and in particular the unusual mechanisms for regulating imports contained in the Corn Laws (see Sharp 2006). Before the grain invasion, British imports were mainly from Europe, in particular Prussia and "Germany"[31]. All this changed, however, with the movement to repeal of the Corn Laws, which were relaxed in 1842, 1846 and 1849; and

[31] These are the descriptions used in the British trade statistics.

were finally abolished in 1869. As figure 2 demonstrates, in the second half of the nineteenth century the UK became more dependent on distant sources of supply, in particular the US, although from the 1880s the US lost ground to other countries, such as Russia, which had long been a main source of supply, as well as new producers in particular from Canada, Argentina, India and Australia. In this sense, the US grain invasion was soon followed by a more general "new world" invasion. Nevertheless, something changed after the 1860s, and the United States led this change.

Figure 2: Sources of imports of wheat to the UK 1792-1913



Sources: BPP (various), Mitchell & Deane (1953). Hundredweight converted to quarters at 4.4 cwt per quarter.

The period of the grain invasion coincided with another key event in the history of American agriculture: the westward movement of the frontier. Over the course of the nineteenth century the centre of wheat production moved from New York State, Virginia and Pennsylvania to the Midwest which dominated around the Civil War, with states such as Illinois, Iowa, Michigan and Wisconsin. But by the end of the nineteenth century the major new wheat producing states were Nebraska, Kansas and North and South Dakota. This westward movement, and the simultaneous introduction of new varieties of wheat which

were suited to the new climates and soil conditions (Olmstead & Rhode, 2002,2008), led to huge increases in production: fuel for the grain invasion. Figure 3 illustrates this.

Figure 3: Wheat production in 1839 and 1909

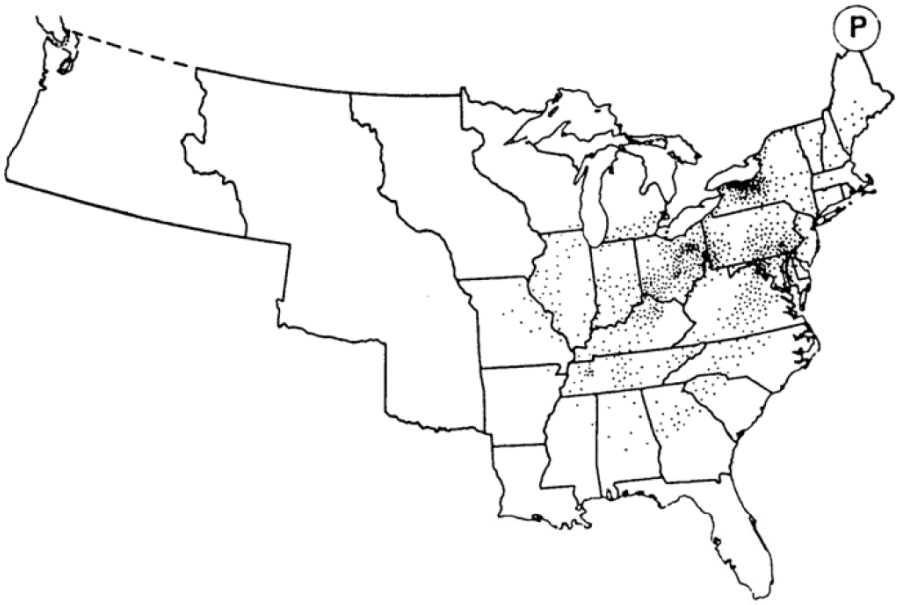


FIGURE 2A
WHEAT PRODUCTION, 1839

Note: Each dot represent 100,000 bushels.
Sources: Paullin, *Atlas,* plate 143P, used by permission.

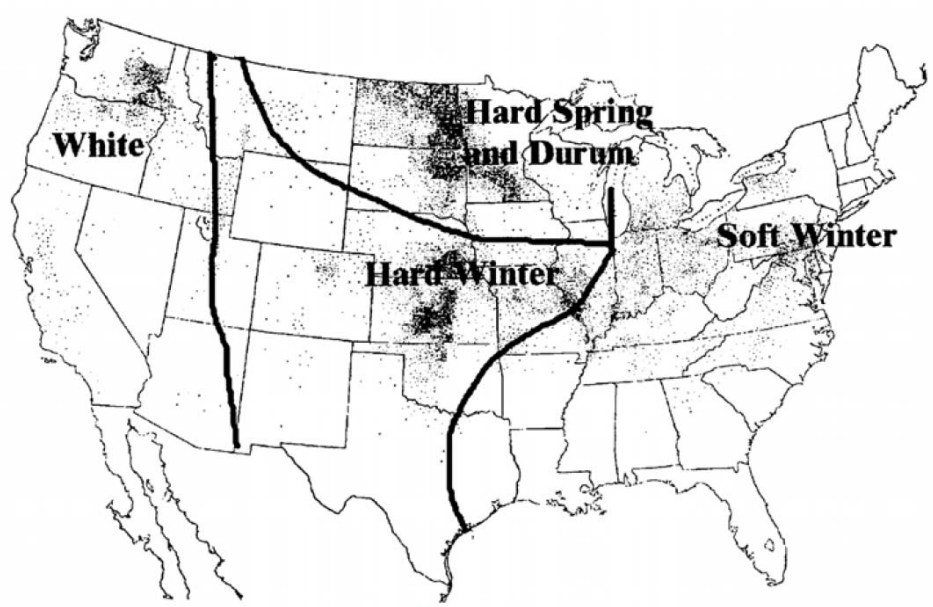
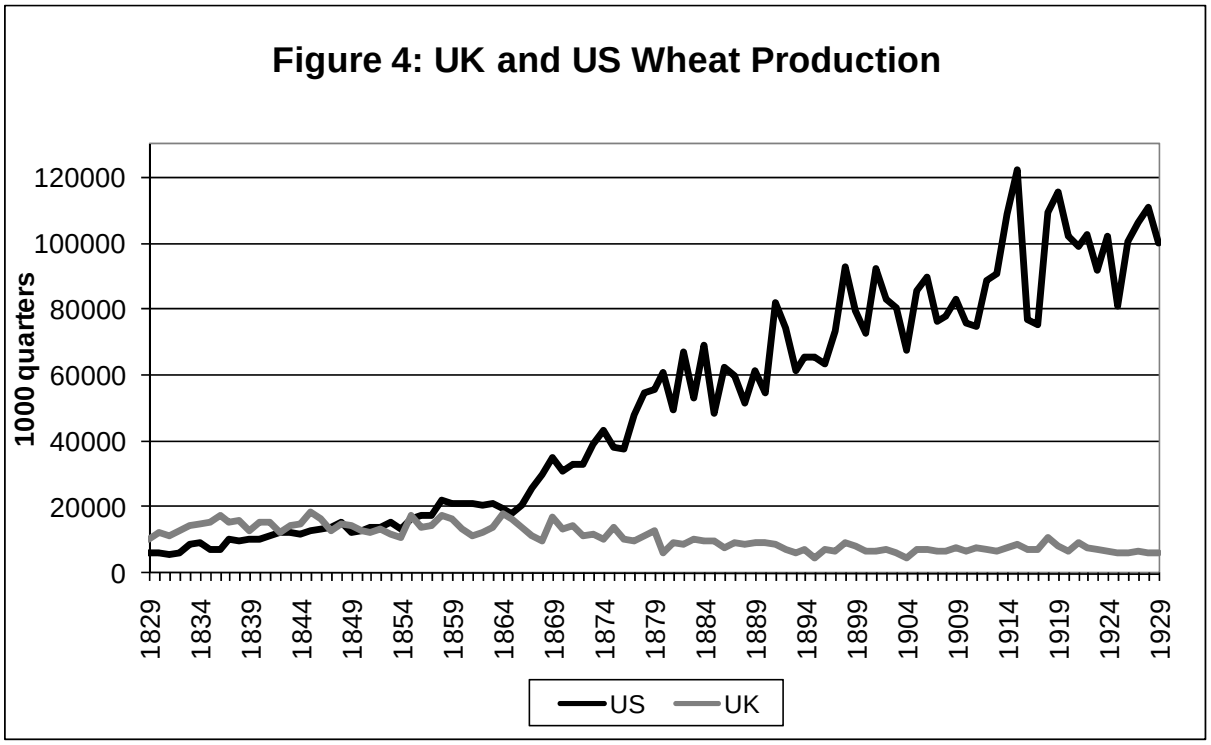


FIGURE 2B
WHEAT PRODUCTION, 1909

Note: Each dot represents 50,000 bushels.
Source: U.S. Bureau of the Census, *Thirteenth Census*, Vol. 5, plate no. 3.

Source: Olmstead & Rhode (2002)

The movement of the frontier was, of course, mirrored by a dramatic increase in the production of wheat in the US, and as a response to the invasion, UK production shrank. I have attempted to reconstruct wheat production data for both countries for the century from 1829 to 1913 (see appendix B). Please note, however, that the US production data prior to 1866 is for illustrative purposes only, and cannot be relied on for econometric analyses.



Source: See appendix B.

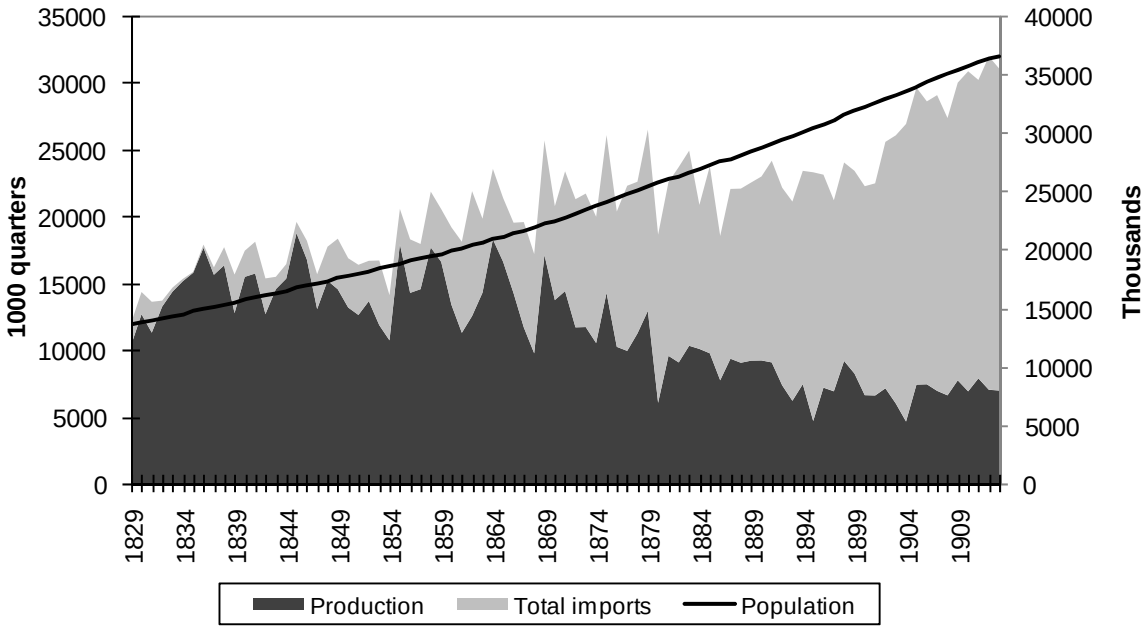
Figure 4 reports the production series for the US and the UK, and makes for fascinating reading in itself. The story of the American supply is one of increase throughout the period, rapidly overtaking that of the UK. Rothstein (1965, pp. 62-63) attributes the expansion of American agriculture after 1850 to technological innovations in agriculture and transportation, a point already noted by Anon (1934, p. 293) for the period after 1870. Olmstead & Rhode (2002, 2008) have stressed that this innovation was largely biological, in

finding varieties of wheat that could be grown in new climates away from the East Coast. The last year when UK production exceeded that of the US is 1855.

The data for UK production are no less interesting: British agriculture certainly does not give up immediately. The largest crop is recorded for 1845 with over 18 million quarters, but a similar level is also reached in 1864. Even by the early 1870s, UK crops are not noticeably below their long-term average level, but a marked decline sets in soon after, falling to about half their historical average by the end of the period. By the 1920s, the UK was producing only about 6 million quarters per year, whilst the US was producing regularly in excess of 100 million quarters.

UK production as a proportion of UK consumption is illustrated in figure 5. Consumption is assumed to be equal to total UK production plus total imports (from Mitchell & Deane, 1962, pp. 97-99). The increase in population from 1829 to 1913 is also shown. (Mitchell & Deane, 1962, pp. 8-10) This increase in demand was the necessary counterpart to the expansion of supply.

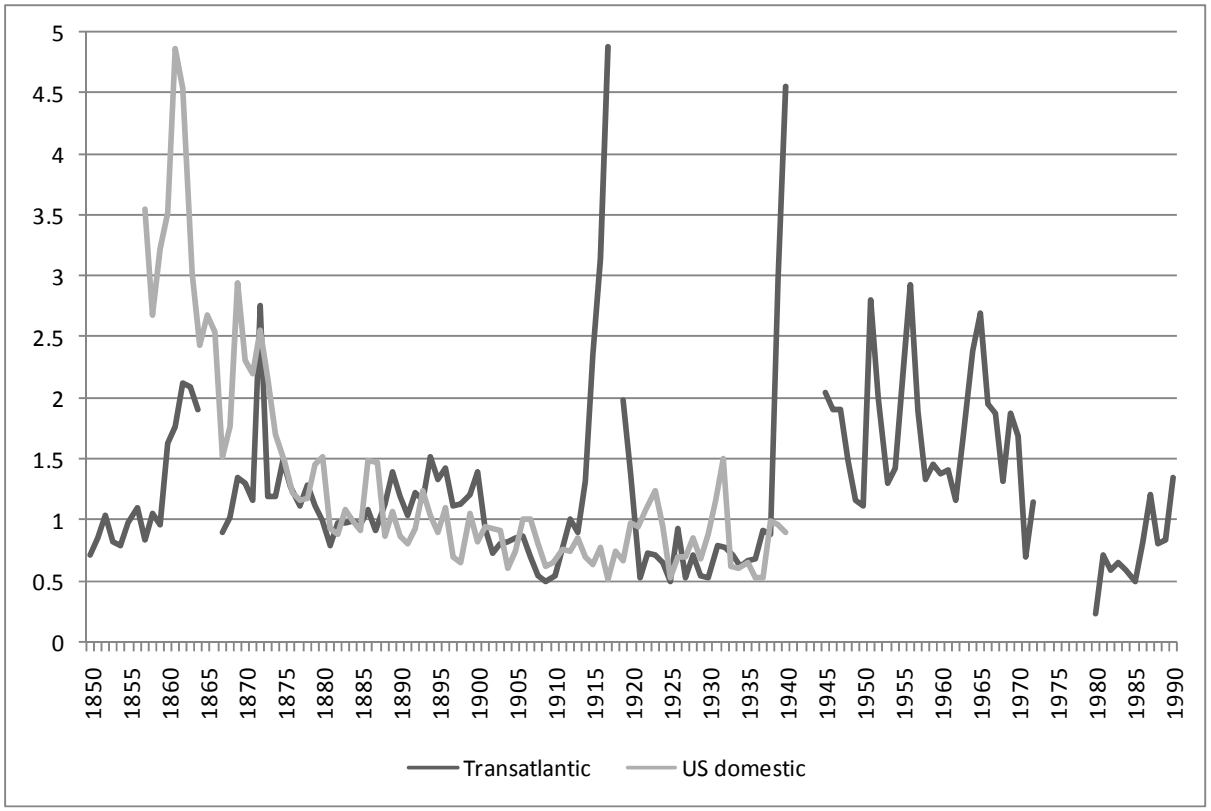
Figure 5: UK production and imports of wheat, and population 1829-1913



Source: Mitchell & Deane (1962), own calculations

The grain invasion and the movement of the frontier was made possible by a dramatic decline in domestic transportation costs, which slashed the per mile cost of transporting wheat. Figure 6 uses the data compiled by Federico & Persson (2007), and shows the "freight factor" (the cost of transporting a unit of wheat divided by the price of a unit of wheat) for the transportation of wheat from Chicago to New York and from New York to London. As the authors note, the striking lesson to be learned from this is that the transatlantic freight factor remained almost constant over the period, and indeed in the long run even to today, although with large fluctuations. The US domestic freight factor, on the other hand, declined during the grain invasion period and until the First World War, most probably largely due to a change in market organization, rather than technological developments.

Figure 6: Freight factors, 1850-1990 (1884 = 1)



Source: Federico & Persson (2007)

This picture of falling transportation costs, frontier movement and increasing exports has led to the compelling story of the grain invasion, as suggested by Knick Harley in the 1980s.

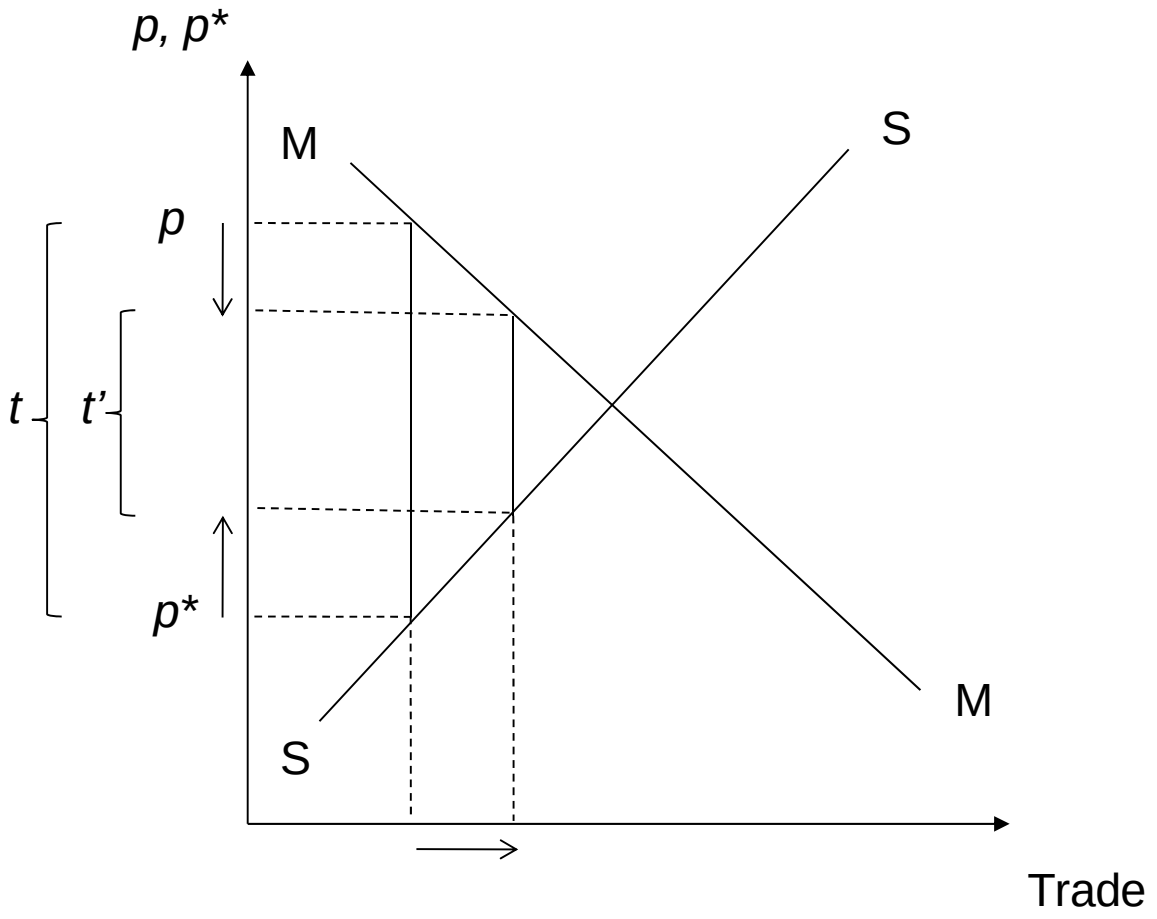
3. The Harley hypothesis

Harley (1986) provides some of the original work on the reasons for the expansion of the transatlantic grain trade. His hypothesis is simple and relies on two elements. First, a model of the world market, and second, a model of the movement of the frontier.

3.1 Harley's model of the world market for wheat

Harley's model for the impact of falling transportation costs is usually summarized as in figure 7 (see for example O'Rourke & Williamson 1999, p. 31). A fuller account of his original model is given in appendix A.

Figure 7: A simple model for explaining the increase in trade



The MM schedule is the UK's import demand function (i.e. UK demand minus UK supply). It is falling with the home market price, *p*. SS is the US export supply schedule (US supply

minus US domestic demand) and is increasing in the price abroad, *p**. The law of one price states that, in the absence of any sort of barriers to trade, then *p* should equal *p** in equilibrium. Any difference in prices would lead to short-term arbitrage, which would return the economy to its equilibrium state. However, with barriers to trade, for example tariffs and transportation costs, a wedge, *t*, is driven between export and import prices – the higher the barriers to trade, the larger the wedge.

Harley's hypothesis can be understood by imagining an inward shift of the transport cost "wedge" in figure 7, i.e. a fall in *t* to *t'*. The old import price, *p*, now corresponds to a higher price (minus transport costs) for the exporting region. This implies that the quantity supplied by the exporting region will increase. *Ceteris paribus* this will result in excess supply in the importing region leading to a decline in price. At the same time, the old price, *p**, in the exporting region now corresponds to a lower price in the importing region, thus leading to excess demand and pushing up the price in the exporting region. Import prices have thus fallen, and export prices have risen. Supply in the exporting region will increase and domestic supply in the importing region will decrease.

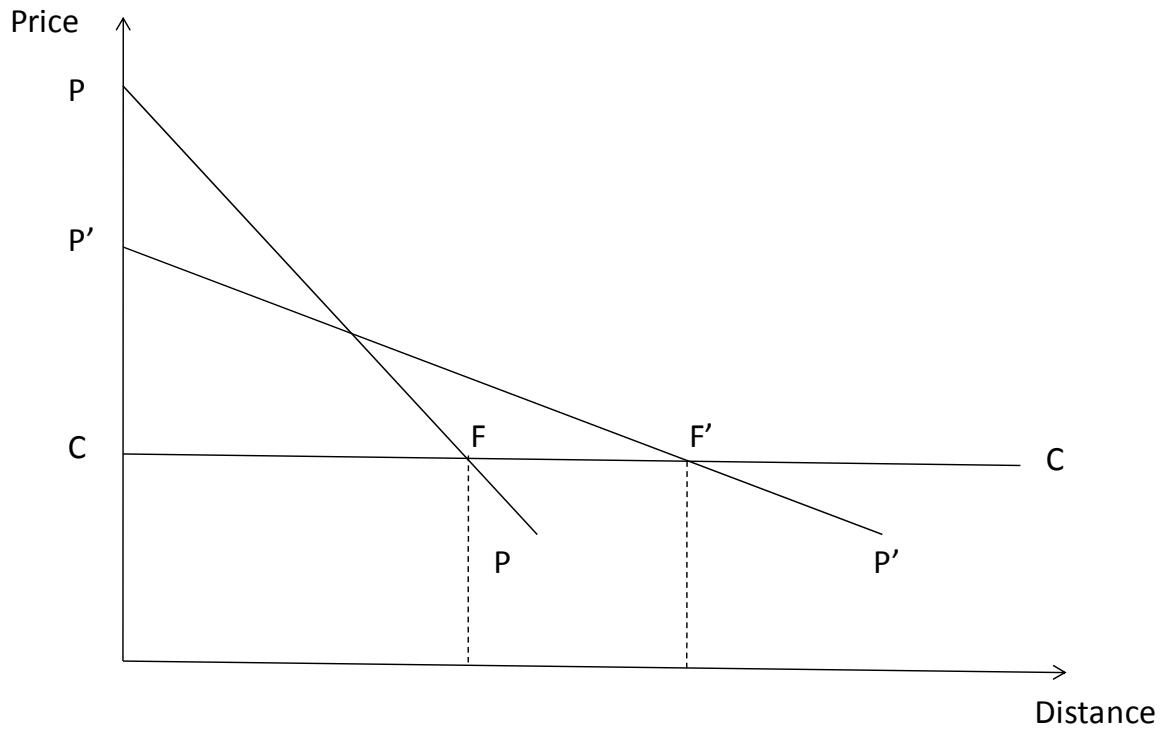
3.2 Harley's model of the movement of the frontier

The basis of this part of the model is Ricardo's extensive margin, which here is determined by transportation costs. At the margin, or frontier, transportation costs exhaust any surplus over the variable costs of production, so no revenue is left as a rent on land. No production will therefore take place beyond the margin.

Figure 8 illustrates this. The horizontal axis gives the distance from Europe, and the local price and costs of production are on the vertical axis. It is assumed that the transportation costs are a linear function of distance. The transportation costs at each location can be read as the vertical distance between the PP schedule and its intercept with the vertical axis.

A fall in transportation costs makes the PP schedule flatter to P'P' and, as shown in figure 7, causes the price in Europe to fall. Farmers at the old frontier will see an increase in the price they can sell their wheat for.

Figure 8: Harley's model for the movement of the frontier



3.3 A brief criticism

Harley presents a simple but powerful story, which has provided a useful way for scholars to understand the grain invasion over the years. We might, however, be inclined to criticize this story on two counts.

First, as noted in the introduction, it suggests a rather Panglossian view of the grain invasion, whereby both UK consumers and US producers won, in terms of lower and higher prices respectively. This is difficult to reconcile with the fact that this was in fact a time of agrarian discontent in America. Why were farmers protesting, if their lot was improving?

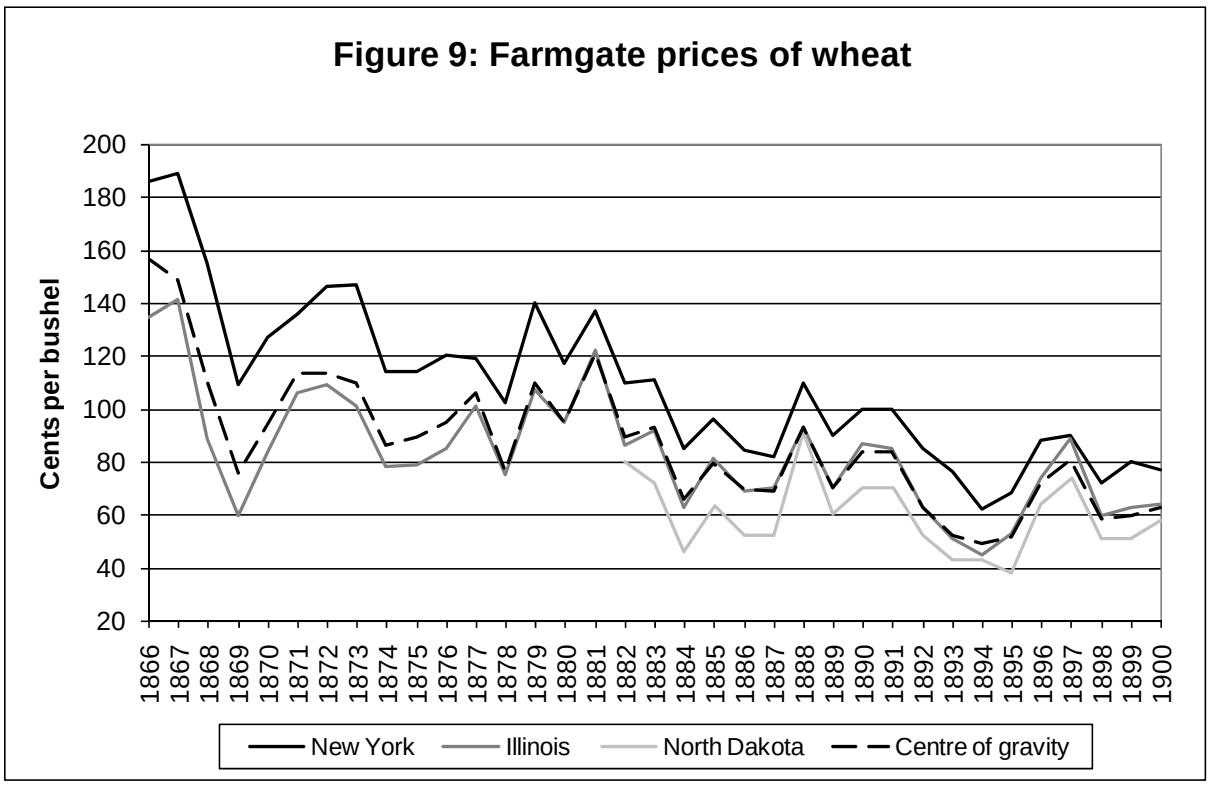
Second, and related to the first, there are difficulties in the interpretation of the wedge in figure 7. It is normally considered to be equivalent to the trading costs between two fixed locations (for example Chicago and Liverpool). This ignores, however, an important point made by Olmstead and Rhode (2007, p. 118). Although per mile transportation costs within the US were undoubtedly falling, the distance grain was being transported was also increasing. Simply looking at the cost of transporting grain from one particular location

(Chicago) to the East Coast as in figure 6 might then hide the true cost of domestic transportation from the main production areas, which were moving west over time. It is strange to ignore the movement of the frontier in this story, at the same time as this was presumably what allowed the massive expansion of production in the US.

4. A closer look at the role of transportation costs

The relevant measure of the barrier to trade implied by domestic transportation costs is the cost of transporting a unit of wheat from the area of production to the UK. There are a couple of problems associated with estimating this. As noted in the previous section, the relevant distance is changing over time. Moreover, there is no data available on transportation costs west of Chicago.

A way of getting around these problems is by making use of price differentials between American states, and assuming that, by the Law of One Price, these differentials must be related to the cost of transportation between these states. This is of course simply the assumption made by Harley, as illustrated in figure 8. That prices were lower further west is clear by comparing farm gate prices in various locations, as illustrated in figure 9.



Source: Cooley, DeCanio & Matthews (1977), own calculations

To illustrate the relevant price for the average farmer, the price at the centre of gravity (COG) of production, p_t^{COG}, is then defined as the weighted average of the farm gate price of wheat using the prices, p_t^i, given for each of the 1 to *I* states included in the sample[32], weighted by the production in each state, q_t^i, i.e.

$$p_t^{COG} = \frac{p_t^1 * q_t^1 + p_t^2 * q_t^2 + p_t^3 * q_t^3 + \cdots + p_t^I * q_t^I}{q_t^1 + q_t^2 + q_t^3 + \cdots + q_t^I} \quad (1)$$

This price is also illustrated in figure 9. The movement of the frontier is clearly discernable, since the centre of gravity price lies between the New York and Illinois prices at the beginning of the period, but by 1900 it is below that in Illinois.

The COG price is then used to get an idea as to the cost of shipping wheat using information on price differentials between the production area, and the East Coast (New York). As figure

[32] In fact, the number of states with data is not constant each year, so *I* is also dependent on time.

8 makes clear, given trade the price differential between each state and New York must be equal to the cost of trading wheat from that state to New York. By calculating the differential between the price in the COG of production and the price in New York, we get an estimate of the price of shipping wheat for the average farmer.

Might these price differences simply be due to quality differences between the states, however? Of course, this is a possibility, but in fact there are theoretical reasons to believe that the wheat furthest from the East Coast should have had the *highest* quality, and thus the highest price *ceteris paribus*. Alchian and Allen (1967) noted long ago that there is good reason to 'ship the best apples out' since transport costs do not differ for good and bad apples making the low quality apple relatively more expensive in foreign markets. Transport is thus simply a specific price increase which lowers the relative price of the higher-quality produce in the distant market. East Coast and European demand will therefore shift to the high quality variety of the commodity. Producers might have been expected to meet that demand by improving the quality of the product.[33] The price differential for a comparable quality of wheat might therefore be underestimated using this method; increasingly over time, as quality further west improved. This has the implication that the fall in US domestic transportation costs might be underestimated.

It is then necessary to construct estimates of transatlantic transportation costs. Although records exist for the cost of transporting wheat from New York to Liverpool or London, these do not reflect all the trading costs involved, which, for example, would also have included the tariffs on wheat imposed in the UK until 1869, and from 1902-3 (Sharp 2006). It is thus preferable to impute trading costs using the price of an identical quality of wheat on both sides of the Atlantic, in this case "American winter".

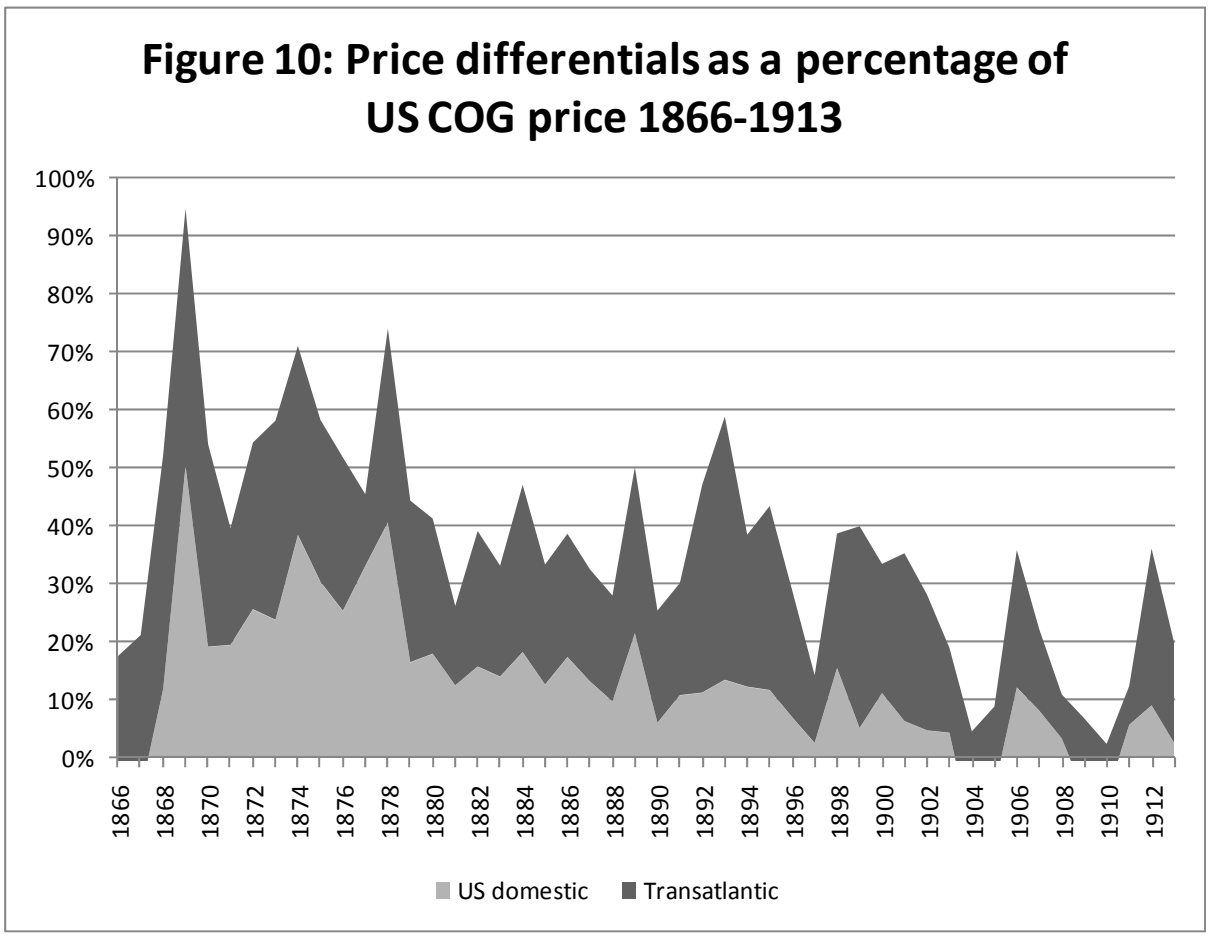
Total trading costs, expressed as a percentage of the COG price, are defined as z_t in equation (2):

[33] Moreover, it is well known that the hard wheat grown further west enjoyed a premium over the softer wheats grown nearer the East Coast, at least with the adoption of roller milling in Europe during the early 1880s. (Bell 1952, p. 272)

$$z_t = \left(\frac{p_t^{UK} - p_t^{US}}{p_t^{COG}} + \frac{p_t^{NY} - p_t^{COG}}{p_t^{COG}}\right) * 100 \approx \left(\frac{p_t^{UK} - p_t^{COG}}{p_t^{COG}}\right) * 100 \quad (2)$$

p_t^{UK} is the price of "American winter" wheat in Liverpool. p_t^{US} is the price of the same in New York. The difference between these should be the transatlantic trading costs. p_t^{NY} is the average farm gate price of wheat in New York state, and p_t^{COG} is defined above. The difference between these should be the US domestic transportation costs. The price differentials are deflated by the price of wheat at the COG. If p_t^{US} and p_t^{NY}were the same, then it would be possible to reduce the equation further, as shown, but the former is the price of a particular quality of export wheat in New York, and the second is the average farm gate price of all wheat produced in New York State, so is clearly not identical. Nevertheless, the sum of the two differentials should be approximately equivalent to the price differential between Liverpool and the COG, controlling for quality differences over the Atlantic.

The two components are illustrated in figure 10, where the total height is the price gap between the COG and Liverpool as a percentage of the COG price. Clearly, there is a decline over the grain invasion period, with most of the decline due to changes in trading costs within the United States. The data starts in 1866, when data on farm gate prices by US states become available.



Sources: The data for "American winter" wheat in Liverpool and New York come from Harley (1980, pp. 246-7). The farm gate prices used to construct the US domestic component are taken from Cooley, DeCanio & Matthews (1977).

The series of prices for the centre of gravity of production also has other implications. For example, it is well known (at least since North 1974, see also Williamson 1980, p. 200) that the price of wheat at individual locations in the US was increasing in the last years of the nineteenth century, in line with the simple analysis of the effect of falling transportation costs above: Harley's model implies that the gains from falling transportation costs were shared between the producing and consuming regions. It is simple to verify this with the data used here.

In the UK, the price of American wheat fell by 2.35 per cent per year while US producers' prices fell by 1.72 per cent per year using a typical measure from one location (Chicago) when calculated as the slope coefficient of a linear regression of the log of prices. However, the grain invasion era was a period of a general and substantial deflation which means that

we need to compute the change in wheat prices relative to the price level. The US wholesale price index fell by 2.0 per cent per year in the period (Carter et al 2006, series Cc125) indicating that the real change in the producer price of wheat, that is the price deflated by the price index, is -1.7 - (-2.0) = 0.3 per cent. Producers thus gained in real terms. A similar calculation for consumers but using the UK wholesale price index as a deflator reveals a fall in the relative price of wheat of -0.58 per cent per year. By these standards consumers and producers seem both to have been treated well, with a small advantage to British consumers. This is completely in line with Harley's predictions.

When looking at the regional pattern of prices, however, it is clear that the farmers further west were getting a significantly lower price for their produce and that the centre of gravity price fell faster than the price at individual locations. The gains for American producers calculated above were thus principally accruing to eastern producers, whilst the frontier farmers got next to nothing. In fact, at the centre of gravity of production, prices fell by 2.12% per year, i.e. at approximately the same level or possibly even greater than the fall in the general price level. Harley's analysis in figure 8 implies constant prices (equal to costs) at the frontier. The above shows that prices at the COG of production were also constant, or possibly falling. This calls for another look at the grain invasion, and the mechanisms which gave rise to it.

5. A re-examination of the Harley hypothesis

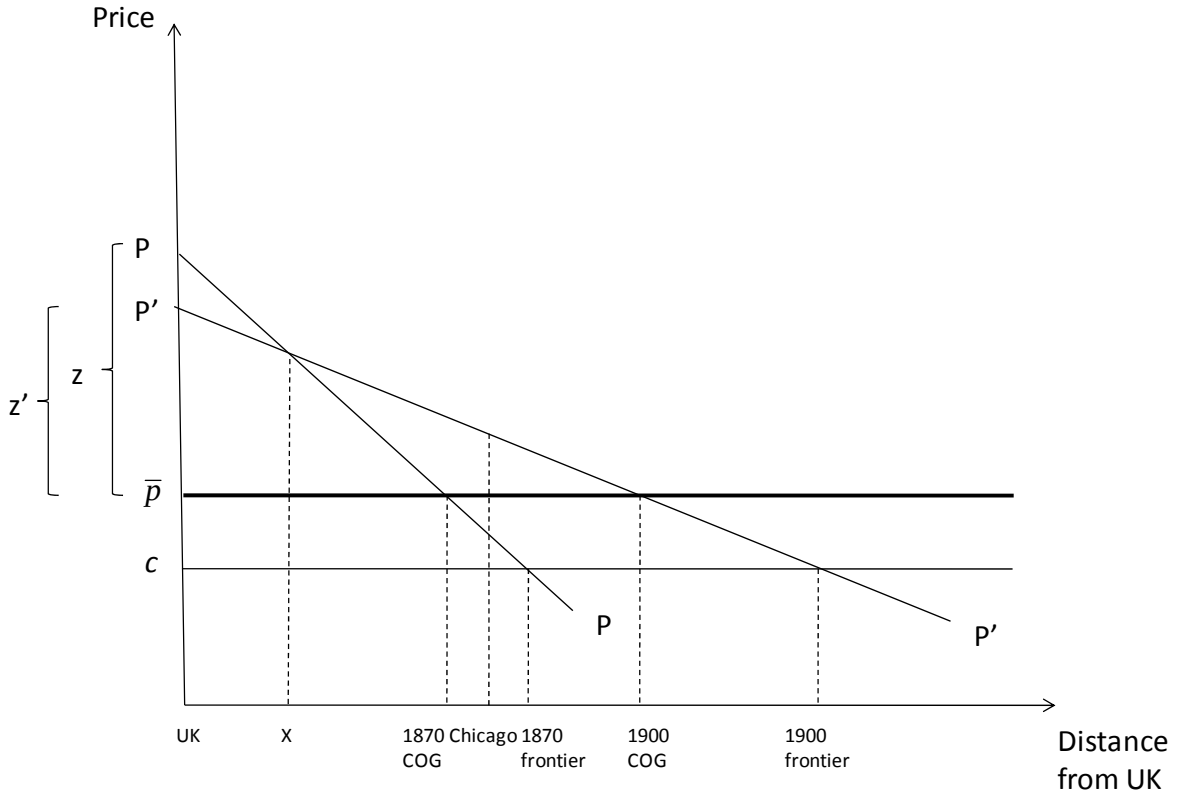
As discussed above, the big change during the course of the nineteenth century was the massive expansion of US wheat supply, which then flooded into Europe.

5.1 Model for the impact of falling transportation costs on the location of production

Figure 11 is a modified version of Harley's original model for the movement of the frontier. The following empirical facts are used:

1. The price of domestic transportation fell on a per mile basis (figure 6). The PP curve thus becomes flatter.
2. The price in the UK decreased in real terms (section 4). The intercept of the PP curve with the vertical axis thus falls.
3. The price at Chicago increased in real terms (section 4). Chicago must therefore have been located to the right of location X (where the real price of wheat remained constant). Chicago was also to the west of the COG in 1870, but to the east of the COG in 1900 (as indicated by the series for Illinois in figure 9)
4. The price at the new centre of gravity is approximately equal to that in the former centre of gravity, $\bar{p}$ (section 4).

Figure 11: The movement of wheat production



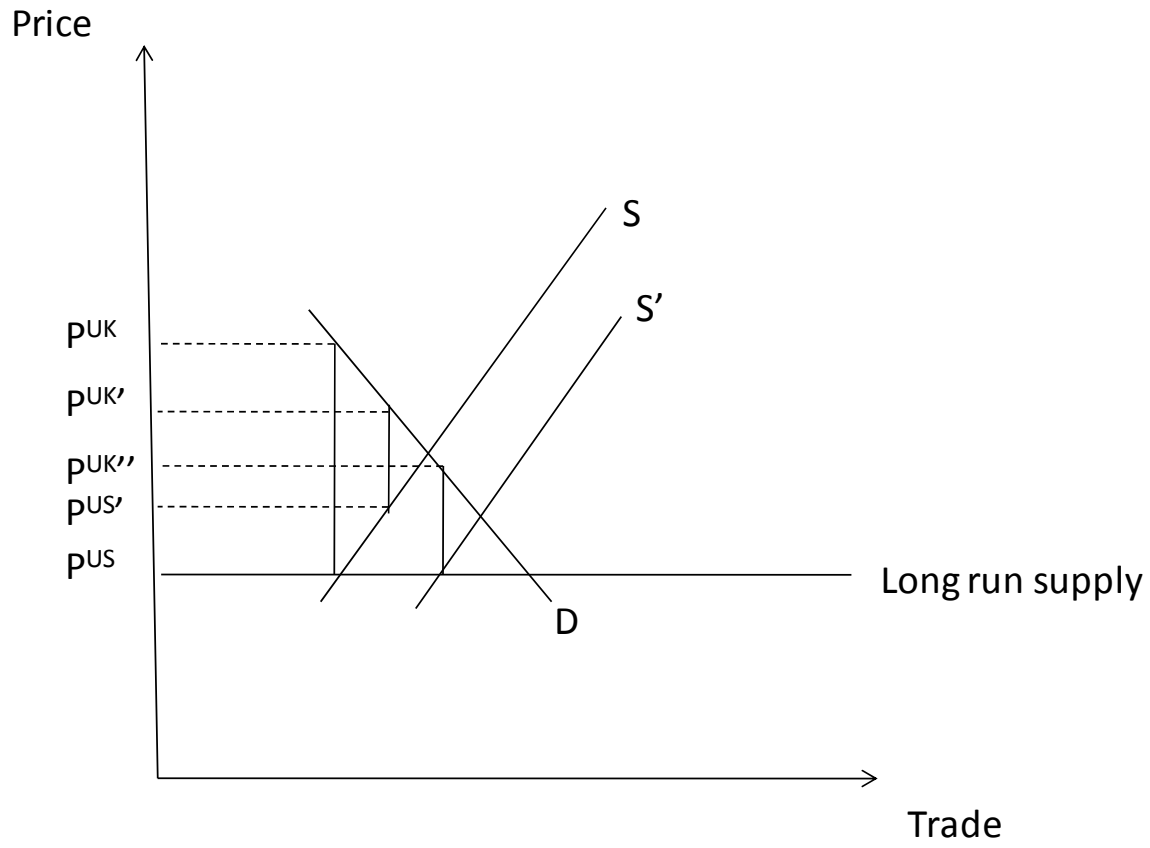
Note that, in this model, there are both short run and long run effects of a decrease in transportation costs. In the short run, the price at the centre of gravity of production will increase. In the long run, however, the centre of gravity will move west and at this new location the price will again be $\bar{p}$. This distinction between the short and long runs is important, and forms the basis of the revised model for the world wheat market.

5.2 Model for the world wheat market

The model in this section is inspired by that described by Shepherd & Walton (1972) to understand the colonial economy. As in their model, a distinction is made between the short and the long run. This reinterpretation suggests a reason why prices for the average farmer remained constant: whenever prices increased above their long run level, then immigrants arrived, extending the frontier, increasing production, but also causing prices to fall back

again. In practice, therefore, the long run supply of wheat was perfectly elastic, due to the elastic supplies of land and labour. This is illustrated in figure 12.

Figure 12: Model of the world wheat economy



Initially, the world price is determined by the intersection of the short run supply curve, S, and the demand curve, D. The short run supply curve is upward sloping, reflecting the costs of extending the frontier, and the fact that immigrants took time to arrive. The long run supply curve, on the other hand, is horizontal, since in the long run immigrants would arrive and force prices at the centre of gravity of production back to $\bar{p}$ again.

Consider a fall in transportation costs, or the move to repeal the Corn Laws. This initially causes the effects in figure 7: the price in the UK falls, and the price in the US increases. As immigrants start to arrive and push the frontier westward, however, the short run supply curve will start to move outwards to S'. At this point, the price of wheat in the US is again at

its long run level, and farmers are receiving $\bar{p}$. Importantly, and in contrast to Harley's original analysis, American producers would then not on average gain from falling transportation costs in terms of higher real prices for their produce, unlike UK consumers, in line with the empirical evidence presented in section 4.

6. What caused the invasion? An empirical test

It is rewarding to attempt a more formal investigation of these theories and the relevance of the price gap, as defined above, for the grain invasion. This is of course, only a partial model. In reality, it is impossible to see the American grain invasion in isolation. More generally, this was a story of increasing wheat imports, only some of which were supplied by the United States. It is therefore not only the British/American price gap that is relevant for the analysis, but a multitude of price gaps between the competing suppliers.

Nevertheless, the theory gives several clear predictions which it is possible to test with the available data. In the long run, the decline in the price differential, z_t, as defined above and thus including the effect from the movement of the frontier, must be responsible for:

i. The increase in trade: falling transportation costs stimulated supply in the US and lessened UK production, leading to an expansion of US exports to the UK (figure 12);
ii. The increase in US production: falling US domestic transportation costs allowed an extension of the frontier through immigration and thus a greater production of wheat (figure 11);
iii. The decrease in UK production: falling transportation costs from the COG of production in the US to the UK causes a fall in the price of wheat in the UK, thus leading to lower British production (figure 11).

6.1 The variables

Imports of wheat from the United States to the United Kingdom is the "trade" variable in figure 12, and the variable(s) which explains this will explain the grain invasion. The volume of UK imports is called m_t and is taken in logarithms. The price gap, z_t has already been defined. Also included are the logs of UK production, q_t^{UK}, and of US production, q_t^{US}.

6.2 The choice of econometric model

The analysis here uses the cointegrated VAR model and the methodology described by Juselius (2006). To model the long-run relationships the following model is estimated:

$$\Delta X_t = \alpha\beta' X_{t-1} + \Gamma\Delta X_{t-1} + \mu + \alpha\beta_0' t + \varepsilon_t \quad (3)$$

where $X_t = (m_t, q_t^{UK}, q_t^{US}, z_t)'$ as described in the previous section, and *t* is the trend. At an early stage of the analysis the trend was, however, found to be insignificant, and was discarded.

This model assumes that the $p = 4$ variables in X_t are related through *r* equilibrium relationships with deviation from equilibrium $u_t = \beta' Z_t$, and α characterizes the equilibrium correction. It holds that α and β are $p \times r$ matrices and the rank of $\Pi = \alpha\beta'$ is $r \leq p$. The autoregressive parameter, Γ, models the short-run dynamics, and throughout it is assumed that $\varepsilon_t \sim iid.N_p(0, \Omega)$.

This approach enjoys many advantages. In particular, all the variables are considered in a very general model in which they are all initially treated as endogenous. This means that any potential relationship between the variables can be modelled, in contrast to other modelling techniques which usually assume a theoretical model and attempt to fit the data into this structure. The relationships found between the variables can thus be considered "sophisticated stylized facts" (Juselius & Franchi, 2007) which the theory model has to replicate before it can claim empirical relevance. Another advantage is that the cointegrating equilibrium relationships between the variables are by definition invariant to the addition of other variables to the model. This implies that, although other relevant variables might be considered to be of importance for the econometric analysis, their omission will not impact on the interpretation of the equilibrium relations that are uncovered: this is a very convenient property for many econometric analyses using historical data.

6.3 The expected results

The three predictions outlined above imply three cointegrating relationships, i.e. negative cointegrating relationships of the form $m_t = m_t(z_t)$ and $q_t^{US} = q_t^{US}(z_t)$, and a positive cointegrating relationship of the form $q_t^{UK} = q_t^{UK}(z_t)$. This would imply reduced rank of the Π matrix, i.e. $r = 3$.

6.4 The results

The results presented here were obtained using CATS in RATS, version 2. The period used for estimation is 1866 to 1900, which is the period during which the grain invasion is usually considered to have taken place. It is tempting to extend the analysis to the years prior to 1866, but reliable estimates for the US production of wheat are impossible to come by prior to 1866.

Estimation of equation (3)[34] gives the unrestricted estimates in equation (4). Bold type indicates that the coefficient is significant at the 5% level.

$$\begin{bmatrix} \Delta m_t \\ \Delta q_t^{UK} \\ \Delta q_t^{US} \\ \Delta z_t \end{bmatrix} = \tag{4}$$

$$\begin{bmatrix} -0.06 & 0.01 & \mathbf{0.15} & -0.01 \\ \mathbf{-0.09} & \mathbf{0.10} & -0.01 & 0.01 \\ \mathbf{-0.08} & 0.01 & \mathbf{0.04} & -0.02 \\ \mathbf{-11.27} & \mathbf{-5.09} & 2.03 & 0.50 \end{bmatrix} \begin{bmatrix} \{-1.3m + 1.8q^{UK} + 5.4q^{US} + 0.1z\}_{t-1} \\ \{0.9m - 6.2q^{UK} - 4.5q^{US} + 0.05z\}_{t-1} \\ \{-3.8m - 1.4q^{UK} + 3.4q^{US} + 0.0z\}_{t-1} \\ \{-1.8m - 2.6q^{UK} + 3.9q^{US} + 0.0z\}_{t-1} \end{bmatrix}$$

$$+ \Gamma \Delta X_{t-1} + \mu + \varepsilon_t$$

The model is well specified under the assumption that the residuals are iid. and normally distributed. Checks for normality and no autocorrelation of the residuals do not reveal major problems with the model. [35]

[34] Without the trend which, as noted, was found to be insignificant.

A crucial step in the analysis is to determine the number of equilibrium relationships. *r* = 3 is found sufficient[36].

Restricting the rank to 3 and normalizing on the relevant variables in each relation gives the estimates in equation (5)[37].

$$\begin{bmatrix} \Delta m_t \\ \Delta q_t^{UK} \\ \Delta q_t^{US} \\ \Delta z_t \end{bmatrix} = \begin{bmatrix} -0.32 & -0.04 & \mathbf{-0.57} \\ \mathbf{-0.48} & \mathbf{-0.59} & -0.04 \\ \mathbf{0.41} & -0.07 & \mathbf{-0.15} \\ \mathbf{-61.02} & \mathbf{31.45} & -7.64 \end{bmatrix} \begin{bmatrix} \{q^{US} - 0.2m + 0.3q^{UK} + 0.0z\}_{t-1} \\ \{q^{UK} - 0.1m + 0.7q^{US} - 0.0z\}_{t-1} \\ \{m + 0.4q^{UK} - 0.9q^{US} - 0.0z\}_{t-1} \end{bmatrix} \quad (5)$$

$$+\Gamma\Delta X_{t-1} + \mu + \varepsilon_t$$

In addition, the relations expected imply the zero-restrictions on the beta coefficients imposed in equation (6).

$$\begin{bmatrix} \Delta m_t \\ \Delta q_t^{UK} \\ \Delta q_t^{US} \\ \Delta z_t \end{bmatrix} = \begin{bmatrix} 0.16 & -0.36 & \mathbf{-0.49} \\ \mathbf{-0.94} & \mathbf{-0.73} & \mathbf{0.24} \\ \mathbf{-0.33} & \mathbf{-0.26} & -0.04 \\ \mathbf{-31.21} & 8.16 & 2.00 \end{bmatrix} \begin{bmatrix} \{q^{US} + \mathbf{0.03}z\}_{t-1} \\ \{q^{UK} - \mathbf{0.03}z\}_{t-1} \\ \{m + \mathbf{0.02}z\}_{t-1} \end{bmatrix} + \Gamma\Delta X_{t-1} + \mu + \varepsilon_t \quad (6)$$

All beta coefficients are highly significant, and all relationships error correct significantly in the variable which has been normalized on (i.e. significant alpha coefficients for q^{US}, q^{UK}

[35] The Doornik & Hansen (1994) test for normality is accepted with a p-value of 0.374. Tests for no autocorrelation of different orders (Godfrey 1988) are likewise accepted with large p-values.

[36] Although the LR rank test suggests $r = 2$ is borderline accepted, the short sample length will have a tendency to bias the rank test towards too low a rank. Examination of the graphs of the cointegrating relations, and recursive estimation of the trace test statistics reveals that the less restrictive specification of $r = 3$ is more reasonable.

[37] The full estimation results are given in table 1, in appendix C.

and *m* respectively). q^{UK} is also adjusting to the second and third relations (i.e. it has two extra significant alpha coefficients), but this is not surprising, since it is clearly also going to be impacted on in the long run by both the increase in imports and the increase in the US supply. As shown above, British wheat production did indeed drop in the wake of the grain invasion. q^{US} is also adjusting to the relationship for q^{UK}, implying again that there was some simultaneity in the determinacy of these variables. *z* is borderline (weakly) exogenous (the t-value for the significant alpha coefficient is only -1.94), although it is weakly adjusting to the first relation – perhaps because increasing trade also increases the demand for shipping, potentially pushing up transportation costs.

Since all variables are in logarithms, and *z* is expressed as a percentage, the coefficients in the β matrix can be interpreted as elasticities. The first and second relations reveal that, in equilibrium, a 1 percentage point decrease in *z* implied a 3 per cent increase in US production and a 3 per cent decrease in UK production. The second relation shows that, in equilibrium, a 1 percentage point decrease in *z* caused a 2 per cent increase in imports. The decline in the price gap, as defined here, was thus responsible for the supply changes and trade increase associated with the grain invasion.

Finally, further tests were made to check the assumptions of the model such as parameter constancy, which did not give reason to question the validity of the estimation results.

7. Conclusion

This paper provides theoretical and empirical support for the hypothesis that the increase in trade associated with the grain invasion was the result of transportation cost reductions which allowed the extension of the frontier without increasing the price for producers. This contrasts with Harley's interpretation: that trade increased because US farmers were paid more due to the reduction in transportation costs. As such, the hypothesis first suggested by Persson (2004), that the growth in world trade expanded due to the elastic supply of nations where "practically unlimited supplies of land were populated by immigrants", has been given empirical and theoretical support. These results have a number of interesting implications.

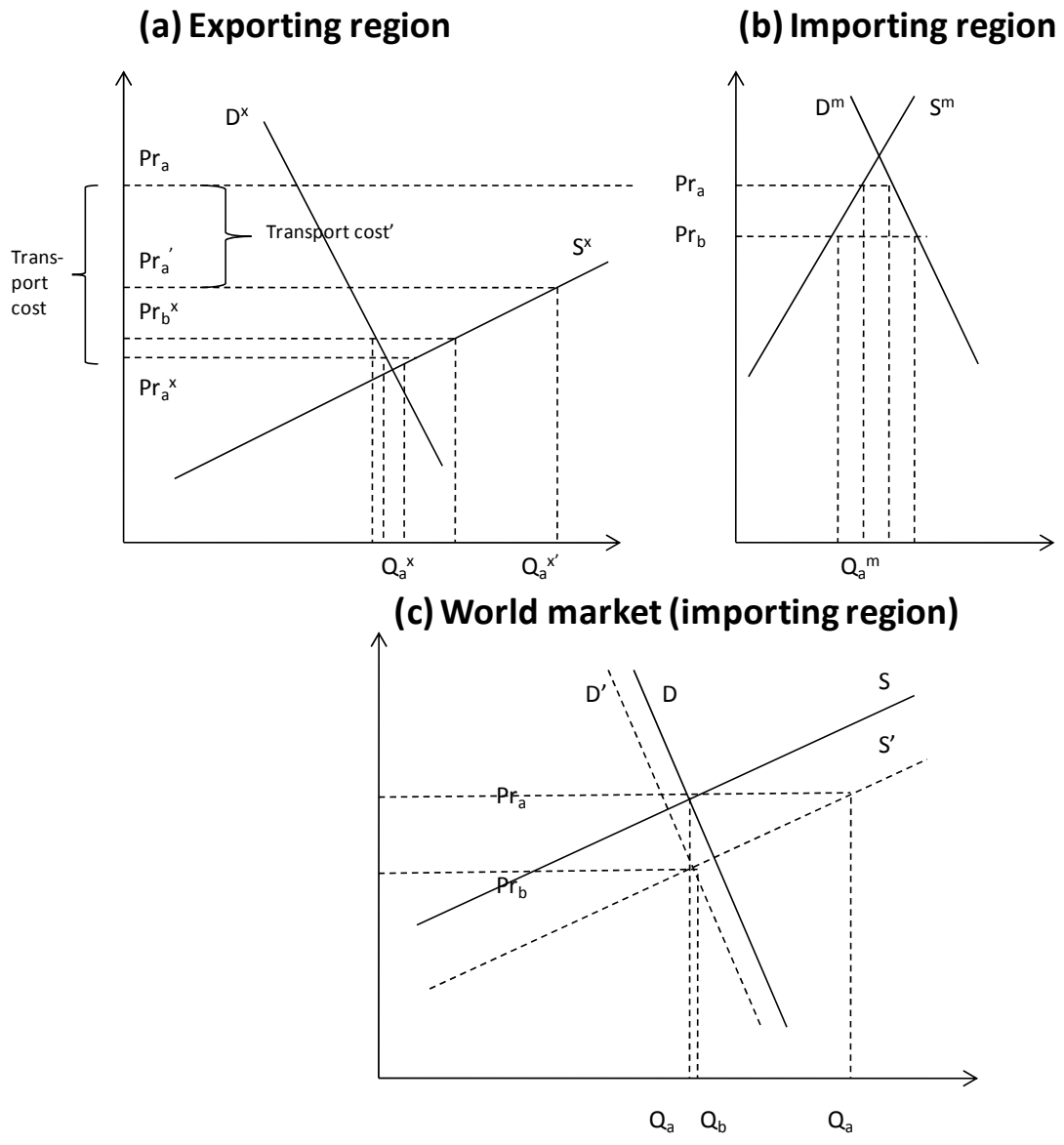
The fact that real farm gate prices did not increase for the representative producer ties into an extensive literature on the reasons for the agricultural discontent in America over this period, which until now have been difficult to understand given the real price increases documented by amongst others Douglass North. This is explored briefly in Appendix D.

The integration of commodity markets due to domestic transportation improvements were a factor in permitting the westward expansion of agriculture and thus the increase in supply. Moreover, what is quite clear is that the enormous increase in production in the US could not have taken place without the substantial immigration she enjoyed throughout this period. Interestingly, this implies another role for “globalization” in the expansion of trade, through the integration of labour markets, as well as through the integration of commodity markets.

Appendix A: Harley's original model of the world market for wheat

This is a model for trade between two locations: an exporting country (the US), and an importing country (Europe, or the UK). The intersection of demand and supply in the two locations is illustrated in figure A1 panels (a) and (b). The model relies on the observation that, if trade actually occurs, then the price of wheat can only differ between regions by an amount equal to the trading costs between the two locations.

Figure A1: Harley's model for the world market for wheat



In figure A1, it is assumed that in the absence of trade, the price would be low in the exporting region (panel a) and high in the importing region (panel b). If the price differential is smaller than the transaction costs, then the price in each location is determined by supply and demand in the individual locations. Otherwise, trade will occur.

At importing price Pr_a, supply can be read from the importing region's supply curve ($Q_{m,a}$). At this price in the importing region, the price in the exporting region is Pr_a minus transportation costs ($Pr_{x,a}$) and the quantity supplied is $Q_{x,a}$. The sum of the quantities is the world quantity supplied, Q_a (illustrated in panel (c)). By choosing different import prices, it is possible to draw the world supply curve. In a similar way, the world demand curve can be derived by choosing prices in the importing region and summing the quantities demanded in that region at the various prices with the quantities demanded in the exporting regions at the corresponding prices, which are lower by the amount of the transportation costs. Given the world demand and supply curves, the equilibrium world price (for the importing region) will be Pr_a.

The important point then is this: when transportation costs fall, the world market must find a new equilibrium. The old price in the importing region now corresponds to a higher price in the exporting region (note that this is the crucial difference between this model, and that described in figure 12, where there is no price increase in the long run). This means that the quantity supplied at that price in the exporting region will increase and the quantity demanded in the exporting region will fall. This leads to an excess supply of wheat, and the price will fall to Pr_b. In the exporting region, the old equilibrium price corresponds to a lower price in the importing region, and thus implies excess demand and a price increase. Prices thus fall in the importing region and increase in the exporting region. In addition, the quantity supplied increases.

Appendix B: Data sources for the production estimates

Although official estimates for the UK are only available from 1884 (Mitchell & Deane 1962, pp. 86-7; see Coppock 1956 for a background on these estimates), unofficial estimates are given by Gilbert & Lawes (1893, appendix table II) for the years 1853-83. They report their estimates in "harvest years" e.g. 1852-3 – I have used the second of the pair in each case. Contemporary estimates are not available for earlier years, but are given by Fairlee (1969, p. 114) for 1829-52. She does not give an estimate for 1842, since her estimates are based on multiplying the quantity of wheat sold in "inspected markets" under the Corn Laws by a constant fraction, which changes from 4 to 14/5 in 1842, since the number of inspected markets increased from 150 to 290 on April 29, 1842. It is not too hard to use Fairlee's method to get a rough estimate of wheat output in 1842. Using BPP (1842, p. 177) we find that 970 thousand quarters of wheat were sold in inspected markets until April 29. Multiplying this by Fairlee's factor of four gives 3,880 thousand quarters. After April 29, 8,739 thousand quarters were sold. Multiplying this by Fairlee's factor of 14/5 gives 8,740 thousand quarters. Adding the two together gives an estimate of 12,620 thousand quarters produced in 1842.

Prior to 1866 the only official estimates for the US are those from the decennial census. These estimates from 1839 can be found in Carter et al (2006, series Da731). Other (sometimes contradictory) estimates exist from various sources for other years. The most complete of these is from Guetter & McKinley (1924, p. 29), which has data for some years back to 1790. (For background information and a discussion on the reliability of the early US estimates, see Benedict (1939), Ebling (1939) and Gallman (1963).) I have used their estimates for the years 1841-49, 1851-58 and 1862-65. This still leaves missing observations for 1829, 1831-38 and 1861. Thorp (1926, pp. 113-145) gives descriptions of the state of the wheat harvest for most years from 1790 to 1925. Wheat crops are given various descriptions such as "failure", "poor", "abundant", "record" to name a few. His descriptions seem to follow the data from Guetter & McKinley very closely, e.g. his description of a "record" crop corresponds to historical highs. The levels for these years have been based on these descriptions. For 1860 and 1861 his description is "good", which as the same as for 1859,

which had a production of 173 million bushels. I have thus chosen a level of 173 for 1860 and 1861. I have assumed production in 1830 was the same as that in 1829, and I have then assigned levels to 1831-8 using linear interpolation between 1830 and 1839. When the description is “failure”, “short” or “shortage”, I have subtracted 15% from the interpolated series. When the description is “good”, “large” or “excellent”, I have added 15%. Other descriptions result in the use of the standard interpolated series. The 1840 production has been assumed to be the same as in 1839.

Appendix C: The full estimation results

Table 1

	H0					
	alpha(1)	alpha(2)	alpha(3)	beta(1)	beta(2)	beta(3)
m	-0.323	-0.043	-0.573	-0.235	-0.148	1.000
t-value	-1.574	-0.182	-4.016			
quk	-0.478	-0.585	-0.042	0.336	1.000	0.365
t-value	-3.352	-3.597	0.424			
qus	-0.408	-0.074	-0.145	1.000	0.728	-0.904
t-value	-3.749	-0.592	-1.909			
z	-61.018	31.448	-7.644	0.015	-0.008	-0.013
t-value	-5.474	2.472	-0.985			

	H1					
	alpha(1)	alpha(2)	alpha(3)	beta(1)	beta(2)	beta(3)
m	0.164	-0.360	-0.491	0.000	0.000	1.000
t-value	0.555	-1.444	-3.177			
quk	-0.942	-0.730	0.241	0.000	1.000	0.000
t-value	-4.575	-4.211	2.243			
qus	-0.331	-0.264	-0.038	1.000	0.000	0.000
t-value	-2.104	-1.989	-0.463			
z	-31.209	8.162	2.003	0.030	-0.026	0.023
t-value	-1.938	0.602	0.238	6.876	-6.003	2.909

Appendix D: Some reflections on the implications of the new price series

Long ago, Douglass North (1974) found that the last decades of the nineteenth century saw a period when the real price of farm products increased and transportation costs fell. In Europe, farmers protested against the invasion of cheap grain. This of course fitted well into the story told by Harley (see above).

The agricultural distress and protest in the Old World in the wake of the grain invasion was both predictable and understandable. Countries either chose to shield themselves through protectionism, as in the cases of Sweden, Germany and France, or allowed their economies to adjust. The UK saw a large decline in agriculture (Ejrnæs, Persson & Rich 2008) whereas Denmark – a particularly interesting case – changed from being a net exporter of grain in the 1850s and 1860s to become a net importer in the 1880s of wheat as well as fodder for an agricultural sector switching to meat and dairy products. (Henriksen 1993)

However, although the last decades of the nineteenth century are perhaps principally associated with agricultural discontent for the European economic historian, somewhat paradoxically the historian of American agriculture would associate this period with the same. In the United States, from the 1860s, a succession of protest movements flourished, culminating with the Presidential campaign of the Populist William Jennings Bryan in 1896. However, it has been difficult to find a wholly convincing argument as to why farmers were angry. The problem rests on evidence that the real incomes of farmers actually *increased* over this period.

The story of the agrarian protest movement in the United States during the latter part of the nineteenth century is well known. A succession of protest movements emerged starting with Oliver Kelly's 'National Grange of the Patrons of Husbandry' in 1867, followed by the Greenback party, the Farmers' Alliance and finally the Populist movement of the 1890s. The farmers' concerns are typically summarized as 'falling commodity prices, increased entry costs to farming, rising tenancy, farm foreclosure, and uncertainties generated by harvests

in another hemisphere and reliance upon markets an ocean away'. (Atack, Bateman & Parker 2000)

However, the reasons for the discontent have long been disputed and putting it into the context of the emergence of the United States as the leading agricultural exporter can only appear to add to the confusion. Indeed, the reaction of American farmers was sharply at odds with the standard interpretation of the Grain Invasion as first suggested by Harley (1980, 1986). The Harley hypothesis fitted well into earlier research by North (1974), who argued that the real price of farm products increased and transport costs fell. However, this made it difficult to relate the agrarian protest movement to deteriorating economic conditions. The consensus view was therefore that the economic plight of farmers seemed to have been exaggerated or misrepresented in earlier research when farmers were taken on their own word. As Frieden (1997, p. 372) points out, 'there is a puzzling weakness of evidence' for a relationship between economic conditions and farm protest.

Accepting this, other researchers have looked elsewhere. One line of argument suggests that income uncertainty increased or was particularly high in regions with strong farm reform movements. The logic here is that there are welfare losses associated with price volatility if farmers were risk averse. (McGuire 1981) Another line of argument looks at the particular problems of indebted farmers in a period of deflation. Since the general price level fell by half or more in the Grain Invasion period, debt as a proportion of current income might increase when nominal prices fall because the nominal debt for a farmer remains unaffected by the fall in prices. The risk of foreclosures increased and fuelled unrest. (Stock 1983) The problem with this interpretation is that foreclosures were not very frequent, but Stock argues that even so most farmers would have known someone who was affected which fuelled a fear of being the next victim. States with a higher frequency of foreclosures were fertile ground for the protest movement.

Interesting as these explanations are they do not seem to have convinced the profession of economic historians. As Mayhew (1972, p. 466) points out much earlier, it is 'puzzling that farmers began complaining about railroad rates, interest rates, and problems of obtaining credit in a period when freight rates and interest rates were falling rapidly and when… credit

was easily available'. She continues that it 'is also puzzling that earlier fluctuations in prices did not provoke farmer protest'. Thus, in a recent survey, Whaples (1995) reports that only 22 per cent of economists in the Economic History Association agreed with the proposition that 'The Agrarian protest movement in the Middle West from 1870 to 1900 was a reaction to the deteriorating economic status of farmers'. 52 per cent disagreed. Did farmers then have nominal illusions, mistaking a nominal fall in income for a real fall? This seems unlikely given that if farmers were aware of the prices of their own produce they must surely also have been informed about the prices of the goods they purchased. [38]

In fact, we ought to be concerned about any argument which implies that people protest for the wrong reasons. Economists usually believe that man acts fairly rationally on the basis of knowledge which is accurate or at least not systematically misleading or biased. Indeed, Cooley & DeCanio (1977) convincingly argued that American farmers responded rationally to price signals during the period of discontent. However, in the dominant explanation for the unrest farmers were simply wrong or seriously misinformed.[39]

In fact, the favoured explanation for the unrest according to Whaples' survey is almost aggressively non-economic. Mayhew (1972) argued that farmers were simply upset by 'commercialization', 'the increasing importance of prices' and their being forced into an economic system in which money was all important. Although we will attempt to reveal an economic basis for the farmers' concerns, our explanation is in fact compatible in a sense with Mayhew's. From a study of the contemporary political debate there is no doubt that farmers themselves were clearly under the impression that their economic condition was deteriorating. And there is also no doubt that the objects of their frustration were those identified by Mayhew: the owners of railroads, moneylenders, manufacturers, banks etc. All these were perhaps a sign of the increasing commercialization of agriculture but more

[38] Although see Friedman (1990, p. 1171) for a dissenting view.

[39] This idea was also apparent in the statements of contemporaries, for example the President of the Boston Manufacturers' Mutual Fire Insurance Company in evidence before the British Royal Commission on Agriculture in 1879 (1881, C. 7400): "You do not think that the [agrarian protest] movement then has any real economic basis?--No…"

generally they were just one aspect of the increasing *internationalization* of agriculture, and indeed economic life in general, which occurred in the second half of the nineteenth century.

What the farmers were then really experiencing was their submergence in the new Atlantic Economy. This gave rise to concerns which were entirely economic in nature. Exposure to distant export markets had differential effects on producers in America. The farmers' concerns were thus entirely consistent with those of rational economic agents.

Farmers in the United States saw something that economists and economic historians have not seen. Those who complained got next to nothing from the export boom despite falling transport costs and despite the surging overseas demand. It was consumers in Europe who got all or almost all the benefits as long as domestic farmers did not succeed in protecting their markets. As this paper has shown, the average farmer did not experience real price increases. This results in the expectation that the farm protest had a particular geographical pattern, being concentrated in areas of the frontier where recently settled farmers gained access to the world market made possible by falling transport costs but at the going farm income. It should be noted, however, that we need to know more about the variable costs of production to know whether farm income was falling with the fall in wheat prices. We know nothing about the relative magnitudes of the fall in the variable costs of production and the fall in output prices.

References

AlCHIAN, A.A. & ALLEN, W.R. (1977). *University Economics.* Belmont: Wadsworth Publishing C

ANON (1934). Decline and Recovery of Wheat Prices in the 'Nineties. *Wheat Studies* **10:8&9**, pp. 289-352

ATACK, J., BATEMAN, F. & PARKER, W.N. (2000). The Farm, the Farmer, and the Market. In GALLMAN (2000)

BELL, J.F. ed. (1952). *Flour for Man's Bread: A History of Milling.* Minneapolis: University of Minneapolis Press

BENEDICT, M.R. (1939). Development of Agricultural Statistics in the Bureau of the Census. *Journal of Farm Economics* **21:4**, pp. 735-760

BOHLIN, J. (2005). Tariff Protection in Sweden, 1885-1914. *Scandinavian Economic History Review* **53:2**, pp. 7-29

BOWMAN, J. & KEEHN, R. (1974). Agricultural Terms of Trade in Four Midwestern States, 1870-1900. *The Journal of Economic History* **34:3**, pp. 592-609

CATS in RATS, version 2, by J.G. Dennis, H. Hansen, S. Johansen and K. Juselius, Estima 2005.

COOLEY, T.F. & DECANIO, S.J. (1977b). Rational Expectations in American Agriculture, 1867-1914. *The Review of Economics and Statistics* **59:1**, pp. 9-17

COPOCK, J.T. (1956). The Statistical Assessment of British Agriculture. *The Agricultural History Review* **4:1**, pp. 4-21

DOORNIK, J.A. & HANSEN, H. (1994). *An Omnibus Test for Univariate and Multivariate Normality.* Working Paper, Nuffield, Oxford

EBLING, W.H. (1939). Why the Government Entered the Field of Crop Reporting and Forecasting. *Journal of Farm Economics* **21:4**, pp. 718-734

EJRNÆS, M, PERSSON, K.G. & RICH, S. (2008). Feeding the British: Convergence and Market Efficiency in 19th Century Grain Trade. *Economic History Review* **61:S1**, pp. 140-171

FAIRLEE, S. (1969). The Corn Laws and British Wheat Production, 1829-76. *The Economic History Review* **22:1**, pp. 88-116

FEDERICO, G. & PERSSON, K.G. (2007). Market Integration and Convergence in the World Wheat Market, 1800-2000 in Hatton, T., O'Rourke, K. & Taylor, A. (eds.), *New Comparative Economic History, Essays in Honour of Jeffrey G. Williamson*, Cambridge, MA: MIT Press

FISHER, F.M. & TEMIN, P. (1970). Regional Specialization and the Supply of Wheat in the United States, 1867-1914. *Review of Economics and Statistics* **52**, pp. 134-149

FRIEDEN, J.A. (1997). Monetary Populism in Nineteenth-Century America: An Open Economy Interpretation. *The Journal of Economic History* **57:2**, pp. 367-395

FRIEDMAN, M. (1990). The Crime of 1873. *The Journal of Political Economy* **98:6**, pp. 1159-1194

GALLMAN, R.E. (1963). A Note of the Patent Office Crop Estimates, 1841-1848. *The Journal of Economic History* **23:2**, pp.185-195

GALLMAN, R.E. (ed.) (2000). *The Cambridge Economic History of the United States, Volume II.* Cambridge University Press

GALPIN, W.F. (1922). The American Grain Trade to the Spanish Peninsula, 1810-1814. *The American*

Historical Review **28:1**, pp. 24-44

GALPIN, W.F. (1925). The Grain Supply of England During the Napoleonic Period. New York: Macmillan

GODFREY, L.G. (1988). *Misspecification Tests in Econometrics.* Cambridge: Cambridge University Press

HARLEY, C.K. (1978). Western Settlement and the Price of Wheat, 1872-1913. *The Journal of Economic History* **38:4**, pp. 865-878

HARLEY, C.K. (1980). Transportation, the World Wheat Trade, and the Kuznets Cycle, 1850-1913. *Explorations in Economic History* **17**, pp. 218-250

HARLEY, C.K. (1986) 'Late Nineteenth Century Transportation, Trade and Settlement' in W. Fisher et al (eds.) *The Emergence of a World Economy 1500-1914, Part II: 1850-1914.* Wiesbaden, West Germany: Franz Steiner Verlag

HARLEY, C.K. (1996). *The Integration of the World Economy I.* Cheltenham: Edward Elgar

HATTON, T.J., O'ROURKE, K.H. & TAYLOR, A.M. eds. (2007). *The New Comparative Economic History: Essays in Honor of Jeffrey G. Williamson.* Cambridge, MA: The MIT Press

HENRIKSEN, I. (1993). 'The Transformation of Danish Agriculture 1870-1914' in K.G. Persson (ed.) *The Economic Development of Denmark and Norway since 1870.* Cheltenham: Edward Elgar

JUSELIUS, K. (2006). The Cointegrated VAR Model: Methodology and Applications. Oxford: OUP

JUSELIUS, K. & FRANCHI, M. (2007). Taking a DSGE Model to the Data Meaningfully. *Economics – The Open-Assessment E-Journal* **4**

KEMP, B. (1962). Reflections on the Repeal of the Corn Laws. *Victorian Studies* **5:3**, pp. 189-204

LEWIS, W.A. (1954), Economic Development with Unlimited Supplies of Labour. *The Manchester School* **22:2**, pp. 139-191

MAYHEW, A. (1972). A Reappraisal of the Causes of Farm Protest in the United States, 1870-1900. *The Journal of Economic History* **32:2**, pp. 464-475

MCGUIRE, R. (1981). Economic Causes of Late Nineteenth Century Agrarian Unrest: New Evidence. *Journal of Economic History* **41**, pp. 835-52.

NORTH, D. (1958). Ocean Freight Rates and Economic Development 1750-1913. *The Journal of Economic History* **18:4**, pp. 537-555

NORTH, D.C. (1974). *Growth and Welfare in the American Past.* Englewood Cliffs

OLMSTEAD, A.L. & RHODE, P.W. (2002). The Red Queen and the Hard Reds: Productivity Growth in American Wheat, 1800-1940. *The Journal of Economic History* **62**, pp. 929-966

OLMSTEAD, A.L. & RHODE, P.W. (2007). Biological Globalization: The Other Grain Invasion. In Hatton et al, eds. (2007)

OLMSTEAD, A.L. & RHODE, P.W. (2008). *Creating Abundance: Biological Innovation and American Agricultural Development.* New York: Cambridge University Press

O'ROURKE, K.H. (1997). The European Grain Invasion 1870-1913. *Journal of Economic History* ***57****,* pp.775-801.

O'ROURKE, K.H. & WILLIAMSON, J.G. (1999). *Globalization and History.* London: The MIT Press

O'ROURKE, K.H. & WILLIAMSON, J.G. (2002a). When did globalisation begin? *European Review of Economic History* **6**, pp. 23-50

O'ROURKE, K.H. & WILLIAMSON, J.G. (2002b). After Columbus: Explaining Europe's Overseas Trade Boom, 1500-1800. *The Journal of Economic History* **62:2**, pp. 417-456

O'ROURKE, K.H. & WILLIAMSON, J.G. (2005). From Malthus to Ohlin: Trade, Industrialisation and Distribution Since 1500. *Journal of Economic Growth* **10**, pp. 5-34

PERSSON, K.G. (2004). Mind the Gap! Transport costs and price convergence in the nineteenth century Atlantic economy. *European Review of Economic History* **8:2**, pp. 125-147

ROTHSTEIN, M. (1964). The International Market for Agricultural Commodities, 1850-1873. In Gilchrist, D.T. & Lewis, W.D. [eds.]. *Economic Change in the Civil War Era.* Greenville, Delaware: Eleutherian Mills-Hagley Foundation

SHARP, P.R. (2006). *1846 and All That: The Rise and Fall of British Wheat Protection in the Nineteenth Century.* Department of Economics, University of Copenhagen Discussion Paper 06-14

STOCK, J.H. (1983). Real Estate Mortgages, Foreclosures and Midwestern Agrarian Unrest, 1865-1920. *Journal of Economic History* **44**, pp. 89-105

THORP, W.L. (1926). *Business Annals.* New York: NBER

VEBLEN, T.B. (1892). The Price of Wheat Since 1867. *The Journal of Political Economy* **1:1**, pp. 68-103

WHAPLES, R. (1995). Where Is There Consensus Among American Economic Historians? The Results of a Survey on Forty Propositions. *Journal of Economic History* **55**, pp.139-54

WILLIAMSON, J.G. (1980). Greasing the Wheels of Sputtering Export Engines: Midwestern Grains and American Growth. *Explorations in Economic History* **17**, pp. 189-217

Data sources

BPP (1843). *Returns Relative to Importation and Exportation of Corn.* HCPP

BPP (1843 to 1852). *Tables of Revenue, Population and Commerce of United Kingdom and Dependencies and of some Foreign Countries.* HCPP

BPP (1849). *Grain, Flour and Meal.* HCPP

BPP (1853 to 1903). *Annual Statement of Trade and Navigation of United Kingdom with Foreign Countries and British Possessions.* HCPP

CARTER, S.B. et al (2006). *Historical Statistics of the United States Millenial Edition.* Online version

COOLEY, T.F., DECANIO, S.J. & MATTHEWS, M.S. (1977a). *ATICS: An Agricultural Time Series-Cross Section Dataset.* NBER Working Paper No. 197

GILBERT, J.H. & LAWES, J.B. (1893). Home produce, imports, consumption, and price of wheat, over forty harvest-years, 1852-53 to 1891-92. *Journal of the Royal Agricultural Society of England* **4**, pp. 77-135

GUETTER, F.J. & MCKINLEY, A.E. (1924). *Statistical Tables Relating to the Economic Growth of the United States.* Philadelphia: McKinley Publishing Co.

MITCHELL, B.R. & DEANE, P. (1953). *Abstract of British Historical Statistics.* Cambridge: Cambridge University Press

Chapter 3

Globalization Revisited: Market integration and the wheat trade between North America and Britain from the Eighteenth Century[40]

Abstract: This paper provides evidence that transatlantic commodity market integration began prior to the "first era of globalization" at the end of the nineteenth century. It does so by giving a long term perspective to the story of the development of an Atlantic Economy in wheat between the United States and Britain. Both trade statistics and contemporary comment reveal the importance of this trade from the middle to late eighteenth century, long before the so-called grain invasion of the late nineteenth century. Using price data for wheat in America and Britain, evidence is found that markets were integrated, but this process was continuously being interrupted by "exogenous" events, such as trade policy, war and politics. Transportation costs cannot be seen to be the driving force behind periods of increased trade, which are more attributable to the absence of these exogenous events. Whether the observed market integration is evidence of "globalization", however, is questioned.

[40] I would like to thank the European Commission for financial support through the Marie Curie Research Training Network "Unifying the European Experience". In addition, I would like to thank Karl Gunnar Persson, Giovanni Federico, Heino Bohn Nielsen, Jeffrey Williamson and seminar and conference participants for their advice and suggestions.

1. Introduction

"Sire, have you not taken away the only remedy for this scarcity; the only relief to which we can now look under a bad harvest – by closing the corn market of America."

– Brougham, Parliamentary Debate, 1812[41]

The concept and consequences of globalization have recently enjoyed a vast amount of scholarly attention. In this literature economic historians have played a key role in demonstrating that globalization is not a new phenomenon, but rather something that has occurred in a series of waves, the first of which was in the nineteenth century (see for example O'Rourke & Williamson, 1999). Moreover, this body of research has been at pains to point out that the traditional indicators, such as volumes of trade in the case of commodity markets, are not sufficient when defining globalization. Trade volumes have for example increased in earlier periods, such as with the discovery of the Americas by Europeans. Globalization in this case is thus defined as commodity market integration, with the increase in trade merely a result of this.

Might economic historians be guilty of the same mistake, however, when choosing in which period to date the "first era of globalization"? Focus has naturally been directed at the late nineteenth century, when trade volumes boomed, and has concentrated primarily on the trade in wheat between the US and the UK. This trade took off in the second half of the nineteenth century after a period of many decades of high protectionism. With very few exceptions, however, and despite this scholarly enthusiasm for the famous "Grain Invasion" of the late nineteenth century, very little attention has been paid to the trade in wheat between America and Britain going back even further to a time when volumes were relatively small: the eighteenth century[42], despite the finding long ago by Shepherd & Walton (1972) that wheat and flour exports were of one of the major export commodities of

[41] Quoted by Galpin (1922, p. 24).

[42] There has been more attention on the export of wheat from Britain, see for example Ormrod (1985).

the colonies, only exceeded in importance by tobacco and that more recent work has stressed the importance of the eighteenth century for the transition to globalization (O'Rourke & Williamson 2005, O'Rourke 2006, Findlay & O'Rourke 2007). It is in fact necessary to go back to the work of W. Freeman Galpin (1922, 1925) to find otherwise. Galpin painstakingly establishes the importance of the American supply of grain for Britons at home and to British forces stationed in Spain and Portugal during the French and Napoleonic Wars. However, even he was under the impression that the "importance… of American grain in English history presented itself for the first time during the Napoleonic era". He does not, however, back his assertion up with any evidence.

Indeed, politicians and farmers of the mid- to late nineteenth century seem to have been under the impression that the importance of grain imports from North America started in their time, and economic historians seem to have been content to accept this (see for example O'Rourke & Williamson 1999). That trade volumes were modest, however, does not mean that there was no commodity market integration. In fact, for prices to move together only the possibility of trade is necessary – and this possibility, often seen as a threat by contemporaries, was very real.

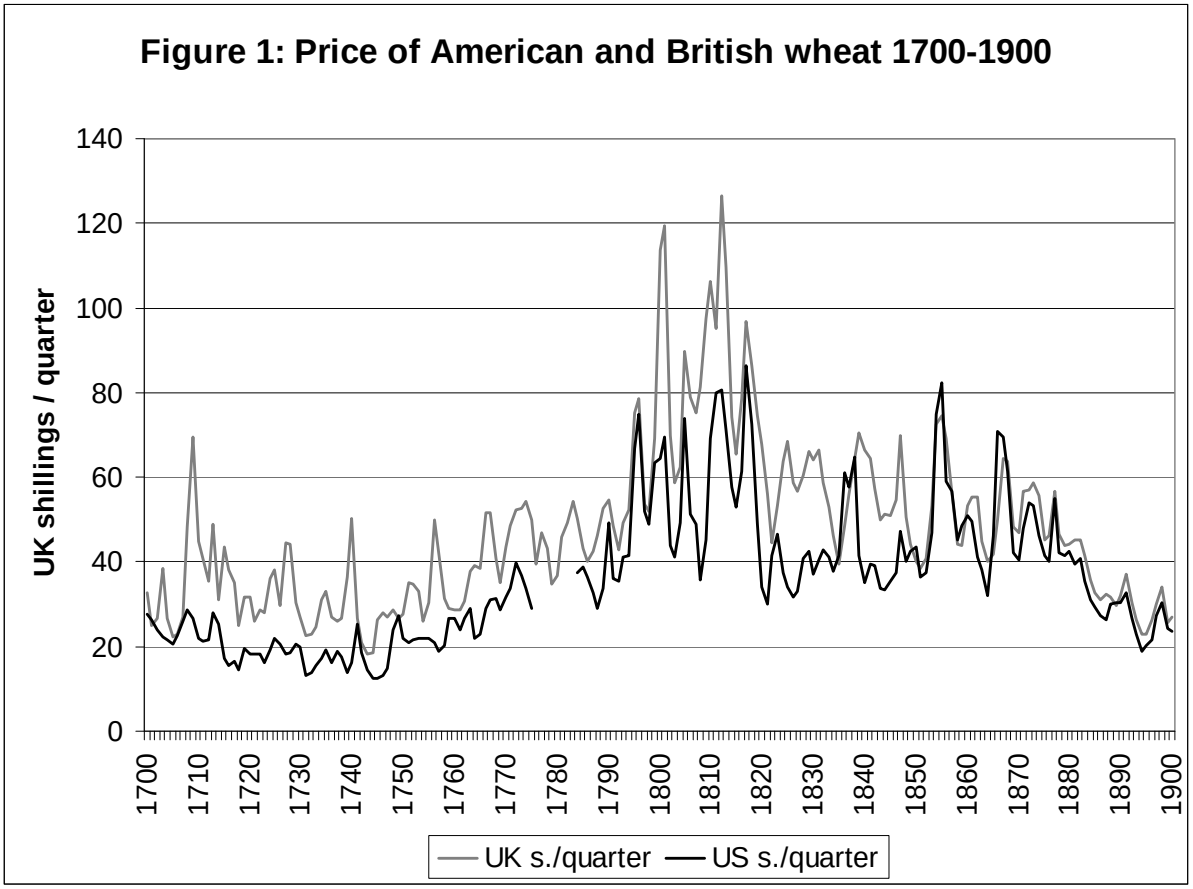
Moreover, although the levels of trade in wheat between the US and the UK were relatively small, they were in fact not insignificant for many years. Trade was, however, continuously being cut off by various "exogenous" events, such as biological phenomena, war and politics. These correspond to those identified by O'Rourke (2006) who notes the possibility that globalization might have started earlier if it had not been for the impact of such shocks[43].

Even if prices move together, is it right to talk of globalization when levels of trade are small, however? And if prices take a long time to return to the law of one price equilibrium, or there are substantial price gaps even in equilibrium, is there really globalization? Asking these questions helps us to identify what really changed during the first era of globalization, and by demonstrating this and pushing the story of the transatlantic wheat trade back in

[43] Jacks (2005, 2006) was one of the first to note that transatlantic market integration began prior to the second half of the nineteenth century and this point has recently been underlined by Williamson (2008).

time, it is possible to learn a great deal about this trade and its importance to contemporaries.

2. Transatlantic wheat market integration in the long run



Sources: The data for Britain is taken from Mitchell & Deane (1953) and is the "Winchester" series until 1770, and thereafter the *Gazette* series. The American data is taken from Carter et al (2006). Until 1783 the prices are taken from series Eg252 converted from Pennsylvania shillings to UK currency using the exchange rates given in series Eg318. No prices are available between 1776-83. From 1784 the prices are in dollars per bushel from series Cc205-208 converted to British shillings per quarter using the exchange rates given in Officer (2008). Since his exchange rates only cover the years from 1791, the missing exchange rates for 1784-1790 are assumed to be the same as in 1791. In all cases, volumes are converted to imperial quarters using the fact that there are 8.256 American bushels to the imperial quarter.

Looking at figure 1, the first thing that is striking is how the prices move together over the long run. The usual way of testing for long run market integration (or, more precisely, that the trading cost adjusted law of one price is valid) is to test for cointegration between the series (see for example Ejrnæs, Persson & Rich, 2008). With the available statistical evidence we cannot, however, hope to fulfil the stringent conditions for testing market integration

described for example in Persson (2004). There is no record of, for example, grain qualities, the only price information being for "wheat" in various markets. Nevertheless, when the available data are assembled, it does in fact seem possible to draw some meaningful conclusions.

Cointegration is tested for using an unrestricted Autoregressive Distributed Lag (ADL) or Dynamic Error Correction (ECM) model by estimating the following equation:

$$puk_t = \beta_0 + \beta_1 puk_{t-1} + \beta_2 puk_{t-2} + \beta_3 pus_t + \beta_4 pus_{t-1} + \beta_5 pus_{t-2} + \beta_6 t + \varepsilon_t \qquad (1)$$

where *puk* and *pus* are the logarithms to the UK and US prices respectively, *t* is the trend and ε_t is the error term, which is assumed to be iid normally distributed. This estimation technique has the advantage, compared to the usual static Engle-Granger approach, that the model is well-specified (since it includes dynamic effects) so, given cointegration, t-ratios constructed from the standard errors follow standard normal distributions under the null.

Initially the model is estimated using PcGive[44] for the period 1750-1900[45]. The estimation results are given in Table 1.

[44] Ox Professional version 5.00 (Windows/U) © J.A. Doornik, 1994-2007.

[45] In the econometric analysis, the US price has been assumed to be unchanging for the years for which data is not available, 1776-83. This will, of course, bias the results against finding a relationship between the two price series.

Table 1: Results for 1750-1900

constant	0.366**
$\log(puk)_{t-1}$	0.911**
$\log(puk)_{t-2}$	-0.337**
$\log(pus)_{t}$	0.554**
$\log(pus)_{t-1}$	-0.353**
$\log(pus)_{t-2}$	0.192**
t	-0.001**

** - significant at the 5% level

The model appears to be fairly well specified, since the LM test for no autocorrelation and the Doornik and Hansen (1994) test for normality of the residuals cannot be rejected at the 1% level[46]. We can thus now solve for the static long-run solution of the model and check for cointegration. This gives the following equation (t-values in parentheses):

$$ECM = \log(puk) - 0.859 - 0.921\log(pus) + 0.002t$$

(3.27) (12.4) (-4.51)

[46] Extending the model back to include years prior to 1750 results in non-normality of the residuals. The results are, however, robust to extending the period of analysis in this way.

The Wald test for joint significance of the variables is accepted with a p-value of 0.000. Moreover, the unit root t-statistic, which gives the PcGive test for the null of no cointegration, is -7.33, which should be compared with a 5% critical value of -3.69 – and is thus evidence of very strongly significant cointegration (critical value from Davidson & MacKinnon 1993).

A test for the (transaction cost adjusted) Law of One Price applies to the long run is equivalent to testing whether the coefficient to *pus* is 1. Based on a standard error of 0.074, this hypothesis yields a t-statistic of 1.068, and it is thus not possible to reject the hypothesis that the coefficient is equal to 1. This implies that US and UK prices almost perfectly follow each other in the long run.

It is of course plausible that prices adjusted more fully at the end of the period. Restricting the analysis to the period 1750-1830, and thus ending well before the period usually associated with the grain invasion, gives the results in table 2.

Table 2: Results for 1750-1830

constant	0.754**
$\log(puk)_{t-1}$	0.804**
$\log(puk)_{t-2}$	-0.488**
$\log(pus)_{t}$	0.529**
$\log(pus)_{t-1}$	-0.314**
$\log(pus)_{t-2}$	0.262**
t	-0.003**

** - significant at the 5% level

Solving again for the static long-run solution of the model gives:

$$ECM = \log(puk) - 1.103 - 0.697\log(pus) + 0.004t$$

(4.38) (7.47) (2.72)

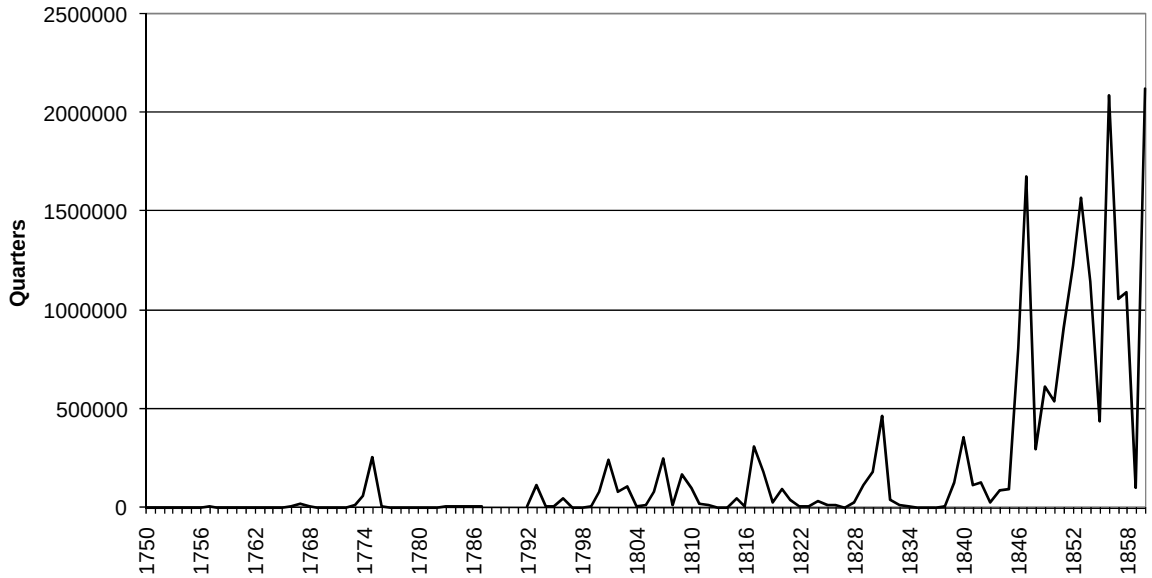
As is to be expected the evidence for market integration is less strong. Nevertheless, the PcGive test for no cointegration unit root t-statistic is -7.29. The long-run coefficient to *pus* is now lower, however, at 0.70. Based on a standard error of 0.093 this gives a t-statistic of 3.258 for the hypothesis that the parameter is equal to 1, and thus a rejection of the transaction cost adjusted law of one price – not surprising, considering that this included many periods during which trade was very difficult or impossible. Nevertheless, the conclusion must be that prices were cointegrated and thus markets integrated in the eighteenth century – to a lesser extent than in the nineteenth century, but still convincingly so.

This just serves to underline the point made in the introduction: even with little or no trade, there can be price arbitrage. Trade is done by wholesalers who have inventories. If they learn about falling prices in foreign ports they will be quick to sell, and thus press down prices. Likewise, if they see that price differences exceed transport costs from exporters they will stop buying in anticipation of falling prices. So all that is needed for prices to move together is reasonably regular information.

In conclusion, there is evidence that there was an early development of a transatlantic market for wheat. Additional evidence comes from looking at the UK trade statistics.

3. The transatlantic wheat trade in the eighteenth century

Figure 2: UK imports of wheat and wheat flour from North American Colonies / United States 1750-1860



Sources: The data to 1787 is for wheat only and comes from BPP (1789). The data includes trifling imports from Canada. Before 1755 the data does not include Scotland. Afterwards it is for the island of Great Britain. I have not been able to locate data for the years 1788-1791. From 1792 all imports are for wheat and wheat flour combined. From 1792-1799 they are from BPP (1815), from 1800-1824 they are from BPP (1827a), from 1825-1828 from BPP (1827b), from 1829-1830 from BPP (1832), from 1829-1839 from BPP (1843) and from 1840-1899 from the *Annual Statements of Trade 1853-1900*. Total imports (including from Ireland) are taken from BPP (1843) until 1842 and the *Annual Statements of Trade 1853-1900*. Where this is not already done in the sources, imports of wheat (measured by volume: quarters) is added to imports of wheat flour (measured by weight: hundredweight, cwt) using the assumption that there are 392 lbs (i.e. 3.5 cwt) of flour to a quarter of wheat (the assumption made in British Parliamentary Papers). For later years imports of wheat are also recorded by weight, and for the sake of comparison it is thus assumed that there are 4.4 cwt of wheat to the quarter.

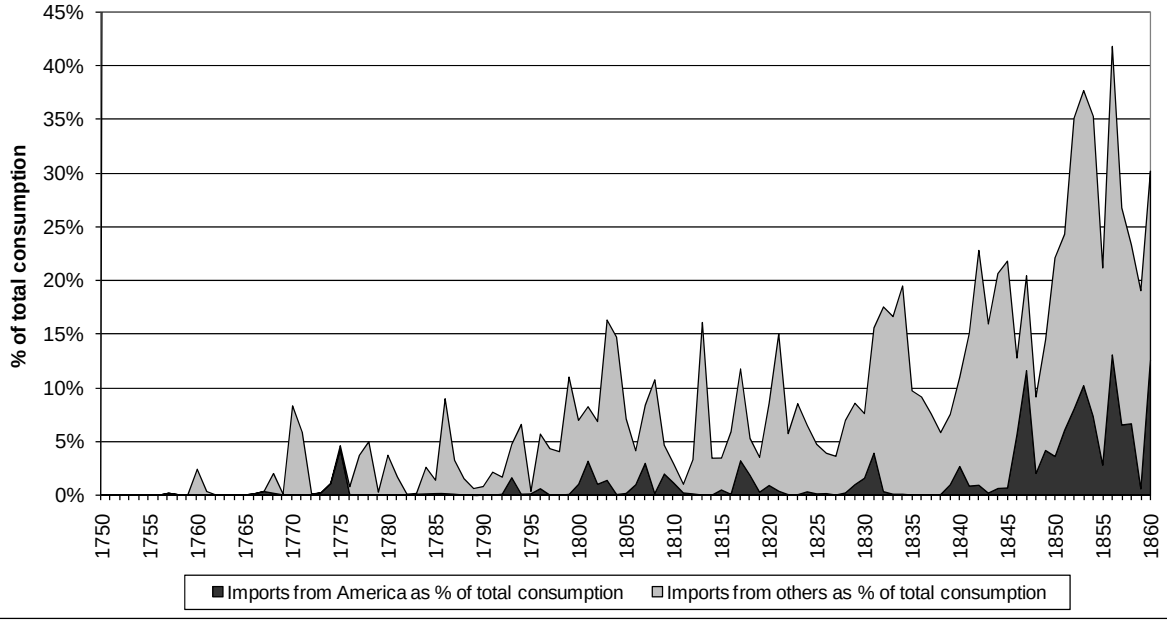
Data on wheat imports from the North American Colonies and the United States from 1750 is illustrated in figure 2. Data is actually available from 1697, when the office of Inspector General of Imports and Exports was established, with the first imports of wheat from North America recorded in the 1720s, but before the 1750s levels are negligible.

Of course, the levels of imports in the eighteenth century are tiny compared to later years. However, population was also rather smaller, so in order to get an idea of the importance of

these imports it is useful to compare the level of imports from America with total imports and estimates of total consumption of wheat in Britain.

Collins (1975) provides a number of estimates of annual wheat consumption per head in the nineteenth century, ranging from 6 to nearly 9 bushels. He also shows, however, that this was changing over time, since in 1800 only 66 per cent of grain consumption was for wheat, as opposed to 88 per cent in 1850 and 97 per cent in 1900. This means that an assumption of 0.9 quarters (over seven bushels) of wheat per person per year is almost certainly an overestimate for the eighteenth century. Nevertheless, making this fairly heroic assumption and multiplying it by the population statistics compiled by Wrigley & Schofield (1981) and Mitchell & Deane (1953, pp. 8-9) it is possible to get an idea of the levels of consumption.

Figure 3: Imports of wheat as a percentage of consumption 1750-1860



Source: See figure 2, own calculations.

As figure 3 illustrates, even before the repeal of the Corn Laws, imports from America were often supplying up to about three or four per cent of consumption. They were thus supplying a significant share of the population. Using data on total imports it is also possible

to give an impression of the relative importance of US imports compared to those from other countries: for many years they were a large proportion of total imports. The rest of the imports are predominantly coming from Prussia/"Germany", which for most years supplies in excess of half of all imports. The lesson is nevertheless clear: the United States' importance as a grain exporting country dates to the eighteenth century. There are, however, large fluctuations.

4. The volatility of early transatlantic wheat trade

It turns out that these fluctuations are surprisingly easy to explain. They are all the result of exogenous shocks to the developing Atlantic Economy, which in some cases cause imports to dwindle to a trickle for many years. It is convenient to divide this story into three periods: one until the 1760s and '70s, when Britain was a net exporter of wheat; the next from the industrial revolution and the accompanying population boom, which resulted in Britain becoming a net importer up until the end of the French and Napoleonic Wars; and finally from the introduction of extreme protectionism after 1815 until the abolition of the Corn Laws sliding scale in 1849. The period after the repeal of the Corn Laws, when American grain assumes its huge importance, which it maintains until the 1930s, is covered by Sharp (2007).

4.1 Imports as a response to harvest failure: The period until 1773

It turns out that the sporadic imports of wheat in the first period are easily explained by harvest failure in Britain. This can be seen by comparing the years in which imports are present with the annual evidence on English harvests collected by Jones (1964). So, for example, Jones records that 1728 and 1729 (the first years for which he collects evidence) were marked by "great dearth". And indeed, we find that American imports are first present in 1729. 1730 to 1739 was, however, a decade of "good harvests", and we find that American imports are entirely absent until 1740, following a "wet, late harvest" in 1739 and "extraordinary scarcity" in 1740. Jones then records that harvests were generally excellent until 1755, when the harvest was late, and 1756, "a year of scarcity". And of course we then find that imports from America appear in 1756 and 1757. The success of American exporters

in these years provoked an embargo on “all American vessels laden with corn, flour, &c” in 1757 (Pitt 1792, p. 266) Harvests are then recorded as being good until 1766, 1767 and 1768 which were all marked by food riots. This resulted in an embargo on the *exportation* of corn from England. Imports from America were then again welcome (Pitt 1792, p. 368), indeed, an “Act for allowing the Importation of Wheat and Wheat-flour from His Majesty’s Colonies in America, into this Kingdom, for a Time to be limited, free of Duty” was passed in 1766 (BPP 1766, p. 29) and was continued the following year (BPP 1767, p. 429).

Until this point we have learned nothing new: imports were largely the consequence of scarcity at home, a point well known from previous studies. However, it might be noted that American farmers were clearly looked to as a source of supply after a bad harvest, and were also obviously able to react. Every year there was a bad harvest the American colonies stepped in to help meet the deficit.

During this period, however, America was mostly seen as competition for British producers, and Britain was of course still at this time a net-exporter of grain. As early as 1713 a parliamentary committee heard of the quality of American wheat, superior to that Britain was able to export to the continent (BPP 1713, p. 368) and similar concerns were expressed in 1737 (BPP 1737, p. 116).

Already in 1740 a bill was read in parliament which proposed to prohibit the exportation of grain from North America, which met with condemnation by traders in the colonies themselves, as well as merchants involved in the trade in London (BPP 1740). In 1742, a petition was sent to Parliament “in Behalf… all the Farmers in Great-Britain” in which the petitioners made clear their fear that “great Quantities of Corn Land” were to be brought into production, and that wheat would be exported into Europe “at those Places, which always have been the British Farmers Markets”, and requesting that Parliament “prohibit the Exportation of Corn from America into Europe, and other Things that may prejudice the British Farmer and Tradesman”. A petition from “several Merchants of London” also makes the point that they are unable to compete with the Americans on exports of wheat to the Continent (BPP 1749, p. 1032).

The advantages enjoyed by American farmers were concisely summarized by William Ellis, a farmer, in a letter from 1742. He expresses concern that Americans "by their great Increase of Land… have been tempted… to carry on the Cultivation of Corn, and have made such Progress in its Improvements, that they are become Masters of prodigious Crops of Grain, especially the finest of Wheat, by enjoying, perhaps, one of the best Opportunities the World affords" and that "they have the richest of Land both dry and wet, a very potent Influence from the Sun's Heat, their Acknowledgement or Rent, little or nothing, their Slaves labour for a Trifle Charge, *and withal the great Cheapness and Conveniency of Water Carriage for transporting their Corn into Europe, to the infinite prejudice of Great-Britain*." (Ellis 1750, emphasis added). The last point he makes is one that has sometimes been neglected by economic historians when focussing on the role of transoceanic transportations costs: the fact that oceanic transport is relatively cheap compared to land or canal transport, meaning that the considerable distance between Britain and America need not necessarily imply large barriers to trade. This point will be taken up again in section 3.4.

What is clear, however, is that the importance of American wheat during these years was only apparent during times of harvest failure and contemporary comment focussed for most years on the problems of competing with this supply for foreign markets.

4.2 The first era of free trade: 1773 to 1815

From the 1770s something changes however, perhaps not coincidentally at the same time as Britain industrialized, experienced a population boom and started to become a permanent net importer of wheat. 1771 and 1772 are recorded by Jones as being years of poor harvests, and American supply seems to respond in the usual way. Harvests are however recorded as being "fine" in 1773, unremarkable but not bad in 1774 and even "plentiful" in 1775, and yet these years see the beginning of large-scale imports from America. Although imports continue to fluctuate greatly after this date, there is no longer the clear correspondence between imports and scarcity that there was in the earlier period.

It is probably no coincidence that large volumes of American grain started in arrive in British ports after the enactment of the Corn Law of 1774, which ushered in a period of "practically free" trade in grain, as stated in a report of an 1821 Parliamentary Select Committee (BPP

1821, p. 15). From 1791 the Corn Laws became more protectionist, but the onset of the French and Napoleonic Wars drove prices so high that only nominal duties were payable on imports (Sharp 2006). The considerable swings in imports from the US we see during this period do, therefore, not seem to be principally related to trade policy. Neither can they be explained by harvest failure in the UK.

The sudden dearth of imports from America after 1775 is actually very easy to explain. First, there was the American War of Independence from 1775-1783 which of course had some impact on wheat and flour production in America. Hunter (2005) notes three phases of the impact of the war: the first until 1777, which saw an increase in demand. Then, with the British invasion of the Philadelphia region in 1777, there was difficulty until 1779. For example, General George Washington ordered the removal of millstones to prevent the British from acquiring flour and the British targeted merchant mills. In addition, throughout the war, the British intermittently from 1776 tried to mount a blockade and in 1778 Congress imposed its own embargo, prohibiting the export of grain and flour, although some illegal exports were possible. The overseas trade was reopened in 1780 and, combined with good harvests, this marked the beginning of the final phase, one of recovery.

Perhaps more important, however, was the impact of the Hessian fly invasion from 1776 which decimated wheat crops. Unfortunately, I have been unable to locate data for wheat imports from America for the years 1787-1791. It is known, however, that in 1788 Philadelphia merchants were planning to ship large amounts of wheat to England, and that this resulted in a total ban on wheat imports from the United States from June 25 that year. How much this ban was attributable to a fear of introducing the fly to England and causing "a Calamity of much more extensive and fatal Consequences than the Admission of the Plague", and how much was due to an antagonism towards the newly independent United States is unclear, although Pauly (2002) notes that the Privy Council Committee for Trade were favourable towards ideas that would realign imperial trade and allow the Americans to suffer the consequences of independence. They also favoured policies that would stimulate home production at a time when higher general tariffs were not politically feasible.

The ban led to a considerable amount of debate and the publication by Parliament in March 1789 of a pamphlet, *Proceedings of His Majesty's Most Honourable Privy Council, and Information Received, Respecting an Insect, Supposed to Infest the Wheat of the Territories of the United States of America*, which attempted to justify the ban to the world[47]. The ban was poorly timed, however, because harvest failures in 1788 and 1789 made Britain's dependence on imports only too clear. The ban was reversed, and HMS *Echo* arrived in New York in February 1790 with the news (Pauly 2002). It appears likely that British leaders decided in 1789 that the United States would in the future be an important reserve food supply, and that the risk posed by French-style revolution was greater than that posed by the fly (Ritcheson 1969, cited by Pauly).

Hunter (2005) notes that "wheat and flour together served as a cornerstone of America's newly independent transatlantic commerce" and from an early date, wheat enjoyed a special status, Revolutionaries considering it to be the "ideal republican crop" in contrast to tobacco, with its association with "royal government, debt, slavery and poor agricultural practices" (Matson 2006, p. 246). The Hessian Fly itself might even have contributed to the long-run success of American wheat production, since it helped spur agricultural improvement, through for example experiments in diversification (Matson 2006, chapter eight). A similar point is made by Hunter (2005), who suggests that the French Revolutionary and Napoleonic Wars helped to ensure America's later success in wheat and flour exports by stimulating the adoption of new milling technologies and regional specialization.

The years from 1792 are of course marked by war. Generally imports from the United States continued their upwards trend, although some years stand out for having no imports or particularly high levels of imports. Wheat exports from America to all destinations started dropping from 1792 when the Hessian fly arrived in Delaware and Maryland, at that time the centres of production. From 1795 to 1799 America virtually ceased exporting wheat, the recovery only coming in the first years of the nineteenth century (Matson 2006, p. 253). In

[47] This useful publication furnished the statistical information on early wheat imports from America used in this paper.

vain successive Committees of the British Privy Council asked witnesses about the possibility of imports from the United States (BPP 1795a).

The recovery when it came, however, was quite impressive. Harvests in Europe were poor in 1799, but those of America were abundant and mostly free of the Hessian fly. Parliament enacted measures for bounties on the import of American wheat (Galpin 1925, p. 136) and by 1801 very large imports of American wheat came in. Indeed, in this year "the Americans so completely drained themselves of corn for this traffic, that bread became as dear, or dearer, at New York, than it was in England" (Board of Agriculture 1806, p. 277). Despite this, a combination of good harvests in England and poor harvests in the US contributed to the low level of imports from the US in the following years.

The imposition of Napoleon's Continental System from late 1806 presented a great opportunity for American exporters, however, and contributed to the large volume of imports from the US in 1807, the year in which the US consul at Liverpool was led to declare that "such quantities of wheat and flour from the United States have lately poured into this market that prices have declined"[48]. This encouraged the belief "in the permanency of this seemingly inexhaustible granary" (Galpin 1925, p. 44). However, in the wake of the Royal Navy's impressment of American citizens on the high seas, the United States itself imposed a trade embargo from 1807, reflected in testimony before a British parliamentary committee that trade in London declined in 1808 after the American embargo (Galpin 1922, p. 24). However, illegal wheat exports continued and Napoleon was quick to conclude that it was impossible to starve Britain, at least in part due to the availability of supplies from the United States. He thus soon, in the wake of bumper harvests in France, allowed exports of grain to resume (Galpin 1925, p. 168). There is no doubt, however, that the years of the embargo and the Non-Intercourse Act of 1809 were an important dampener on the level of trade (Galpin 1925, p. 147).

From this point on relations between the US and the UK gradually deteriorated and this, combined with good harvests in Europe, contributed to the low level of imports from

[48] Quoted in Galpin (1922, p. 24)

America. The last years of the Napoleonic Wars saw the beginning of a new war, this time between the United States and the United Kingdom. The war lasted from the summer of 1812 to the beginning of 1815 and witnessed a blockade by the British of the American coastline (Galpin 1925, p. 149).

Although farmers continued to voice predictable concerns[49], what is notable about contemporary comment over this period is rather than it changes from being focussed on the danger of American competition to a focus on the opportunities the American supply presented for meeting the demands of a growing population in Britain. Donaldson (1775), previously of the Jamaican government, wrote in a letter to the king that "The lands so liberally granted in America should be cultivated… and the mother country supplied from their industry; what magazines of corn might we hope to see from such resources!" This idea became more and more widely accepted, so that by 1790, a report of the British Privy Council (BPP 1790) concluded that "whenever the crops fail, in any degree, the deficiency can only be supplied from the harvests of America" (Glasgow Chamber of Commerce and Manufactures 1790). Although John Lord Sheffield argues vehemently against this conclusion in his *Observations on the Commerce of the United States*, other commentators were quick to back it up (Sheffield 17xx, Anon 17xx). A committee "on the high price of corn" looked first to the United States and the "abundant" supply there as a means of affording relief caused in part by the poor harvest in England (BPP 1795b, p. 85). By 1800, the British Board of Agriculture stated that "America be, or is hereafter to be the granary of Europe" (Board of Agriculture 1800, p. 148). A committee to "consider of the present high price of provisions" in 1801 also looked to America (BPP 1801a, p. 7, BPP 1801b, p. 8) as did a committee of 1805 (BPP 1805, p. 13).

Although the available statistics do not discriminate between imports of wheat and imports of wheat flour, it seems that most imports during these years were in fact of flour, in contrast to the years before the onset of the French Wars, when imports of wheat were

[49] For example, "A Farmer" writing in 1773 writes that "The only country from whence we can apprehend such an importation [of grain which could sell cheaper than British farmers could sell it for] is America" (A Farmer, 1773).

"very considerable" (BPP 1813, p. 115). This caused millers to complain, and evidence was presented before a select committee in 1813 from a miller to the effect that the imports of flour from the United States in 1806, 1807, 1809 and 1810 were bad for millers (BPP 1813, p. 99). Indeed, it seems they had good reason to. Select Committees heard that US flour was of very high quality owing to a sophisticated system of inspections and branding, and that it was easy to transport (BPP 1813, BPP 1814).

4.3 Prohibitive tariffs and the movement to free trade: 1815 to 1849

With peace, the Corn Laws soon became protectionist and this is reflected by the decline in American imports after 1818 (when prices fell sufficiently from wartime levels for imports to be prohibited under the terms of the Corn Law of 1815). Imports only really recovered with the introduction of the new Corn Law and the sliding scale of 1828 at which point swings in imports become clearly related to swings in import duties, which varied considerably from year to year (Sharp 2006), although it might be noted that during the 1830s America was again suffering from attacks of the Hessian fly.

In general, however, these years see a gradual decline in interest in the supply from America. Mentions in Parliamentary reports are rare[50] despite the huge volume of material published by Parliament during the debate in the run up to the repeal of the Corn Laws. So William Jacob's famous report on the "Agriculture and Corn of some of the Continental States of Europe" (BPP 1827) was just that, with no mention of America, and before a select committee in 1833 he dismissed the importance of the American supply (BPP 1833, p. 6).

With the repeal of the sliding scale in 1849, import duties become insignificant and were eventually abolished, allowing the great expansion of trade with America which was to become known as the Grain Invasion.

[50] Those there are concern rumours of small-scale smuggling of American grain via Canada (BPP 1820, pp. 18, 30 & 35; BPP 1821, pp. 277, 314-5 & 320-1; BPP 1836a, p. 43; BPP 1836b, pp. 113-4) and a brief mention that the Corn Laws harmed bilateral trade with the United States (BPP 1840).

An important lesson from this paper is thus an understanding of the importance of the American grain supply far back into the eighteenth century[51]. That this was the case is strikingly brought home by the following: In 1791 a petition was presented to the House of Commons by "Merchants of the City of London, concerned in the Commerce with the United States of America" (BPP 1791b, p.445) and petitions were received from Norwich, Somerset, Dorset, making it clear that these areas were unable to supply themselves with grain (BPP 1791b, pp. 466-467). A petition from Bailiffs and Burgesses of the Borough of Bridport, Dorset explicitly requested that Bridport be made a "Granary Port" so that the town might enjoy a "greater Connection with America, and that the Merchants will thereby be enabled to import Wheat, in Part, for their Manufacturies" (BPP 1791b, p.469). Even more explicitly a "Petition from the Mayor, Merchants, and principal Inhabitants, of the City of Bristol" stated that "the Western Part of the Kingdom does not grown Corn sufficient for the Consumption of its Inhabitants" and relied on imports "chiefly from America" through the port of Bristol (BPP 1791b, p. 653). If American crops had not have been ruined by the Hessian fly, and war had not intervened, might not the Anti-Corn Law League have emerged at this time? And then quite possibly we would now date the grain invasion – and possibly even the origins of globalization – to the late 1700s, rather than a century later.

4.4 The role of transportation costs

Until now no mention has been made of the role of transportation costs, which are often cited as being the main reason for the grain invasion of the late nineteenth century.

Recent research on the grain invasion of the late nineteenth century has concentrated on the role of falling domestic transportation costs, allowing grain to be shipped more easily from new production areas as the centre of American agriculture moved westward. However, the role of domestic transportation costs must have been negligible for the early days of the Atlantic wheat economy, since the vast majority of American wheat was grown near the east coast. Indeed, even as late as 1839, the geographic centre of production was

[51] There is also some evidence of its importance for other European countries, such as Portugal and Spain (Galpin 1922) and France (Kaplan 1976, p. 634).

east of Wheeling, (West) Virginia, with cultivation concentrated in Ohio and upstate New York and relatively little grown as far west as Illinois (Olmstead & Rhode 2002, p. 936).

The evidence on transatlantic rates is sketchy, but intriguingly, it appears that freight rates were *highest* at the times when imports were greatest. For example, Douglass North's British import freight rate index, available from 1790, is highest in the years 1799-1801 and again in 1807, which correspond to years when imports from America were greatest. No "meaningful" freight index is available from 1808-1813, when "freights rose to very high levels", but even for these years historically significant levels of wheat imports were arriving from the United States for most years. This pattern repeats itself in the figures North collected for the East Coast American freight factor for wheat, available from 1826. This is again highest from 1829-1831 and from 1845-47, the years of greatest imports[52] (North 1958). Unless we are to believe that high transportation costs encouraged imports, then one possible alternative explanation is that the high volumes of imports were pushing up demand for shipping and increasing freight rates.

Some evidence on transatlantic costs of transporting wheat is available for the eighteenth century. For example, A Farmer (1773, p. 102) gives a detailed breakdown of the cost of transporting wheat from America, although some of his assumptions might be rather suspect[53], since he is trying to show that British farmers have nothing to fear from imports. But by far the largest cost he records is for freight, which amounts to 8 shillings per quarter of wheat. By 1791, information received by the Committee of Privy Council for Trade suggested that it amounted to 8s. 8d. (BPP 1791a). Dividing this by the price of wheat in Britain for each year gives freight factors of 15 and 17 per cent respectively, about the same as for most of the early nineteenth century and only marginally below that of the late nineteenth century, after the "transport revolution" (Sharp 2007). Perhaps surprisingly, in evidence before a select committee in 1821, one witness describes the difficulty of Irish competing with American flour due to the cheapness of freight. It was actually cheaper to

[52] He provides no data for the years 1839-1841, when imports were also high.

[53] Such as that 10 per cent must be added to the cost due to waste and damage and an additional cost due to the decline in value because the grain has been on the ship for too long.

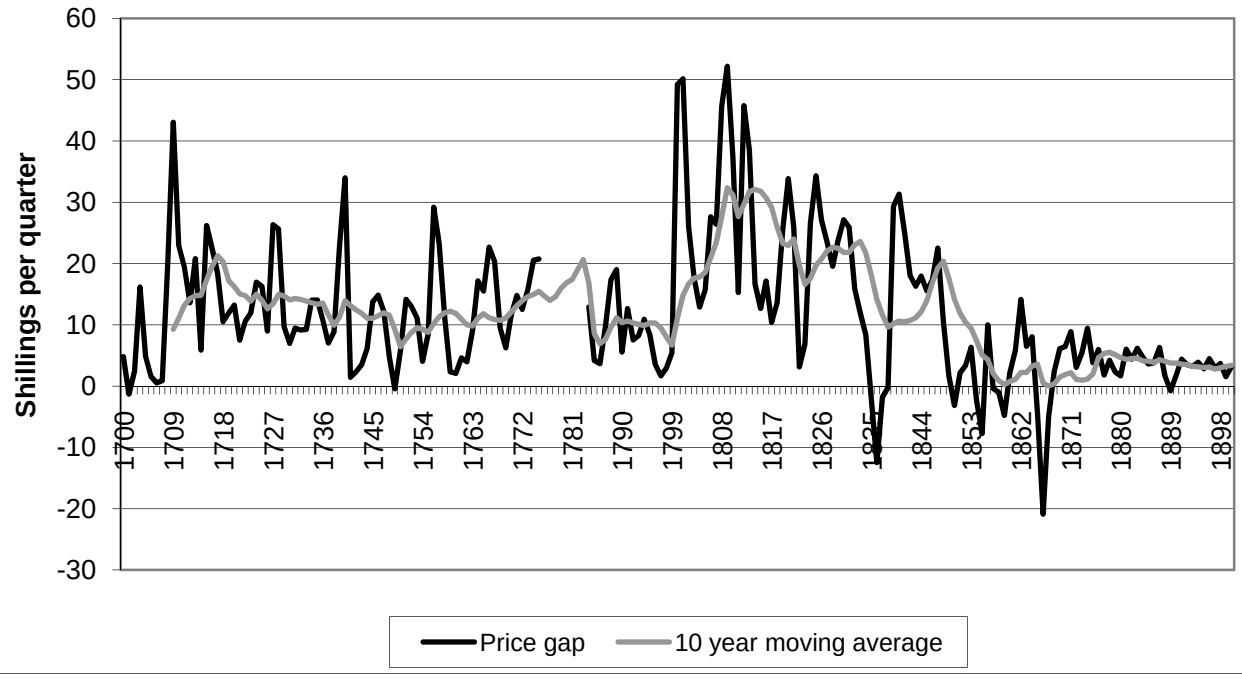
ship flour from America to Liverpool than from Ireland through Dublin to Liverpool, which required the use of expensive canal transport (BPP 1821, p. 319).

In short, it seems that at no time were transportation costs an important barrier to trade. Indeed, this was the point made long ago by Ellis (1750) - as quoted above.

5. Was this globalization?

It has thus been established that the transatlantic market for wheat was developing from the eighteenth century, and that this caused prices to fluctuate together, despite many setbacks to actual trade. It seems, however, unreasonable to consider this an era of globalization, since although there is evidence of market integration, the levels of actual trade were very low. To get a better understanding as to why this was the case, the price gap between the two markets is illustrated in figure 4. Given the finding earlier that, in the long run, prices largely moved together, the price gap in this case is simply equivalent to the deviation from the transaction cost adjusted law of one price.

Figure 4: Price gap between UK and US



Sources: See figure 1.

Except for extraordinary periods, such as during the American Civil War, and a time during the 1830s when American harvests were ravished by the Hessian fly, the price gap is positive over the entire period. The general trend is illustrated by the ten year moving average: for the part of the eighteenth century when the wheat trade was significant, the price gap fluctuates around a level of about 10 shillings per quarter, clearly compatible with the likely level of trading costs given in section 3.4 and thus with the trading costs adjusted law of one price. Prior to this, there is little or no trade, and the price gap does indeed seem on average to exceed the level of trading costs. After the repeal of the Corn Laws the gap falls to around half this level in line with the fall in transatlantic shipping costs (Persson 2004). The disruption caused by the Napoleonic Wars and the Corn Laws (see Sharp 2006) is also clear.

Looking more closely at the data, the times when trade is possible do indeed seem to be reflected in a narrowing of the price gap, most notably after the liberalization of trade in the 1770s, but even for shorter periods, such as around the extraordinary year of imports in 1807 and the short lived period of free trade immediately following the Napoleonic Wars. Thus, when trade was possible, there was a marked tendency of prices to respond in accordance with the law of one price.

To summarize, using one traditional measure of market integration, the degree of cointegration, markets were integrated. Looking closer at this through the price gaps shows the importance of understanding exogenous events when looking at divergence from the law of one price. However, the data point to trade being quite possible throughout the eighteenth century, if it hadn't been for the various disruptions outlined in section 3.

Ideally, it would be possible to examine the speed of adjustment back to the law of one price equilibrium. However, the data are not frequent enough to allow for testing in the sense described by Ejrnæs et al (2008). Clearly, however, when trade was relatively free, prices converged and levels of imports could reach those first experienced again half a century later.

6. Conclusion

Some degree of long run market integration was already present in the trade in wheat between the US and the UK from the eighteenth century. This trade was not insignificant, as the words and actions of contemporaries confirms. The change in the nineteenth century was not that prices began to follow each other, and neither was it particularly significant that the price gap narrowed (Persson 2004). The important change was that prices adjusted faster towards the law of one price equilibrium, as demonstrated by Ejrnæs et al (2008). It is not possible to test for this with the eighteenth century data, but it is clear that trade was too sporadic for markets to develop sufficiently.

What is interesting, however, is that trade could and did increase during the periods when exogenous events did not preclude this from happening. Volumes could not feasibly have been as high as they were by the end of the nineteenth century (when the US was exporting more than she produced in total in the eighteenth century), but they were significant. And importantly this was without the transport revolution. Whether we call this globalization or not, it is an important precursor to the globalization story of the nineteenth century, and an illustration of the beginning of the story of the American grain invasion of Britain.

References

A FARMER (1773). *An Inquiry into the Connection between the present Price of Provisions, and the Size of Farms.* London: T. Cadell

ANON (17xx). *A Brief Examination of Lord Sheffield's Observations on the Commerce of the United States.*

BOARD OF AGRICULTURE (1800). *Communications to the Board of Agriculture: Vol. II.* London: W. Bulmer & Co.

BOARD OF AGRICULTURE (1806). *Communications to the Board of Agriculture: Vol. V, Part I.* London: W. Bulmer & Co.

BPP (various). *Annual Statement of Trade 1853-1900.*

BPP (1713). *Journals of the House of Commons.*

BPP (1737). *Journals of the House of Commons.*

BPP (1740). *Considerations on the Bill for Prohibiting the Exportation of Corn, &c. from North America.*

BPP (1749). *Journals of the House of Commons.*

BPP (1766). *Journals of the House of Commons.*

BPP (1767). *Journals of the House of Commons.*

BPP (1789). *Proceedings of His Majesty's Most Honourable Privy Council, and Information Received, Respecting an Insect, Supposed to infest the Wheat of the Territories of the United States of America.*

BPP (1790). *Representation of the Lords of the Committee of the Council, appointed for the Consideration of all Matters relating to Trade and Foreign Plantations.*

BPP (1791a). *Information received by the Lords of the Committee of Privy Council for Trade, from Mr. Claude Scott, relative to the Charges for Freight of Corn.*

BPP (1791b). *Journals of the House of Commons.*

BPP (1795a). Various

BPP (1795b). *Journals of the House of Commons.*

BPP (1801a), *First Report from the Committee appointed to consider of the present High Price of Provisions.*

BPP (1801b), *Second Report By the Lords Committees, to whom it was referred to consider so much of His Majesty's Speech as relates to the Dearth of Provisions.*

BPP (1805). *Report from the Committee to whom the several Petitions, praying Relief from the Effects of an Act, passed in the last Session of Parliament, intituled, "An Act to regulate the Importation and Exportation of Corn, and the Bounties and Duties payable thereon," were referred.*

BPP (1813). *Report from the Select Committee on Petitions relating to the Corn Laws of this Kingdom.*

BPP (1814). *Reports Respecting Grain, and the Corn Laws.*

BPP (1815). *An Account of the Quantity of Grain, Meal, and Flour Imported into Great Britain, from Foreign Countries; and also, from Ireland, in each Year, from 1792 to 1814, both inclusive; distinguishing the Countries from which Imported, and the different kinds of Grain.*

BPP (1820). *Report from the Select Committee on Petitions complaining of Agricultural Distress, &c.*

BPP (1821). *Report from the Select Committee to whom the several petitions complaining of the depressed state of agriculture of the United Kingdom were referred.*

BPP (1825). *Account of Grain, Meal and Flour Imported into Great Britain from Foreign Parts and From Ireland.*

BPP (1827a). *Account of Quantity of Wheat and other Grain imported and exported from Great Britain, 1697-1825.*

BPP (1827b). *Account of Grain, Meal and Flour imported into Great Britain, 1825-26.*

BPP (1827c). *Second Report, made to the Lords of the Committee of His Majesty's Privy Council for Trade, on the Agriculture and Corn of the Continental States of Europe; with Observations: Collected in a Journey through those States, in the Autumn of 1827; By William Jacob, Esq. F.R.S. Comptroller of Corn Returns.*

BPP (1832). *Account of Grain, Meal and Flour imported into Great Britain, 1827-31.*

BPP (1833). *Report from the Select Committee on Agriculture.*

BPP (1836a), *Second Report from the Select Committee appointed to inquire into the State of Agriculture.*

BPP (1836b), *Third Report from the Select Committee appointed to inquire into the State of Agriculture.*

BPP (1840). *Report from the Select Committee on Import Duties*

BPP (1843). *Corn.*

CARTER, S.B. et al (2006). *Historical Statistics of the United States Millenial Edition.* Online version

COLLINS, E.J.T. (1965). Dietary Change and Cereal Consumption in Britain in the Nineteenth Century. *The Agricultural History Review* **23:2**, pp. 97-115

DAVIDSON, R. & MACKINNON, J.G. (1993). *Estimation and inference in econometrics.* Oxford University Press

DONALDSON, W. (1775). *Agriculture considered as a Moral and Political Duty.* London: T. Becket

DOORNIK, J. A., and HANSEN, H. (1994). *A practical test for univariate and multivariate normality.* Discussion paper, Nuffield College.

ELLIS, W. (1750). *The Modern Husbandman, Complete in Eight Volumes.* London: D. Browne

EJRNÆS, M, PERSSON, K.G. & RICH, S. Feeding the British: convergence and market efficiency in the nineteenth-century grain trade. *Economic History Review* **61:S1**, pp. 140-171

FINDLAY, R. & O'ROURKE, K.H. *Power and Plenty: Trade, War, and the World Economy.* Princeton University Press

GALPIN, W.F. (1922). The American Grain Trade to the Spanish Peninsula, 1810-1814. *The American*

Historical Review **28:1**, pp. 24-44

GALPIN, W.F. (1925). The *Grain Supply of England During the Napoleonic Period.* New York: Macmillan

GLASGOW CHAMBER OF COMMERCE (1790). *Third Report of a Committee of the Chamber of Commerce and Manufactures.* Glasgow: R. Chapman and A. Duncan

GUETTER, F.J. & MCKINLEY, A.E. (1924). *Statistical Tables Relating to the Economic Growth of the United States.* Philadelphia: McKinley Publishing Co.

HUNTER, B. (2005). Wheat, War, and the American Economy during the Age of Revolution. *The William and Mary Quarterly* **62:3**, pp. 505-5xx

JACKS, D.S. (2005). Intra- and international commodity market integration in the Atlantic economy, 1800-1913. *Explorations in Economic History* **42**, pp. 381-413

JACKS, D.S. (2006). What drove 19th century commodity market integration? *Explorations in Economic History* **43**, pp. 383-412

JONES, E.L. (1964). *Seasons and Prices. The Role of the Weather in English Agricultural History.* London: George Allen & Unwin Ltd.

KAPLAN, S.L. (1976). *Bread, Politics and Political Economy in the Reign of Louis XV: Volume 2.* The Hague: M. Nijhoff

MATSON, C. (2006). *The Economy of Early America.* Pennsylvania: Penn State University Press

MITCHELL, B.R. & DEANE, P. (1953). *Abstract of British Historical Statistics.* Cambridge: Cambridge University Press

NORTH, D.C. (1958). Ocean Freight Rates and Economic Development 1750-1913. *The Journal of Economic History* **18:4**, pp. 537-555

OFFICER, L.H. (2008). *Dollar-Pound Exchange Rate From 1791*. MeasuringWorth.com

OLMSTEAD, A.L. & RHODE, P.W. (2002). The Red Queen and the Hard Reds: Productivity Growth in American Wheat, 1800-1940. *The Journal of Economic History* **62:4**, pp. 929-966

ORMROD, D. (1985). *English Grain Exports and the Structure of Agrarian Capitalism 1700-1760.* Hull University Press: Occasional Papers in Economic and Social History No. 12

O'ROURKE, K.H. (2006). The worldwide economic impact of the French Revolutionary and Napoleonic Wars, 1793-1815. *Journal of Global History* **1**, pp. 123-149

O'ROURKE, K.H. & WILLIAMSON, J.G. (1999). *Globalization and History.* London: The MIT Press

O'ROURKE, K.H. & WILLIAMSON, J.G. (2005). From Malthus to Ohlin: Trade, Growth and Distribution Since 1500. *Journal of Economic Growth* **10:1**, pp. 5-34

PAULY, P.J. (2002). Fighting the Hessian Fly: American and British Responses to Insect Invasion, 1776-1789. *Environmental History* **7:3**, pp. 485-507

PERSSON, K.G. (2004). Mind the Gap! Transport costs and price convergence in the nineteenth century Atlantic economy. *European Review of Economic History* **8:2**, pp. 125-147

PITT, W. (1792). *Anecdotes of the Life of The Right Hon. William Pitt, Earl of Chatham.* Dublin: W. Porter

RITCHESON, C.R. (1969). *Aftermath of Revolution: British Policy Toward the United States, 1783-1795*. Southern Methodist University Press

SHARP, P.R. (2006). *1846 and All That: The Rise and Fall of British Wheat Protection in the Nineteenth Century.* Department of Economics, Copenhagen, Discussion Paper 06-14

SHARP, P.R. (2007). *Pushing Wheat: Why Supply Mattered for the American Grain Invasion of Britain in the Nineteenth Century.* Mimeo

SHEFFIELD, J. (17xx). *Observations on the Commerce of the American States.* London: J. Debrett

SHEPHERD, J.F. & WALTON, G.M. (1972). *Shipping, Maritime Trade, and the Economic Development of Colonial North America.* Cambridge: Cambridge University Press

UNITED STATES (1975). *Historical Statistics of the United States.* Washington: Government Printing Office

WILLIAMSON, J.G. (2008). Globalization and the Great Divergence: Terms of Trade Booms and Volatility in the Poor Periphery 1782-1913. *NBER Working Paper* No. W13841

Chapter 4 (with Jacob Weisdorf)

From preventive to permissive checks: the changing nature of the Malthusian relationship between nuptiality and the price of provisions in the nineteenth century[54]

Abstract: The Malthusian "preventive check" mechanism has been well documented for pre-industrial England through evidence for a negative correlation between the marriage rate and the price of wheat. Other literature, however, speculates that the correlation was in fact positive from the early nineteenth century. This paper uses the cointegrated VAR model and recursive estimation techniques to document the changing relationship between nuptiality and the price of wheat from 1541 to 1965. The relationship is indeed positive from the early nineteenth century to the First World War. A simple theoretical model shows that this result is not in fact inconsistent with a stylised Malthusian mechanism, and can be understood within the context of an increasing dominance of shocks to aggregate demand rather than to aggregate supply.

[54] This chapter has been published in 2009 as an article under the same title in the journal *Cliometrica* **3:1**, pp. 55-70.

1 Introduction

This purpose of this paper is to examine a statistical curiosity: the fact that the relationship between the price of wheat and the marriage rate in England changed from negative to positive at some point around the time of the Industrial Revolution.

Since Malthus (1798), scholars have been fascinated by the evidence for a negative correlation between marriage rates and what Malthus termed the "price of provisions", for which a usual proxy is considered to be the price of wheat. This relationship seemed to provide evidence of a "preventive check" mechanism, at least in the pre-industrial period, whereby marriage and hence childbirth was postponed in the expectation of hard times ahead. Most studies have at least implicitly assumed that this relationship ceased to be significant with the onset of industrialization, and intuitively, it would seem unlikely that the price of wheat has any important impact in modern times, at least on marriage rates.

However, in the late nineteenth and early twentieth centuries, economists and statisticians, starting with Ogle (1890), noted that there was now a *positive* relationship between marriage rates and wheat prices. This revelation, first reported by Ogle at a meeting of the Royal Statistical Society in London on March 18, 1890, and announced to the country by *The Times* on the following day (*The Times*, March 19, 1890, p. 10) seems to have caught the public imagination. The satirical magazine, *Punch*, in a parody of a popular nineteenth century song[55] had the singer announce that

The "quarter" stands at fifty, love,

Which for Mark Lane is dear.

Our wedding day is coming, love,

Our married course is clear.

[55] *My Pretty Jane* by Sir Henry Bishop and Edward Fitzball.

In the chorus he therefore asks his love to

… meet me, meet me at the Altar,

When the price of wheat rules high!

(*Punch*, Vol. 99, September 27, 1890)

However, despite becoming "conventional wisdom" in the interwar years, the relationship proposed by Ogle seems to have been almost completely forgotten after the Second World War. Our aim in this paper is thus first to establish, using state-of-the-art empirical methods, whether a statistical relationship ever existed and then to document how it changed over time. Although a positive relationship between nuptiality and the price of provisions would appear to contradict Malthus' prediction, we use a simple theoretical model to demonstrate that it is, in fact, possible for it to be understood within a simple Malthusian framework.

Section 2 presents a brief overview of the literature on the relationship between the marriage rate and the price of wheat. Section 3 uses the cointegrated VAR model and recursive estimation techniques to examine the change in this *statistical* relationship over time. We deliberately abstract from any theoretical discussions here, leaving these to section 4, which details a simple theoretical basis for the relationship and the change from a negative to a positive correspondence. Section 5 concludes.

2 Summary of the literature

Malthus (1798) seems to have been the first to suggest a relationship between the price of food, which he termed "provisions" and the marriage rate. He wrote that in times of distress caused, he believed, by overpopulation, "the price of provisions would … tend to rise. The labourer therefore must work harder to earn the same as he did before. During this season of distress, the discouragements to marriage, and the difficulty of rearing a family are so great, that population is at a stand". (Malthus 1798, II.25) In later work, Malthus (1830)

concluded that for many countries "the principal check which at present keeps the population down to the level of the actual means of subsistence is the prudential restraint on marriage." (Quoted in Schofield 1983, p. 267)

For many years, however, it was impossible to test the validity of Malthus' theory for his own country, since the first English census was in 1801, and annual marriage statistics were not recorded on a nationwide basis until well into the nineteenth century. Following in the wake of Wrigley & Schofield's (1981) "reconstruction" of marriage rates going all the way back to 1541, however, a large literature sprang up documenting the negative relationship between marriage rates and the price of wheat (used as a proxy for "price of provisions") for the pre-industrial English society.

The first such investigation was by Ronald Lee in Chapter 9 of Wrigley & Schofield (1981). He found a significant negative effect of prices on nuptiality, although in the last period he looked at, 1746-1834, the effect is weaker. Similar results are reached for a number of European countries by Galloway (1988) and again for England by Bailey & Chambers (1998) using some sophisticated econometrics and real wages instead of wheat prices.[56]

However, this modern work largely ignores an older literature which focuses on the modern period. In 1890 Ogle presented his simple statistical analysis, suggesting a positive relationship between the marriage rate and the price of wheat. He cited a number of scholars, including J. Stuart Mill, who assumed the reverse, but noted that "… neither these writers, nor those other authorities in political economy who have made similar statements, give, so far as I have been able to ascertain, the actual figures on which their statements are based; so that it remains doubtful whether they have themselves personally examined into the facts, or whether they have merely adopted, without personal investigation, an article of general belief." (Ogle 1890, pp. 256-7) Ogle pointed out that civil registration only began in

[56] The authors admit that given inflexible nominal wages and that the price index was dominated by the price of wheat, the two are almost interchangeable. (op.cit. p. 421) In fact the latter might be preferable, since the Phelps Brown-Hopkins (1981) real wage series is unsuitable for accounting for short-run fluctuations—see the discussion in Lindert (1985, p. 618).

1839, and estimates from before this date only went back to 1820, and that for these years, a clear positive correlation was apparent.[57]

Nevertheless, Ogle accepted that a positive relationship is, on the face of it, a paradox, since although the Malthusian negative relationship might be expected to become insignificant with an increase in the standard of living "… it does not explain why they [marriage rates] increase when food, or rather when wheat, is dear".

Ogle nevertheless provides a simple theoretical solution: "Men marry… in greater numbers when trade is brisk, and when the value of exports increases; but when the exports increase, so also do freights, and this rise in freights causes a corresponding rise in wheat, the largest part of our wheat being imported from abroad". So, as he explains, the dominant relationship is between the marriage rate and the "briskness of trade" and thus indirectly through transport costs with the price of wheat.

Hooker (1901) tested Ogle's theory using contemporary state-of-the-art statistical methodology (Pearson correlation coefficients) to show that the marriage rate was more highly correlated with trade than with the price of wheat[58] and this conclusion was reinforced with similar methodology by Thomas (1927, Chapter III).

By 1920 Arhur C. Pigou felt able to write that "It is well known that the English marriage rate was negatively correlated with wheat prices in the earlier part of the nineteenth century and was positively correlated with exports … in the latter part". (Pigou 1920, I.IX.2) Even as late as 1931, Beveridge (1931, p. 42) included the marriage rate as one of his indicators of the "pulse of the nation", noting that "… [t]he tendency to matrimony … is undoubtedly related to the comparative prosperity or adversity of the times".[59] However, with, to our knowledge,

[57] He charitably suggests that the confusion of other scholars must be due to their data being "derived from foreign sources". (op.cit. p. 257)

[58] This early literature is summarized by Westermarck (1925, pp. 390-1) in his famous *History of Human Marriage*.

[59] Modern economists, so used to relying on GDP data to illustrate the health of the economy, might envy the host of indicators used by the pre-war economist, such as Beveridge's marriage rate and data for the consumption of beer per head in gallons!

one exception,[60] this relationship, apparently "conventional wisdom" in the interwar years, has been entirely neglected since the Second World War.[61] Moreover, the timing and nature of the change from a negative to a positive relationship has not been examined.

3 From Malthus to Ogle: An empirical investigation of the change from a negative to a positive relationship

Ogle (1890) accepted that his finding seemed to be "… so paradoxical… that it is necessary before seeking for its explanation to show that it is an actual fact". With modern econometrics it is possible to do so.

The variables used in the subsequent analysis are *lcmr*, which is the natural logarithm to the crude marriage rate (marriages per 1000 head of population), and *lprice*, which is the natural logarithm to the price of wheat. The data run from 1541 to 1965.

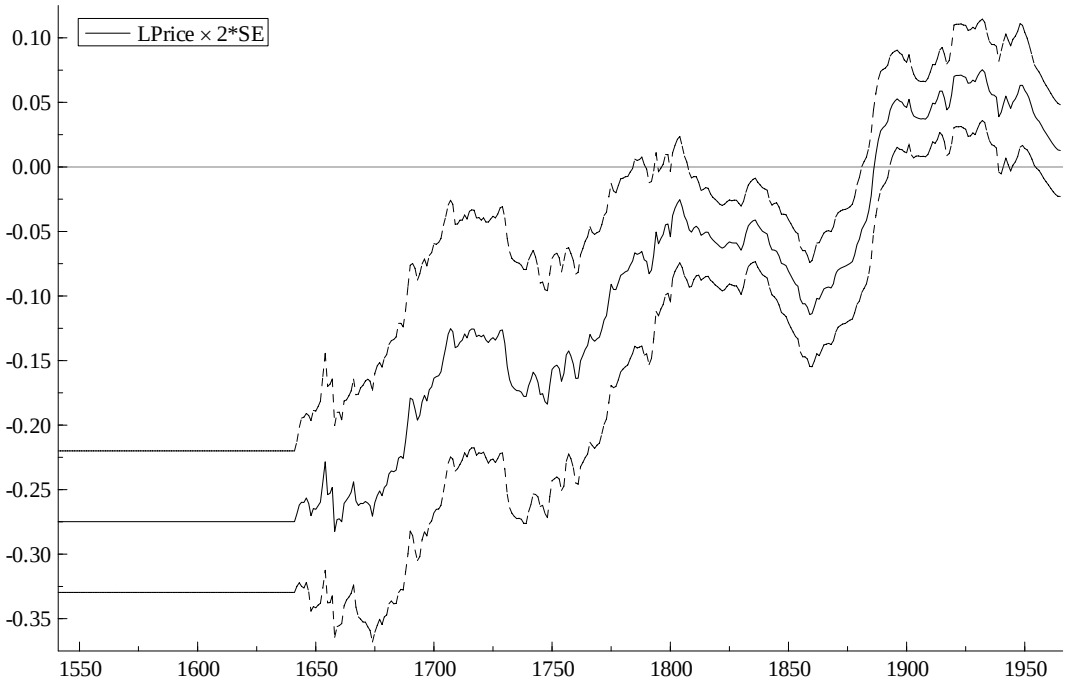
We start by illustrating the changing correlation of the crude marriage rate with the price of wheat using a simple OLS framework and sequential regression. Figure 3.1 illustrates the change in the beta-coefficient from an OLS regression of *lcmr* on *lprice*. The sample at each point is 100 observations, so for example the first regression is for the years 1541-1640 and the final regression is for the years 1866 to 1965. The coefficient becomes positive for the sample running from approximately 1801-1900, but before this period nearly all samples result in negative coefficients. Adding a trend makes no difference to this conclusion.

[60] Southall & Gilbert (1996) cite the aforementioned literature as justification for using marriage rates as indicators of local economic distress.

[61] In fact, the last discussion of the impact of prosperity on the marriage rate in modern times was in 1938, when Glass (1938) demonstrated that marriages rates and real wages were still highly correlated in the interwar period.

Figure 3.1: From negative to positive:

100 year sequential regressions of the marriage rate on the price of wheat



Of course, although this simple analysis is useful to illustrate the point that the simple correlation between the marriage rate and the price of wheat did change, it is not necessarily a robust conclusion and certainly cannot be used to make any statements about causality. To do so we therefore turn to a cointegration analysis, based on the methodology suggested by Juselius (2006).[62]

In order to model the long-run relationship between the crude marriage rate and the price of wheat the following model is estimated:

$$\Delta X_t = \alpha\beta' X_{t-1} + \Gamma\Delta X_{t-1} + \mu + \Phi D_t + \alpha\beta_0^{'} t + \varepsilon_t, \qquad (2)$$

[62] The results were obtained using CATS in RATS, version 2.

where $X_t = \left(lcmr_t, lprice_t\right)'$ and *t* is the trend.

This model assumes that the $p = 2$ variables in X_t are related through *r* equilibrium relationships with deviation from equilibrium $u_t = \beta' Z_t$, and α characterizes the equilibrium correction. It holds that α and β are $p \times r$ matrices and the rank of $\Pi = \alpha\beta'$ is $r \leq p$. The autoregressive parameter, Γ, models the short-run dynamics, and throughout it is assumed that $\varepsilon_t \sim iid.N_p\left(0, \Omega\right)$. D_t is a vector of dummies.

In order for the assumptions of the model to be fulfilled, in particular that residuals are iid and normally distributed, it is necessary to control for special or "extreme" events which are not otherwise captured by the model. These are detected through a detailed analysis of the residuals, and are classified as either having transitory or permanent effects on the levels of the variables. Special events which have only transitory effects, from period T_0 to T_x are modelled by dummies of the form $Di_t = 1_{\{t=T_0\}} - 1_{\{t=T_x\}}$. A dummy of the form $Dp_t = 1_{\{t=T_0\}}$ allows for the special event to have permanent effects on the levels of the variables. By controlling for the above it is possible to uncover the underlying long-run model for "normal" observations. As will be demonstrated below, it turns out to be necessary to control for a number of special events, which are almost exclusively wars.[63]

Since the model assumes constant parameters, and there is strong evidence of the relationship changing around about the year 1800, the sample is split in two: 1541-1799 and 1800-1965. This division is also consistent with work on the "end of the Malthusian era", which suggests a break at around 1800. (Schofield 1983, Clark 2007)

All subsequent analysis relies on the choice of a lag-length of 2 in the model in equation (2) being correct. Using information criteria, it is found that *k*=2 lags are in fact sufficient to characterize the systematic variation in the model in both periods after controlling for

[63] It turns out, perhaps surprisingly, that legislative changes, such as the Marriage Act of 1753, which abolished common-law marriage, and the Marriage Act of 1836, which introduced civil marriage, do not have an impact on the statistical relationship between the two variables.

special events. This assumption was then verified at various points during the subsequent analysis.

There are many advantages of performing a cointegration analysis in this case. For example, although there might be reasons to believe that the data is of poorer quality for the earlier years, this will not affect our results. We are looking for long-run relationships between the variables (the beta-coefficients in the cointegrated VAR model). These are not affected by errors in the data, unless of course they are systematic, which there is no reason to believe they are. Moreover, the finding of cointegration means that there is a genuine (non-spurious) relationship between the variables.

3.1 Pre-industrial England, 1541-1799

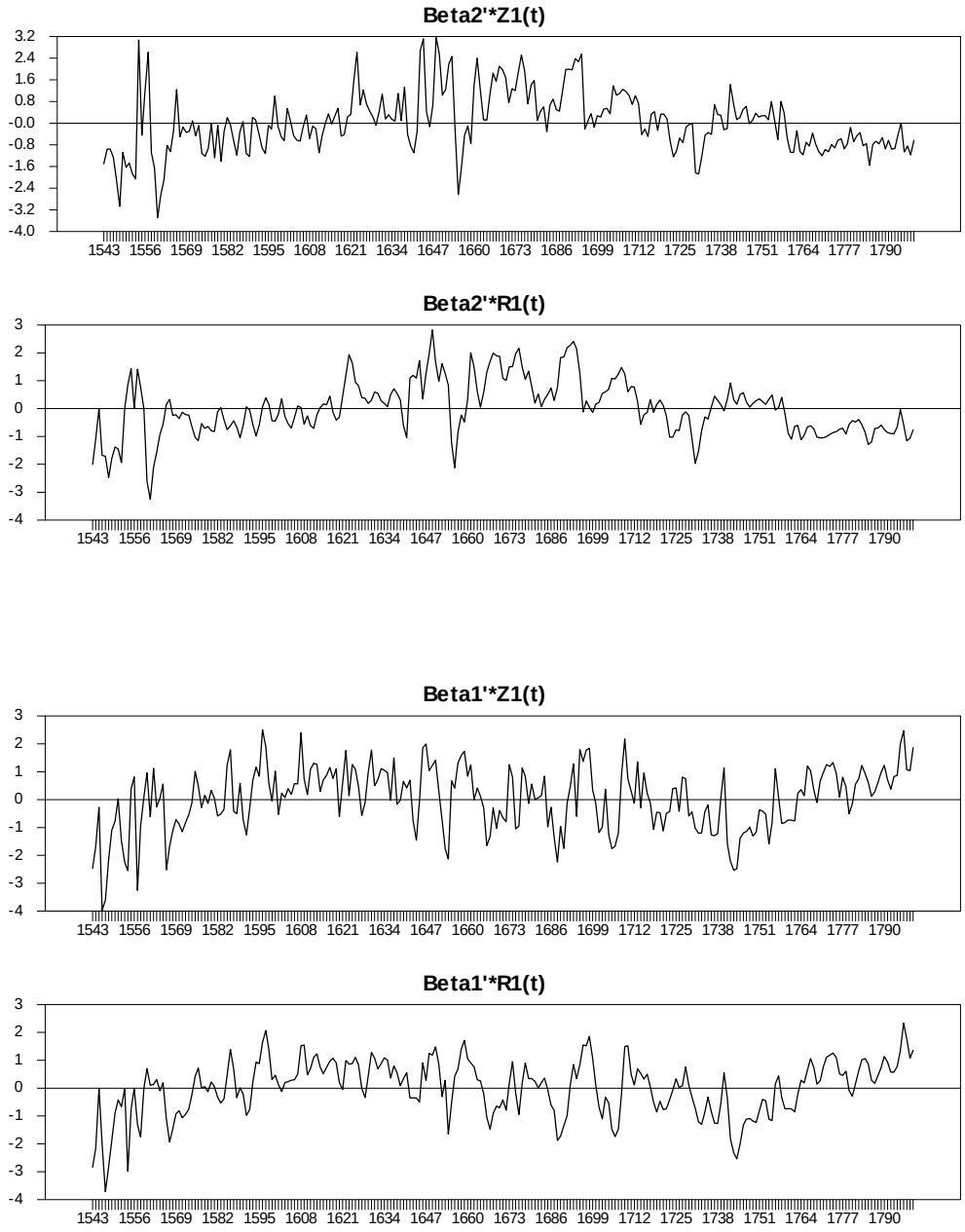
Although the negative relationship between the marriage rate and the price of wheat is well documented for the pre-industrial world, we demonstrate it again here for the sake of completeness.

As explained, dummies are introduced to model events exogenous to the other variables. The inclusion of and choice of dummies was motivated by the guidelines laid down in Juselius (2006) and is the standard method when working with the CVAR model. These events are a permanent negative impact on prices of peace with France in 1546 after the Italian War of 1542-46 and the successful Spanish and English invasion of France in 1557 as part of the Italian War of 1551-9; a permanent negative impact on the marriage rate in 1554, possibly due to Wyatt's Rebellion of 1554; a permanent positive impact on the marriage rate in 1560 attributable to peace after the final Italian War of 1551-59; and finally temporary negative effects on the marriage rate from 1643-5 and 1648-54. These last seem likely to be due to uncertainty surrounding the First English Civil War (1643-5); and the Second and Third English Civil Wars (1648-9, 1649-51) and the period of the Commonwealth (1649-53).

After introducing the dummies, the model appears to fulfil the iid.-normality assumption. The F-test for (no) autocorrelation up to second order is accepted with a p-value of 0.54. The Doornik & Hansen (1994) test for normality is accepted with a p-value of 0.26. The univariate tests for the individual variables are likewise accepted.

A crucial step in the analysis is to determine the number of equilibrium relationships, *r*, but this causes some difficulties, since, as it turns out, the model is poorly specified for the final years. We thus rely on a number of other methods, two of which are reported below. First, it is clear from figure 3.2 that the first relation is far more clearly stationary than the second and that any non-stationarity is largely attributable to the period from the early eighteenth century. Second, the largest root of the companion matrix is 0.76 while the second is 0.62. Imposing one unit root removes the largest unit root and the second is reduced to 0.61. In summary, an assumption of one unit root seems appropriate and is justified in as much as it allows for greater ease of interpreting the estimation results.

Figure 3.2: Graphs of the cointegrating relations



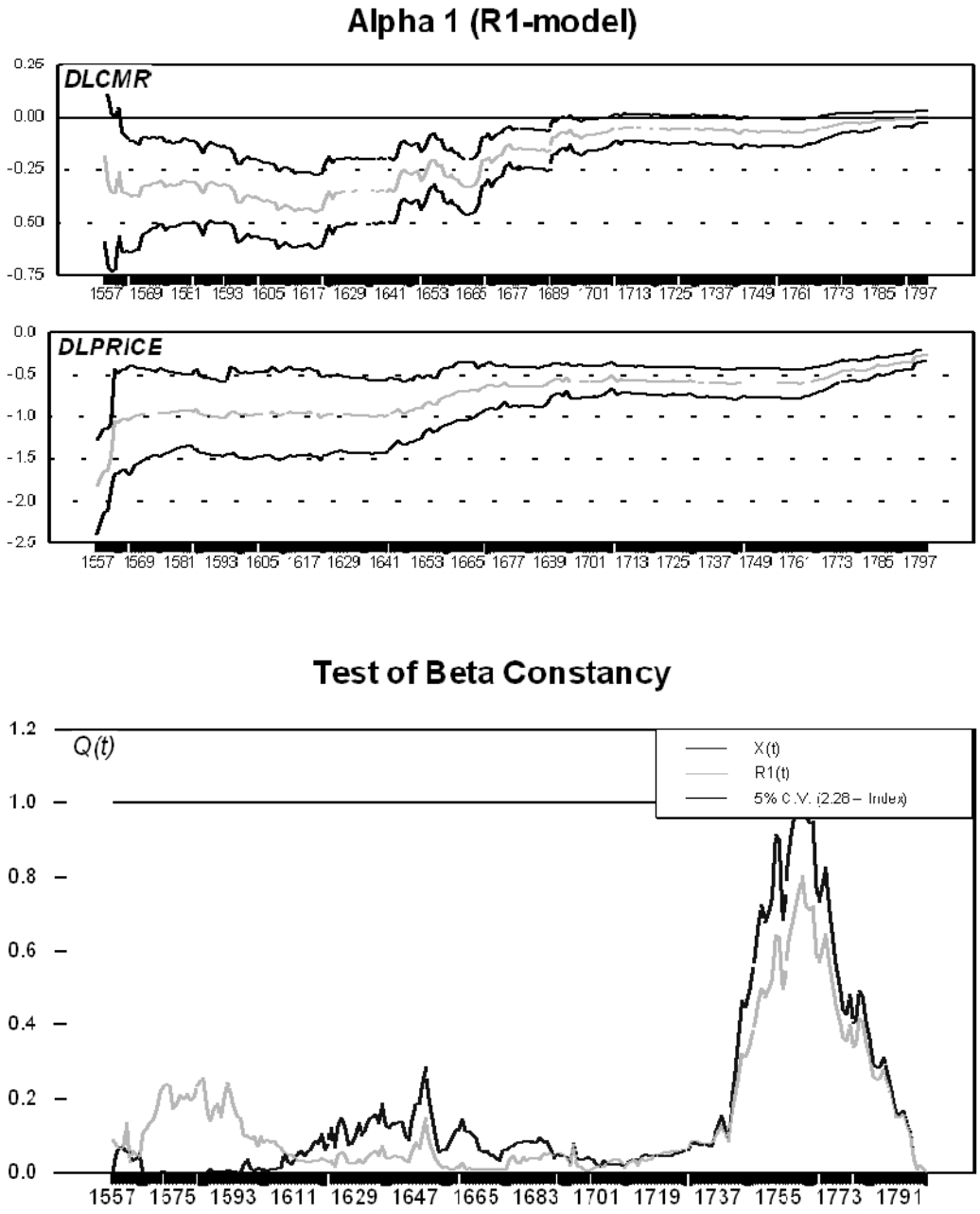
After the assumption of $r = 1$, a number of tests are performed using recursive estimation[64] in order to test the assumption of parameter constancy. The important test for beta

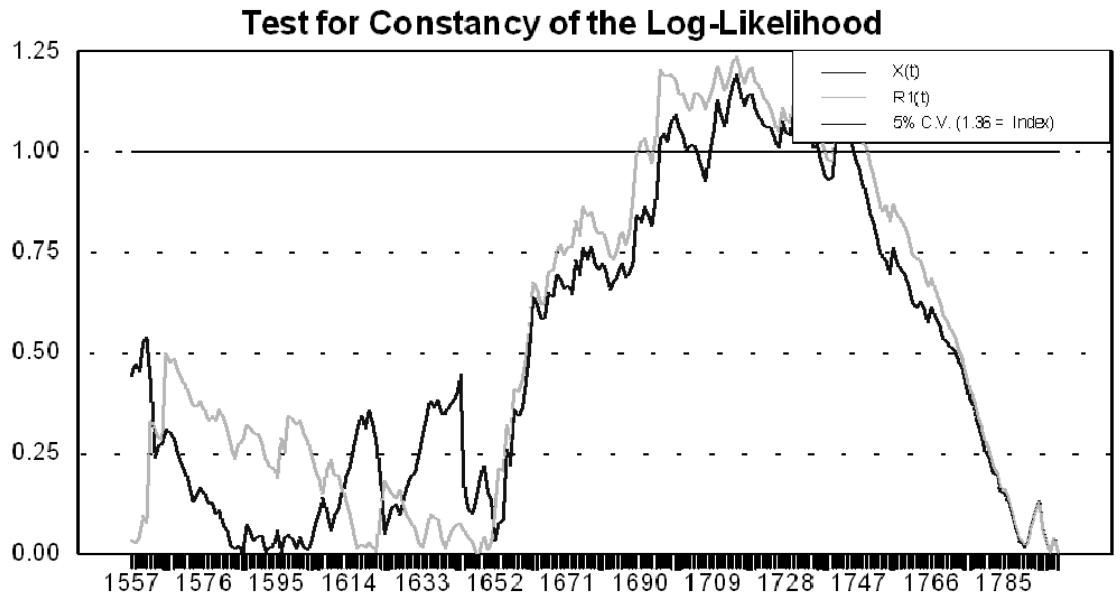
[64] In contrast to the sequential estimation used for the OLS analysis, the recursive estimation here starts with a base sample, and then adds one observation at a time.

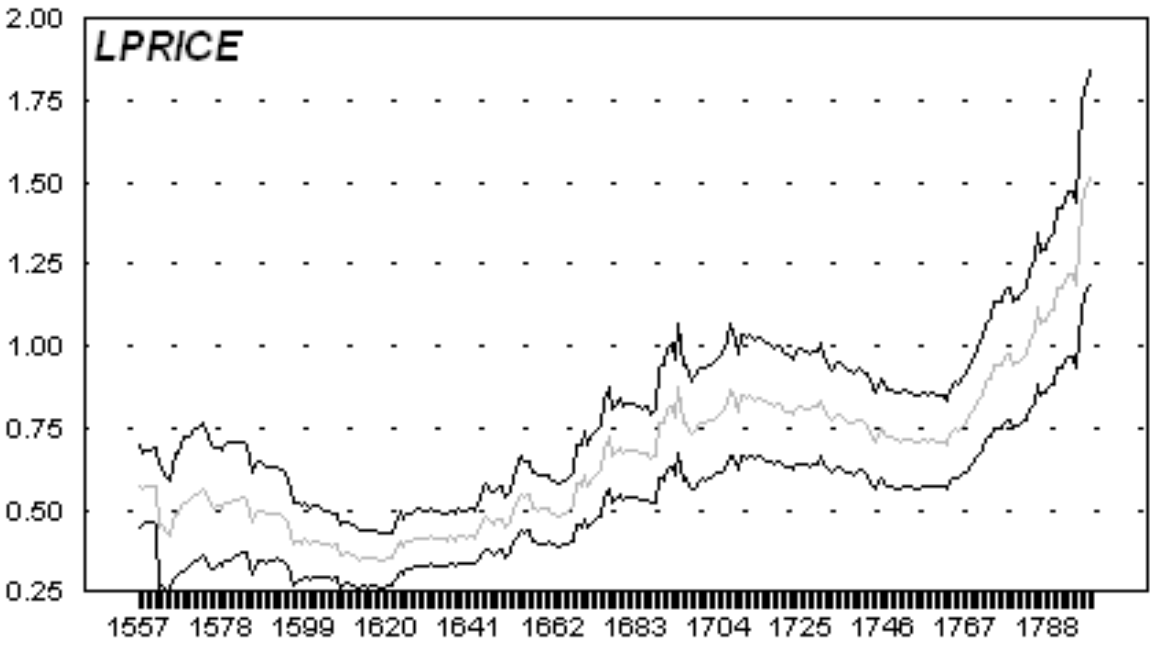
constancy is accepted for all sample lengths. However, the test for constancy of the log-likelihood suggests a structural break from around about 1700.

The structural break is clearly associated with a movement towards exogeneity of the marriage rate, as shown in the graph for the alpha (adjustment) coefficients in the second panel of figure 3.3. This is consistent with the movement from a negative correspondence between prices and the marriage rate, through a period of no significant correspondence to one of a positive relationship, as will be demonstrated in the next section.

Figure 3.3: Some tests for parameter constancy







The coefficient beta, which can be interpreted as the elasticity of the marriage rate with respect to the price of wheat, is found to be -1.52 with a t-value of 8.94. This seems very high, but a more representative elasticity of around -0.5 prevails until the late 1600s, at which point, as already noted, the marriage rate seems to become exogenous, giving the beta-coefficient a spurious interpretation. Indeed, Kelly (2007) finds that while the elasticity

of marriages with respect to the real wage (using weather as an instrument) is strongly significant from 1541-1700 with an elasticity of 1.4, it is insignificant for the years 1701-1800. (Kelly 2007, p. 11) The results here are thus clearly compatible with his.

3.2 Modern England, 1800-1965

For this period, the trend *t* was found to be insignificant and was thus excluded. Special events were controlled for in a similar fashion to in the preceding section. A temporary period of very high wheat prices from 1800-2 associated with the Napoleonic wars is found to have a transitory effect as did the First World War, which caused a temporary increase in the marriage rate in 1915.[65] The end of the First World War, however, is found to have a permanent and positive effect on the marriage rate; and the onset of the Second World War is found to usher in a period of permanently high prices, controlled for using a permanent blip dummy for 1940. Marriages are also affected, such that the level is temporarily high from 1939 to 1943 and permanently high from the end of the war in 1945.

After introducing the dummies, the model appears to fulfil the iid-normality assumption. The F-test for (no) autocorrelation up to second order is accepted with a p-value of 0.25. The Doornik & Hansen (1994) test for normality is accepted with a p-value of 0.07. The univariate tests for the individual variables are likewise accepted.

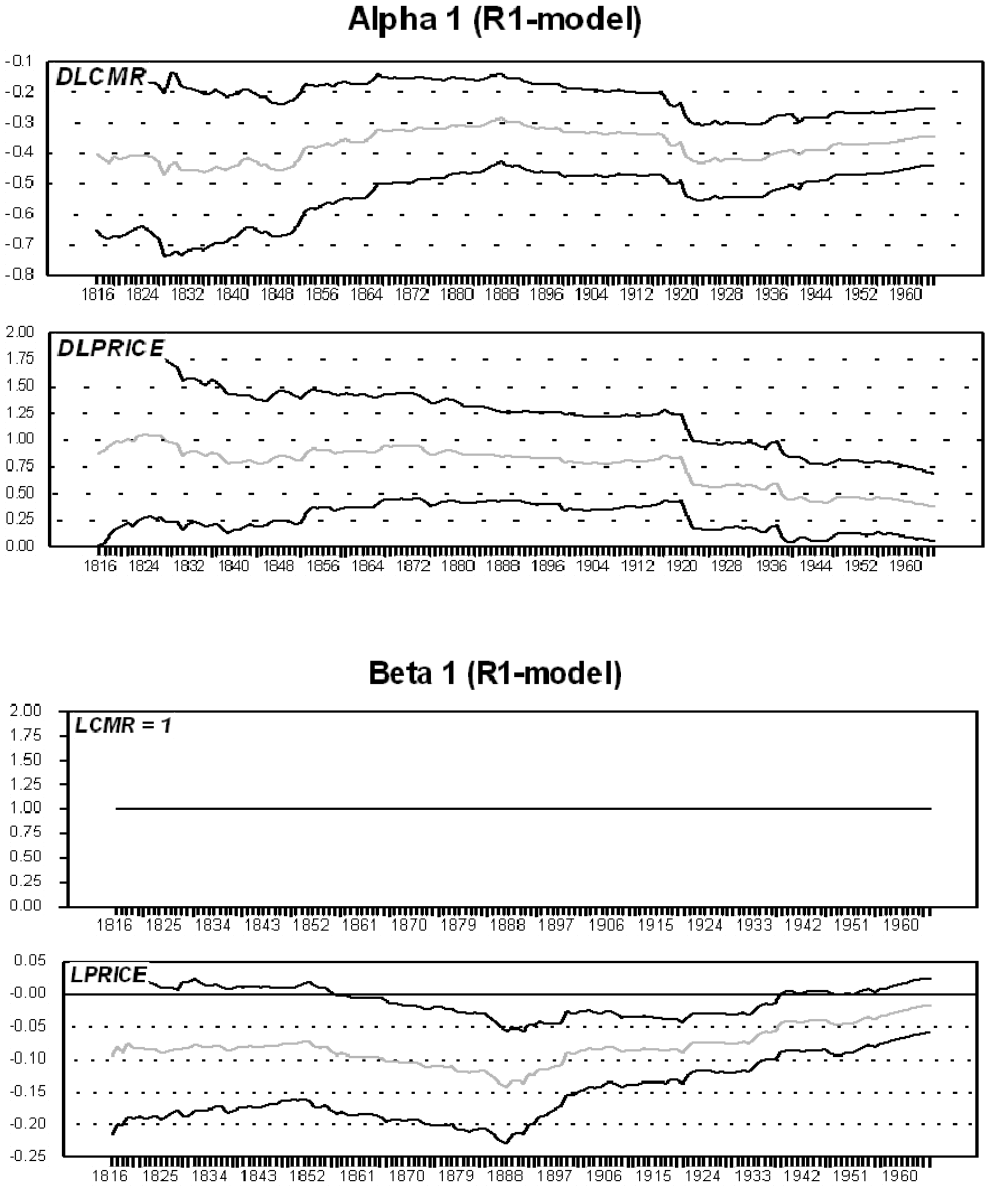
For this period, the choice of cointegration rank is simple. There is one very large root of the companion matrix (0.91), and the next highest is just 0.48 and stays at approximately this level with one unit root imposed. It is therefore assumed that $r = 1$.

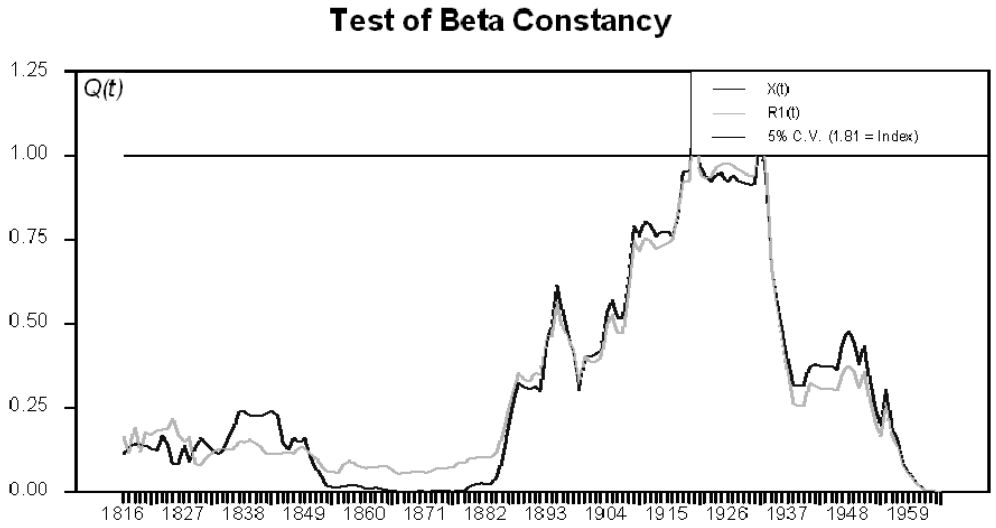
A number of tests are again performed using recursive estimation in order to test the assumption of parameter constancy. The beta-coefficient, which again can be interpreted as the elasticity of the crude marriage rate with respect to the price of wheat, despite being constant at around 0.1 for the majority of the period, becomes significant in the first half of the nineteenth century, and can then be seen to be declining in importance and becoming

[65] Marriages were stimulated by the offer of a generous separation allowance and pensions, and by the policy of taking single men first in the first period of the war. (Westermarck, p. 391)

insignificant with samples longer than until the 1930s, as seen in the second panel of figure 3.4.

Figure 3.4: Some tests for parameter constancy





The variable *lcmr* is significantly adjusting throughout the period, whereas the variable *lprice* becomes increasingly exogenous, as illustrated by the third panel of figure 3.4. This is consistent with a movement from the 1820s towards free trade and a price determined by the law of one price on world markets.

4 A Simple Theoretical Framework: Towards an explanation for Ogle's Paradox

It is tempting to interpret the positive relationship between prices and marriages observed after 1800 as evidence for the collapse of Malthus' hypothesis and indeed a paradox in terms of his model. However, the positive relationship would then remain to be explained, so it would be far more satisfactory if it was possible to understand the change within the context of Malthus' position. The following presents a simple model where this is the case.

As previously explained, Ogle (1890) considered that an increase in the price of wheat might suggest that exports are on the rise, which Ogle saw as evidence of mounting economic prosperity. More broadly speaking, what Ogle meant was that the English economy experienced an economic boom. An economic boom would imply not only that exports are on the rise but that the economy's total output is on the rise. In addition, rather than thinking about higher prices as resulting from a rise in freights, as Ogle did, a price increase

more generally can be thought of as resulting from an uncompensated increase in aggregate demand or a drop in supply.

This can all be seen more clearly in the context of a regular supply-demand analysis. Such an analysis would consist of two components. The first component would concern the aggregate demand for marriages (i.e. the marriage rate) and its relationship with the economy's total output. Following Malthus (1798), marriage means children with whom the family's resources must be shared. If such anticipated sharing means living below one's expected life-style, then marriage will be delayed until economic conditions improve. Under an economic recession, therefore, people would have fewer resources, resulting in fewer people getting married and fewer early marriages taking place.

To put this more rigorously, an economy's marriage rate, symbolically denoted *M*, would be given by the functional relationship

$$M_t = M\left(Y_t\right), \qquad (3)$$

where it is assumed that $M\left(\cdot\right)$ is continuous and monotonic, with *Y* measuring aggregate output in real terms.

The second component of the framework would be a standard *AS-AD* model, comprising the economy's aggregate demand and supply of goods. As usual, the supply curve is upward-sloping, while the demand curve is downward-sloping. Together supply and demand determine the aggregate output, *Y* and the general price level, *P*. The *AS-AD* model on the one hand, and the relationship between output and marriages on the other, are illustrated in Figure 4 below.

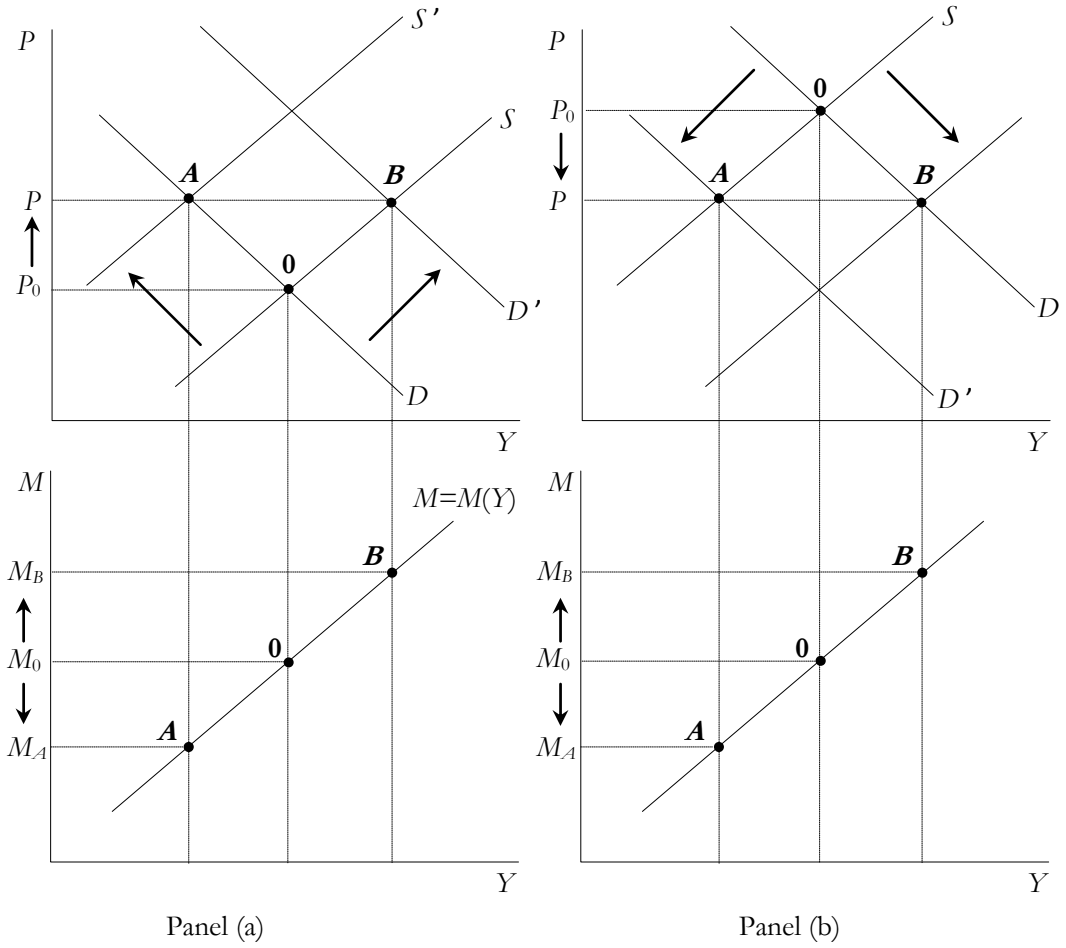
We can now turn to the analysis.

Analysis

In the analysis below, we look for shocks to supply and demand to examine the relationship between prices and marriages.

From the initial equilibrium (points marked **0** in Figure 4), two types of shocks are responsible for a price *increase* (panel a): an upward (rightward) shift in the *AD*-curve (i.e. a positive demand shock) and an upward (leftward) shift in the *AS*-curve (i.e. a negative supply shock). It follows that the impact on the marriage rate depends on the type of shock: a negative supply shock *reduces* the marriage rate (the point marked **A** in panel a); a positive demand shock *increases* the marriage rate (the point marked **B** in panel a). Whereas the first observation supports Malthus' conjectures (a price increase causes a marriage rate decrease), the second observation is in favour of Ogle's speculations (a price increase causes a marriage rate increase).

Figure 4: The effects to the marriage rate of shocks to supply and demand



Next, two types of shocks are responsible for a price *reduction* (panel b): a downward (rightward) shift in the *AS*-curve (i.e. a positive supply shock) and a downward (leftward) shift in the *AD*-curve (i.e., a negative demand shock). Again, the impact on the marriage rate depends on the type of shock: a positive supply shock *increases* the marriage rate (the point marked **B** in panel b); a negative demand shock *reduces* the marriage rate (the point marked **A** in panel b). Again, whereas the first observation supports Malthus conjectures (a price reduction causes a marriage rate increase), the second observation favours of Ogle's speculations (a price decrease causes a marriage rate decrease).

Taken together, therefore, panels (a) and (b) of Figure 4 demonstrate that *supply shocks imply a negative correlation between prices and marriage rates*, as Malthus imagined it. On

the other hand, *shocks to demand imply a positive correlation between prices and marriage rates*, as Ogle (1890) was able to observe. This suggests that supply shocks were more pronounced when Malthus studied the economy, whereas demand shocks were more prevalent a century later when Ogle studied the economy, a prediction which can be made subject to testing.

There is, however, an obvious reason why we might expect the above prediction to be founded in historical fact. In the nineteenth century, England moved from a dependence on domestic production to an increasing dependence on foreign imports, and thus became less susceptible to supply shocks: if the American harvest failed, for example, it was possible to import from elsewhere. Demand shocks—which in any case had probably been less prevalent in the pre-industrial society, when many people were living close to subsistence level—would thus have come to dominate.

5 Conclusion

Is the positive relationship between prices and marriages observed after 1800 to be taken as evidence of a collapse of Malthus' hypothesis? Or can it be explained within the context of his theory?

The analysis performed above suggests that Malthus' position—if we interpret it as a positive relationship between output and marriages—leaves ample room for a positive relationship between prices and marriages. Conveniently, then, as the above analysis also established, this interpretation of Malthus' theory makes Ogle's apparent paradox—that prices and marriages are *positively* correlated—perfectly compatible with the Malthusian story.

The timing of the end of the Malthusian era has been subject to much debate. A key part of Malthus' story was the preventive check mechanism. If this is identified with a negative relationship between prices and marriages, then the Malthusian era ended by the beginning of the nineteenth century when the positive relationship between prices and marriages emerged. If, on the other hand, we recognise Malthus' hypothesis by a positive relationship

between output and marriages, then the Malthusian era would have persisted up until the early twentieth century and maybe even longer.

In any case, an obvious implication of this current work is that marriage rates can be understood to be indicative of economic distress in England from at least the sixteenth century until the early twentieth century. In addition, the price of wheat is seen to be an important determinant of a key demographic variable until very recent times. Although this latter at least might initially seem as unlikely as Malthus' famous ostrich theory,[66] we feel that the evidence is conclusive.

[66] "A writer may tell me that he thinks man will ultimately become an ostrich. I cannot properly contradict him. But before he can expect to bring any reasonable person over to his opinion, he ought to shew that the necks of mankind have been gradually elongating, that the lips have grown harder and more prominent, that the legs and feet are daily altering their shape, and that the hair is beginning to change into stubs of feathers." (Malthus 1798, I.13)

References

CLARK, G. (2007). *A Farewell to Alms: A Brief Economic History of the World.* Princeton: Princeton University Press

GALLOWAY, P.R. (1988). Basic Patterns in Annual Variations in Fertility, Nuptiality, Mortality, and Prices in Pre-industrial Europe. *Population Studies* **42**, pp. 275-303

GLASS, D.V. (1938). Marriage Frequency and Economic Fluctuations in England and Wales, 1851 to 1934. In Hogben (1938)

HENDRY, D.F. & MORGAN, M.S. eds. (1995). *The Foundations of Statistical Analysis.* Cambridge: CUP

HOGBEN, L. ed. (1938). *Political Arithmetic: A Symposium of Population Studies.* London: George Allen & Unwin Ltd.

HOOKER, R.H. (1901). Correlation of the Marriage-Rate with Trade. *Journal of the Royal Statistical Society* **64**, pp. 485-92 [Reprinted in Hendry & Morgan (1995)]

JUSELIUS, K. (2006). The Cointegrated VAR Model: Methodology and Applications. Oxford: OUP

KELLY, M. (2007). *Living Standards and Population Growth: Malthus was Right.* Mimeo

LINDERT, P.H. (1985). English Population, Wages, and Prices: 1541-1913. *Journal of Interdisciplinary History* **15:4**, pp. 609-634

MALTHUS, T.R. (1798). *An Essay on the Principle of Population.* London: J. Johnson

MALTHUS, T.R. (1830). *A Summary View of the Principle of Population.* London

MITCHELL, B.R. & DEANE, P. (1962). *Abstract of British Historical Statistics.* Cambridge: Cambridge University Press

MITCHELL, B.R. & JONES, H.G. (1971). *Second Abstract of British Historical Statistics.* Cambridge: Cambridge University Press

NORTH, D. (1958). Ocean Freight Rates and Economic Development 1750-1913. *The Journal of Economic*

History **18:4**, pp. 537-555

OGLE, W. (1890). On Marriage-Rates and Marriage-Ages, with Special Reference to the Growth of Population. Journal of the Royal Statistical Society 53:2, pp. 253-289

PHELPS BROWN, H. & HOPKINS, S.V. (1981). *A Perspective of Wages and Prices.* London: Methuen

PIGOU, A.C. (1920). *The Economics of Welfare.* London: Macmillan and Co.

SCHOFIELD, R.S. (1983). The Impact of Scarcity and Plenty on Population Change in England, 1541-1871. *Journal of Interdisciplinary History* **14:2**, pp. 265-291

SOUTHALL, H. & GILBERT, D. (1996). A Good Time to Wed?: Marriage and Economic Distress in England and Wales, 1839-1914. *The Economic History Review* **49:1**, pp. 35-57

SHARP, P.R. (2006). *1846 and All That: The Rise and Fall of British Wheat Protection in the Nineteenth Century.* Department of Economics, University of Copenhagen Discussion Paper 06-14

THOMAS, D.S. (1927). *Social Aspects of the Business Cycle.* New York: Gordon and Breach

WESTERMARCK, E. (1925). *The History of Human Marriage, Vol. I.* London: Macmillan and Co. Ltd.

WRIGLEY, E.A. & SCHOFIELD, R.S. (1981). *The Population History of England 1541-1871: A reconstruction.* London: Edward Arnold Ltd.

Data

Crude Marriage Rates:

1541-1836 Wrigley & Schofield (1981, Table A3.3)

1837-1965 UK Office of National Statistics (www.statistics.gov.uk)

Price of Wheat:

From Mitchell (1962, pp. 486-9) and (1971, p. 193):

1541-1593 "Exeter" series

1594-1629 "Eton College" series

1630-1770 "Winchester College" series

1771-1965 *Gazette* series