War and Welfare: Britain, France and the United States 1807-14

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1. Introduction

As is well known, the Revolutionary and Napoleonic Wars of the late 18th and early 19th centuries were not just unusually lengthy and bloody, but involved widespread economic warfare as well. As early as 1793, when war broke out between Britain and France, France banned the importation of British manufactured goods, and Britain set in place a blockade of French ports. However, this trade disruption would be greatly increased after Napoleon's military victories over Austria, Prussia and Russia in 1805 and 1806. With much of the Continent under his control, Napoleon's mercantilist ambitions to starve the British economy of export revenues now seemed closer to fruition. There followed the famous Berlin Decree of November 1806, under which all ships arriving from Britain or her colonies were to be barred from France, as well as from vassal states such as Naples, Spain and Holland. The scope of this 'Continental Blockade' would widen further in 1807, following Napoleon's defeat of a Russian army at Friedland. Under the subsequent Treat of Tilsit, Russia and Prussia joined the blockade, and Portugal and Denmark would soon follow, with Sweden being forced to join in 1810.

The Continental Blockade is the best-known example of economic warfare during this period, but it was not the only one.[1] Three other examples deserve special attention. First, Britain responded to Napoleon's blockade with a counter-blockade of the European continent, issuing a series of 'Orders in Council' beginning in Novermber 1807. As a result of these, neutrals were seized if they attempted to sail directly to an enemy port, without putting in at a British port first. The Continent was not just in a state of self-imposed blockade, but was facing an externally imposed blockade as well.

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[1] For a valuable overview of these and other blockades in history, see Davis and Engerman (forthcoming). Ellis (1981) provides a good account of the effects of the Continental Blockade in one region, Alsace.

Second, these Franco-British manoeuvres would have serious implications for neutral powers, and not just within Europe, where countries such as Sweden and Denmark found themselves caught up in the dispute despite their desire to remain aloof from it. In particular, the young United States now found itself involved as well. Napoleon responded to the British Orders in Council by declaring that neutral ships putting into British ports would be seized by the French authorities. The upshot was that American merchants, who as neutrals had for years been carrying out a lucrative carrying trade between French colonies and France itself, now found themselves in a position whereby if they continued to try to do so, then no matter what they did they would be seized by either the British or the French. Thomas Jefferson responded with an Embargo Act in December 1807, which closed American ports to foreign ships and forbade American ships to leave port. As both Frankel (1982) and Irwin (forthcoming) have shown, this Act succeeded in its basic aim of reducing the United States to a state of virtual autarky, until it was repealed in 1809.

A third major development came in 1812, when the United States and Britain went to war as a result of continuing disputes regarding trade, as well as the impressment of British seamen aboard American merchant vessels. This was at a time when the Continental Blockade was unravelling; the Russian Tsar had broken with it on New Year's Eve 1810, and 1812 was the year that saw Napoleon's ill-fated invasion of Russia, which marked the beginning of the end of his control over the European Continent. The new war between Britain and her former colonies lowered trade between the two Anglo-Saxon powers, but matters would come to a head in 1814, following Napoleon's defeat and banishment to Elba. Immediately, Britain ordered that the entire US coastline be blockaded, and redeployed her navy to carry this policy into effect.

The years between 1807 and 1814 thus represent the high water mark of trade

disruption during the 'French Wars.' Anglo-Continental trade was disrupted by the Continental Blockade, and the British blockade of Continental ports; while Euro-American trade was disrupted first by the American Embargo Act, and later by the British blockade of the US, especially during 1814. The question now arises as to what were the effects of these various embargos and blockades. In what follows, I will not attempt to disentangle their separate effects, but rather examine their joint impact on trade and welfare. I will be particularly interested in measuring the *comparative* impact of these policies across different countries, and will ask: Did the Anglo-French blockades have a bigger impact on British or on French welfare? And did the Anglo-American blockades have a bigger impact on British or on American welfare?

Before doing so, I need to establish that these embargos and blockades had at least some effect on trade and welfare. After all, there is a venerable tradition which holds that such economic warfare was relatively ineffective, as a result of smuggling, and corrupt officials turning a blind eye to enemy goods being imported into their jurisdictions. Such is the position, for example, of Eli Heckscher (1964 [1922]), as well as of some contemporary observers. On the other hand, François Crouzet (1987) argues that the Continental Blockade did cause hardship within British manufacturing during those periods when it was effectively applied, which according to Crouzet consisted of the periods between the middle of 1807 and the middle of 1808, and again between the spring of 1810 and the disastrous winter of 1812. In a separate, widely cited article, Crouzet (1964) has argued strongly that the British and French blockades had important effects on the structure of Continental industry; while as previously mentioned both Frankel (1982) and Irwin (forthcoming) have demonstrated that Jefferson's Embargo Act was effective in restricting American trade during 1808.

Frankel's paper was an important step forward in the debate, since it made extensive

use of price evidence to demonstrate his point. Since Heckscher's argument is that smuggling and corruption undermined the Continental Blockade, one can hardly point to official trade statistics, showing a collapse in trade volumes, and argue that this demonstrates the weakness of his position. On the other hand, price data do not lie: they faithfully reflect conditions of relative abundance or scarcity within an economy. If the blockades were effective, then one should observe the prices of imported goods rising, relative to the prices of export goods; and Frankel found that this was indeed the case. Furthermore, Frankel went one step further, comparing the extent of these terms of trade shocks in Britain and the United States. He found that, for the commodities he was interested in, relative import prices rose by more in Britain than in the United States during 1808. Since standard trade theory tells us that the welfare costs of trade disruption will be related, *ceteris paribus*, to the size of the terms of trade shock, Frankel's conclusion was that the United States had in some sense the better of the British during the Embargo episode.

In this paper, I concentrate on the impact of these blockades and embargos, between the years 1807 and 1814, on three of the major protagonists: Britain, France and the United States. I follow Frankel in using prices as my measure of trade disruption, and I also follow his lead in trying to assess the relative impact of these trade disputes on the different protagonists involved. I go one step further, however, by following Irwin's (forthcoming) attempt to quantify the welfare cost of trade disruption during the period. In particular, I want to take seriously the notion that the welfare costs of a terms of trade deterioration will depend not just on the size of the terms of trade shock, but on the extent to which the country concerned is exposed to international trade. I also want to show how estimates of welfare loss depend critically on the assumptions made about elasticities of substitution in both consumption and production: obviously, the greater the substitution possibilities in an

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economy, the more the economy will be able to adjust to an adverse terms of trade shock, and the lower will be the ultimate welfare costs of the shock.

In its emphasis on trade disruption and welfare costs, this paper is closely related to a more technical literature on the impact of war on trade. This literature, of which Glick and Taylor (2005) is the most recent example, typically uses the volume of trade as the dependent variable, and employs gravity models to see how wars affected it. Glick and Taylor go further, by using separately generated (by Frankel and Romer 1999) estimates of the relationship between trade and welfare to calculate the welfare effects of war within the context of a panel of countries between 1870 and 1997. Their results suggest that the welfare effects of war-related trade disruption have been large: during World War I, for example, they were equivalent to a permanent flow loss of 2.74% of GDP for belligerents, and 2.09% of GDP for neutrals. This paper also stresses the impact of war on neutrals, but differs from Glick and Taylor's work in that relative prices are the basis for my welfare calculations, rather than trade volumes.[2] It also differs from theirs in that it generates welfare estimates country by country, rather than using coefficients which are common across a group of countries. As will be seen, this is an important difference, since not all countries were the same, and war affected their trade, and welfare, in very different ways.[3]

The plan of the paper is as follows. I first review some of the price evidence which indicates clearly that embargos and blockades had an important trade-disrupting impact

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[2] This stress on relative prices is largely dictated by considerations of data quality, and mirrors the strategy adopted by O'Rourke and Williamson (2002).

[3] The paper is also somewhat related to the literature on sanctions, epitomised by Hufbauer *et al.* (1990), who find that roughly a third of all sanctions episodes in the 20th century have been successful. Not surprisingly, success is related to the relative costs imposed upon the sender and the target of the sanctions (Eaton and Engers 1999), and these relative costs are one of the principal foci of the present paper.

between 1807 and 1814, contrary to Heckscher's assertions. I then outline a simple economic model which can be used to calculate welfare losses for Britain, France and the United States, and show how these losses depend on the assumptions made about substitution elasticities. While the estimates of absolute losses will turn out to depend heavily on these elasticities, it turns out that it is possible to reach some unambiguous conclusions regarding the *relative* welfare losses of the three countries concerned.

2. Relative price evidence

Although this paper will, as stated, rely on price evidence rather than quantity evidence, it is useful to begin with an overview of what the available quantity indices have to say about trade in Britain, France and the United States during the dispute. These are brought together in Figure 1, which plots exports and imports for each of the three countries between 1780 and 1830, indexed to 1820 equals 100. The first and last years of the Franco-British wars (1793 and 1815) are marked on the figure, and the shaded area in each graph represents the crucial years 1807 to 1814, which are the focus of this paper. The vertical scales are identical in each figure, so that movements in trade volumes can be more easily compared across countries.

As can be seen, Britain seems to have been relatively unaffected by these embargos and blockades. On the other hand, there was a pronounced decline in French imports. Most noticeably, perhaps, is the very large decline in both American exports and imports following 1807, after a number of years of strong trade growth. There was a very sharp dip in trade during the Embargo year of 1808, but according to these figures the blockade year of 1814 had an even more damaging effect on American trade. Relative to their (quadratic) trends, French and American imports were down by slightly more than 50% during 1807-14, US

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exports were down by slightly more than a third, and British trade volumes were affected only marginally, and in a statistically insignificant way (O'Rourke forthcoming).

What about the price evidence? The clearest evidence that international markets were being disrupted during the war would of course be information on international price gaps for particular commodities. There does exist some scattered evidence of this kind, and all of it suggests that the blockades and embargoes of the period were indeed effective. For example, Frankel (1982, pp. 307-8) finds that while Liverpool cotton prices were just 27.5% higher than Charleston prices during 1807, the price gap was no less than 293% during the final two months of Jefferson's Embargo. Similarly, it cost between 30 and 50 shillings to ship a quarter of wheat from the Baltic to Britain during 1810, as compared with 4s/6d during 1837 (Hueckel 1973, p. 369). However, such evidence remains fairly scarce: it is easier to get systematic evidence on the behaviour of relative import prices within individual countries. Moreover, showing that an international price gap opened up during the conflict says nothing about which country bore the associated cost: in general, this will depend on elasticities of supply and demand. Country-specific relative price evidence, on the other hand, can allow us to see where the embargos bit the most.

A companion piece to this paper, O'Rourke (forthcoming), explores the behaviour of a wide range of relative commodity prices during the blockades in several countries. Table 1 reproduces some of the main results for the countries of concern in this paper: Britain; countries which were part of the Continental Blockade; and the United States. The table confines itself to data on relative prices for comparable commodities across countries; in each case, it gives the percentage amount by which relative import prices exceeded their long run (quadratic) trend level during the years 1807-1814 inclusive. Of course, if relative import prices increased during these blockade years, that might not be solely as a result of

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international commodity market disintegration; in particular cases it might simply reflect the vagaries of supply and demand. However, if the relative price of a particular commodity were to rise in countries which imported it, and to fall in countries exporting it, then it would be much more difficult to argue that rising barriers to trade had nothing to do with these price developments.

Figure 2 shows that precisely this occurred in the case of the relative wheat/textile price in Britain and France. In Britain, which was a food-importer, the relative price of wheat rose, by an average of 41% over the period 1807-14 (Table 1, Panel A), while in France the relative price of textiles rose, by an average of 20% over the period as a whole. Similarly, while the price of raw cotton relative to textiles rose in Europe, which imported raw cotton (by 79% in France, 31% in Holland, and 59% in Germany: Table 1, Panel C), the same relative price fell in the United States, which imported textiles (where the relative price of textiles rose by almost 200%). Figure 3 plots the two relative raw cotton/textiles price series side by side for the British and US cases. During 1808 and 1809, relative cotton prices rose in Britain and fell in the United States (i.e. the relative price of textiles rose in the latter case); and relative textile prices rose sharply in the US during 1812-13, while relative raw cotton prices rose sharply in Britain during 1814.[4]

Figure 2 appears to show that the Continental Blockade and British counter-blockade increased relative import prices in Britain and France by roughly the same order of magnitude. It seems that Crouzet was right in his insistence that the Blockade did affect the British economy. Indeed, the figures in Panel A of Table 1 suggest that the intra-European

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[4] The figure helps explain why the average increase in relative raw cotton prices between 1807 and 1814 was small in Britain: there, the relative raw cotton price seems to have trended continuously downwards, and the spikes during the Embargo and war of 1812 were small when set against this overall trend. In the US case, by contrast, 1807-14 stands out far more sharply as a period of increased relative textile prices.

terms of trade turned against Britain by more than they did against France. However, when it came to the relative prices of goods produced outside Europe – not just spices such as pepper, but essential inputs into manufacturing as raw cotton, or sugar – then the picture is very different. Relative to the price of wheat (which as we have seen was increasing in Britain), pepper, raw cotton and sugar became cheaper in Britain, but significantly more expensive in France, Holland and Germany. Relative to the price of textiles (which was falling in relative terms in Britain), the price of such overseas imports rose by between 5% and 37% in Britain, but by between 79% and 126% in France, by between 31% and 215% in Holland, and between 59% and 130% in Germany. The European Continent was able to produce more textiles via import substitution when British supplies were cut off; it was not able to produce more pepper or raw cotton. Famously, the Blockades did give a boost to Continental sugar beet production; the first sugar beet factory opened in Silesia in 1802, and after Napoleon took an interest in the process in 1811, 40 factories were established in France. Nonetheless, the price evidence clearly shows that sugar did become scarcer on the Continent – and it was of course this scarcity that prompted the development of sugar beet production in the first place.

None of this is particularly surprising: given the Royal Navy's dominance of the oceans, especially after Trafalgar, it makes sense that non-European goods should have become dramatically scarcer on the European Continent as a result of the Anglo-French blockades. Furthermore, it turns out that this effect was so large, quantitatively, as to dominate movements in the average terms of trade during the period. Figure 4 graphs the price of imports, relative to the price of exports, for the two main belligerents, Britain and France, as well as for the United States. Once again, the shaded area in the figures refers to the high-water mark of war-time trade restrictions, 1807-14. The figure indicates substantial

increases in relative import prices during the conflict, consistent with the diplomatic and naval histories of the period. For example, in France the terms of trade improved during the Peace of Amiens, before deteriorating dramatically during the period of the Blockade. The figure also bears out the impression given by the data on individual commodity prices, namely that Britain was less severely affected by these trade disputes than France, presumably as a result of the Royal Navy's supremacy at sea. Intra-European trade disruption might have affected both of the main belligerents in a similar manner, and even raised import prices to a greater extent in Britain than in France (as Panel A of Table 1 suggested); but the impact of the wars on the price of non-European imports was so much greater on the Continent than in the British Isles that this swamped any other effects. Indeed, the effect of war on aggregate British relative import prices seems to be smaller than that in America as well: there were spikes in the relative price of imports in Britain in 1809 and 1814, but these were dwarfed by the enormous increase in the United States in 1814, when the Royal Navy successfully blockaded much of the US coastline. It looks therefore, as if Britain was the economic 'victor' in these trade disputes, emerging relatively unscathed while her rivals did not. On average, during the years 1807-1814, Britain suffered a terms of trade loss (i.e. higher relative import prices) of 11.9% during 1807-14: that is, her relative import prices were 11.9% above their (quadratic) trend level during this period. This compares with terms of trade losses of 49.4% in the United States, and an impressive 61.2% in France. It now remains to be seen what were the relative welfare costs of these adverse terms of trade shocks.

3. Welfare costs: comparing losses in Britain, France and the United States

In order to estimate the welfare losses associated with these terms of trade shocks, it

is of course necessary to commit oneself to some sort of economic model, even if only as basic a one as a partial equilibrium model of import demand. It makes sense to use some sort of a general equilibrium framework, however, since the key issue in estimating the size of the welfare costs associated with an adverse terms of trade shock will be the extent to which consumers are able to substitute away from expensive imports towards relatively cheaper domestic substitutes; and the extent to which domestic producers can shift their production away from export activities towards goods which will be consumed domestically.

As mentioned previously, Irwin (forthcoming) estimates the welfare costs of Jefferson's blockade. To this end, he uses a very simple general equilibrium model, and calculates the compensating variation change in welfare which arises when moving from free trade to an embargo situation (that is, the difference, measured at embargo prices, between the expenditure necessary to provide the embargo level of utility, and that necessary to provide the pre-embargo level of utility). As the discussion above points out, this welfare cost will depend critically on the elasticities of substitution in both consumption and production. Irwin provides an extensive discussion of the likely magnitude of each of these, and concludes that the scope for substitution was probably quite limited, especially in consumption.

In this paper I use an equally simply model, but solve it numerically, using MPS/GE, a readily available package which has been frequently used in the past by economic historians to solve a wide variety of general equilibrium models. I use the simplest possible general equilibrium model that can generate estimates of the welfare effects of adverse terms of trade shocks, and that also takes into account the fact that all these economies had substantial non-traded goods sectors, and varied in terms of their openness to trade. In order to be able to impose terms of trade shocks, I of course require that the model incorporate both

an export good and an import good. Introducing a third, non-traded good allows me to account for the fact that some countries were less exposed to trade than were others. The model is a simplified version of the well-known model suggested by Anderson and Neary (1996) with which to estimate their trade restrictiveness index; and its appeal lies in the fact that the only information needed to calibrate the model is the trade share.

All production takes place in one sector, which uses a single factor of production (call it 'value added' or VA) to produce two composite outputs, a non-traded good (NT) which is entirely consumed domestically, and an exportable good (X) which is entirely exported (see Figure 5). We thus have

$$(X, NT) = f(VA) \tag{1}$$

The production function f( ) in equation **(1)** is assumed to take on a constant elasticity of transformation form, with the elasticity of transformation denoted by τ.

The exportable good is exchanged on international markets for a composite imported good, M, which is entirely consumed. The exportable is taken to be the *numéraire* good, and trade is assumed to be balanced; thus

$$p_M M = X \tag{2}$$

The key relative price in the model is then the (exogenous) relative price of the import good, p_M, which is set equal to one in the benchmark equilibrium, but can be changed in order to simulate the effects of terms of trade shocks. Finally, there is one consumer in the model, who is endowed with all the value added in the economy; the consumer derives utility

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from their consumption of the non-traded good and the imported good, and maximises utility

subject to the normal budget constraint. The problem facing the consumer is:

$$\max U(NT, M) \text{ s.t. } p_{VA}VA = p_{NT}NT + p_M M \qquad \textbf{(3)}$$

where p_{VA} and p_{NT} are the (endogenous) prices of 'value added' and the non-traded good. The

utility function U( ) in equation **(3)** is assumed to be CES, with the constant elasticity of

substitution denoted by σ.

As is standard, I assume perfect competition in production: thus, corresponding to

equation **(1)** there is a price equals cost equation that has to be satisfied in equilibrium. In

addition, for each good in the model (including 'value added') there will be a demand equals

supply equation; and finally the consumer's budget constraint is assumed to be binding,

giving rise to an income equals expenditure equation. These equations are sufficient to solve

for all endogenous variables in the model; and are generated automatically by MPS/GE once

the model has been calibrated (i.e. ince particular values have been chosen for the

parameters).

In order to calibrate the model, let the export share of GDP (equal to the import share

by assumption) equal t, and assume that the country's endowment of value added equals 100

(the number chosen here is of course irrelevant to the results). Then the production of the

non-traded good will equal (1-t)*100; the production of the exportable will equal t*100; and

imports will equal t*100. Consumption of the non-traded and imported goods will take place

in the proportion (1-t) to t respectively.

The trade share is thus the key parameter in the model, and is based on historical data.

In addition, there are two elasticities in the mode whose values have to be specified: the

elasticity of transformation τ between the non-traded good and the exportable in production, and the elasticity of substitution σ in consumption between the non-traded good and the importable. The results depend in particular on the latter elasticity: the higher is the elasticity of substitution in consumption, the easier it is for consumers to switch away from imports when wartime blockades raise their price, and the lower the resultant welfare loss. Welfare losses should also depend on the value of τ, with higher values again leading to lower welfare losses. In what follows I start by presenting results which assume the same transformation elasticity as do Anderson and Neary (that is, τ = 5), while allowing σ to vary. A rationale for proceeding in this fashion is that Anderson and Neary find that their results are typically very insensitive to the value used for τ. I then perform a wider sensitivity analysis, by allowing τ to vary over a wide range, and seeing how my results change. In the appendix, I provide the MPS/GE code required to solve the model for Britain, using base-case elasticity assumptions (σ = 0.7 and τ = 5);[5] all other results quoted in the paper can be generated by changing just four numbers in this input file (the terms of trade shock itself, the trade share, and the elasticities of substitution and transformation in production).

Table 2 presents a range of welfare estimates for each country, for values of σ ranging from 0.25 to 10 (the latter being an absolute upper bound, since typically CGE models assume elasticity values less than unity: see Irwin forthcoming). The results suggest that French welfare losses were roughly twice as high as British losses, lying in the 3-4% range for consumption elasticities of 2 and under, as opposed to British losses of 1.7-1.8% *per annum*. The table thus confirms the earlier impression that the blockades hit Britain much less severely than they did her main Continental rival.

The most striking result of Table 2, however, concerns a country which had initially

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[5] Anderson and Neary's baseline assumption is that σ = 0.7.

been neutral, namely the United States. The results suggests that *per annum* American welfare losses were much higher than those incurred in either France of Britain, lying in the 5-6% range for consumption elasticities of 2 and under. (Even in the unlikely case that these elasticities were as high as 10, the US welfare loss would still have amounted to almost 3% per annum.) These estimates are remarkably close to Irwin's estimate of a 5% welfare loss for the United States during the period of Jefferson's embargo; the difference is that these are average estimates calculated for the period 1807-14 as a whole, since, as the terms of trade figures suggest, wartime curtailment of trade continued to impose a cost on the American economy well after the repeal of the Embargo Act. Indeed, the terms of trade data suggest that the American welfare losses actually reached a peak in 1814, not 1808.

Welfare losses of 5 to 6% *per annum* over an eight year period were a substantial burden: the final two rows of Table 2 show that the cumulative welfare loss, assuming the Anderson-Neary benchmark value for σ of 0.7, amounted to 36% in the United States. This was equivalent to a permanent flow loss of 1.8%. The cumulative loss is simply the discounted value, in 1807, of the annual welfare losses (given in the row headed 'σ=0.7') for each of the years 1807-14; the calculation assumes a discount rate of 5%, so as to make the calculation comparable with the welfare estimates provided by Glick and Taylor (2005), who also assume a 5% discount rate. As in the case of that article, the permanent flow loss here is simply the *per annum* permanent loss which would produce the same discounted cumulative loss.

To put these losses in perspective, as already mentioned Glick and Taylor estimate that the permanent flow losses associated with the trade disruption of World War I amounted to 2.74% for belligerents, and 2.09% for neutrals. Strikingly, American losses associated with the trade disruption of the Napoleonic Wars were almost as big as the latter figure; and my

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estimates do not even take into account any losses incurred between 1793 and 1806 inclusive.

Permanent flow losses were lower for the other countries considered here, a notable fact

given that France and Britain were the two main belligerents during the conflict (they

amounted to 1.12% p.a. in France and 0.6% in Britain), but they were still very substantial.

Furthermore, Table 1 suggests that welfare losses are also likely to have been high in areas

under French control during the period, such as the Netherlands and Germany.[6] Moreover, it

could be argued that this model will *understate* the welfare effects of war and blockades,

since it assumes full employment, and thus excludes by assumption any costs associated with

unemployment, which as Crouzet (1987) emphasizes became a problem in Britain during

1808 and 1811-12 .

Finally, Table 3 explores how changing the elasticity of transformation in production

matters for welfare. As mentioned, the 'folk wisdom' emerging from the Anderson-Neary

trade restrictiveness literature is that τ is empirically not very important in determining the

welfare costs of protection (or, in this case, of terms of trade shocks). Table 3 shows,

however, that this conclusion depends to a rather large extent on the value assumed for σ. As

can be seen, in the case of Cobb-Douglas utility ($\sigma = 1$), the welfare cost of a given terms of

trade shock is *completely* insensitive to the value of τ. The reason for this is that, in the case

of Cobb-Douglas utility, a constant share of income is spent on the non-traded good. Given

income, this ties down non-tradable consumption, and actual non-tradable production has to

equal this amount no matter what the elasticity of transformation in production.

On the other hand, the further away from Cobb-Douglas is the utility function, the

more the elasticity of transformation matters. For example, in the case of the United States,

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[6] Indeed, the impact of the Revolutionary and Napoleonic Wars on the highly open
Dutch economy was catastrophic: see de Vries and van der Woude (1997).

the welfare cost of the terms of trade shock is 5.1% *per annum* when utility is Cobb-Douglas. For very low substitution elasticities ($\sigma = 0.25$), welfare costs are higher, but now they also depend on the elasticity of transformation, ranging from 7% for low values of the elasticity ($\tau = 0.25$) to 5.8% in the case of high elasticities ($\tau = 10$). For very high substitution elasticities ($\sigma = 10$), welfare costs are lower than in the Cobb-Douglas case, and range from 4.2% for low values of the elasticity ($\tau = 0.25$) to 2.4% in the case of high elasticities ($\tau = 10$). Elasticities of transformation in production therefore matter for the results; nonetheless, it remains true that they matter less for the results than does the elasticity of substitution in consumption, as can be seen by comparing the change in welfare estimates as one moves across rows as against columns in Table 3.

4. Conclusions

The trade disruption associated with the Napoleonic Wars – the Continental Blockade, the British counter-blockade of the Continent, Jefferson's Embargo, and the British blockade of the United States – had a major impact on trade flows and economic welfare. In many ways, the most striking aspect of the results presented above is that the greatest losses were suffered by a country which had initially been neutral, namely the United States. Also notable, in the context of the cliometric literature on the subject, is that it seems highly likely that the greatest losses suffered by the United States came in 1814, as a result of the Royal Navy's blockade of its coastline, rather than as a result of its self-imposed blockade which has been the focus of much recent work. If the benchmark elasticity assumptions, associated with Anderson and Neary's TRI work, are accepted, then the United States suffered a loss during 1807-14 equivalent to a permanent flow loss of 1.8% *per annum*, a sizeable loss indeed.

However, this paper has also stressed that the absolute level of the welfare loss depends on assumptions about elasticities in both consumption and production. On the other hand, I am on far less ambiguous ground when it comes to conclusions about *relative* welfare losses. According to Table 3, welfare losses were highest in the United States, and by a long way, no matter what assumptions are made about elasticities. Furthermore, in all but one case (the extreme case where both elasticities are assumed equal to ten) French welfare losses turn out to be greater than British welfare losses.

Clearly, it is not the case that wartime trade disruption imposed equal penalties on all belligerents, or indeed on all neutrals; nor would one expect this to be the case. The average correlations that would have been revealed in a cross-sectional regression, had I had the data with which to perform it, would have masked important variations across countries. First, countries suffered different terms of trade shocks; and second, some were more open to trade, and thus more exposed to trade shocks, than others. The terms of trade shocks were larger in France than in any other country, but France was also much less open, implying that French welfare losses, while very considerable, were lower than in the United States. Crucially, terms of trade shocks were substantially lower in Britain, implying smaller welfare losses there, in spite of the relatively open nature of the British economy. Having control of the seas, as was the case for Britain in the early 19th century, proved far more useful in terms of waging economic warfare than did the land-based power of Napoleon (O'Brien 2003). As for the United States, it was a relatively open economy, *and* suffered a relatively high terms of trade shock; it thus fared the worst of these three countries in terms of welfare losses.

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Table 1. Price impact of Napoleonic Wars

(percentage increase in relative price relative to peace-time counterfactual)

Relative price	Country	Blockade effect
Panel A. Intra-European		
Wheat/textiles	Britain	41.35
Textiles/wheat	France	19.84
Textiles/wheat	Germany	5.71
Panel B. Europe-Asia		
Pepper/wheat	France	216.36
	Britain	-8.21
	Holland	119.46
Pepper/textiles	France	109.82
	Britain	29.74
	Holland	167.37
Panel C. Europe-Americas		
Sugar/wheat	France	195.03
	Britain	-2.90
	Holland	165.10
	Germany	143.09
Raw cotton/wheat	France	114.28
	Britain	-26.17
	Holland	11.45
	Germany	67.89
Sugar/textiles	France	125.59
	Britain	37.25
	Holland	214.64
	Germany	129.95
Raw cotton/textiles	France	78.81
	Britain	4.93
	Holland	31.23
	Germany	58.82
Textiles/Raw cotton	USA	182.51
Wine/raw cotton	USA	137.05

Source:O'Rourke (forthcoming, Table 3).

Table 2. Estimates of welfare loss (percent)

| Country	Britain	France	USA
Terms of trade shock (percent increase in relative import price)	11.9	61.2	49.4
Trade share (percent)	15.7	6.6	13
Welfare Effects (percent decline)			
$\sigma=0.25$	1.82	3.76	5.89
$\sigma=0.5$	1.80	3.50	5.58
$\sigma=0.7$	1.78	3.33	5.37
$\sigma=1.0$	1.75	3.10	5.09
$\sigma=2.0$	1.68	2.58	4.40
$\sigma=5.0$	1.56	1.90	3.43
$\sigma=10.0$	1.48	1.54	2.87
Cumulative loss ($\sigma=0.7$, 5% discount rate)	12	22.4	36.1
Permanent flow loss ($\sigma=0.7$, 5% discount rate)	0.6	1.12	1.81

Source: see text.

Table 3. Welfare results: further sensitivity analysis

	τ =	0.3	0.5	1.0	2.0	*5.0*	10.0
Britain							
σ =							
0.3		1.91	1.88	1.85	1.83	*1.82*	1.82
0.5		1.82	1.81	1.81	1.80	*1.80*	1.79
0.7		*1.78*	*1.78*	*1.78*	*1.78*	*1.78*	*1.78*
1.0		1.75	1.75	1.75	1.75	*1.75*	1.75
2.0		1.70	1.70	1.70	1.69	*1.68*	1.68
5.0		1.67	1.66	1.64	1.61	*1.56*	1.53
10.0		1.66	1.65	1.62	1.58	*1.48*	1.39

	τ =	0.25	0.50	1.00	2.00	*5.00*	10.00
France							
σ =							
0.3		4.75	4.36	4.06	3.88	*3.76*	3.71
0.5		3.74	3.67	3.60	3.55	*3.50*	3.49
0.7		*3.39*	*3.37*	*3.35*	*3.34*	*3.33*	*3.32*
1.0		3.10	3.10	3.10	3.10	*3.10*	3.10
2.0		2.75	2.73	2.69	2.64	*2.58*	2.55
5.0		2.53	2.46	2.34	2.17	*1.90*	1.72
10.0		2.46	2.36	2.20	1.96	*1.54*	1.24

|	τ =	0.25	0.50	1.00	2.00	*5.00*	10.00
United States							
σ =							
0.3		7.01	6.57	6.25	6.03	*5.89*	5.84
0.5		5.86	5.78	5.70	5.63	*5.58*	5.56
0.7		*5.44*	*5.42*	*5.40*	*5.38*	*5.37*	*5.36*
1.0		5.09	5.09	5.09	5.09	*5.09*	5.09
2.0		4.63	4.59	4.54	4.48	*4.40*	4.36
5.0		4.33	4.23	4.07	3.83	*3.43*	3.16
10.0		4.23	4.10	3.87	3.51	*2.87*	2.38

Source: see text. Results incorporating baseline elasticity assumptions are highlighted in bold.
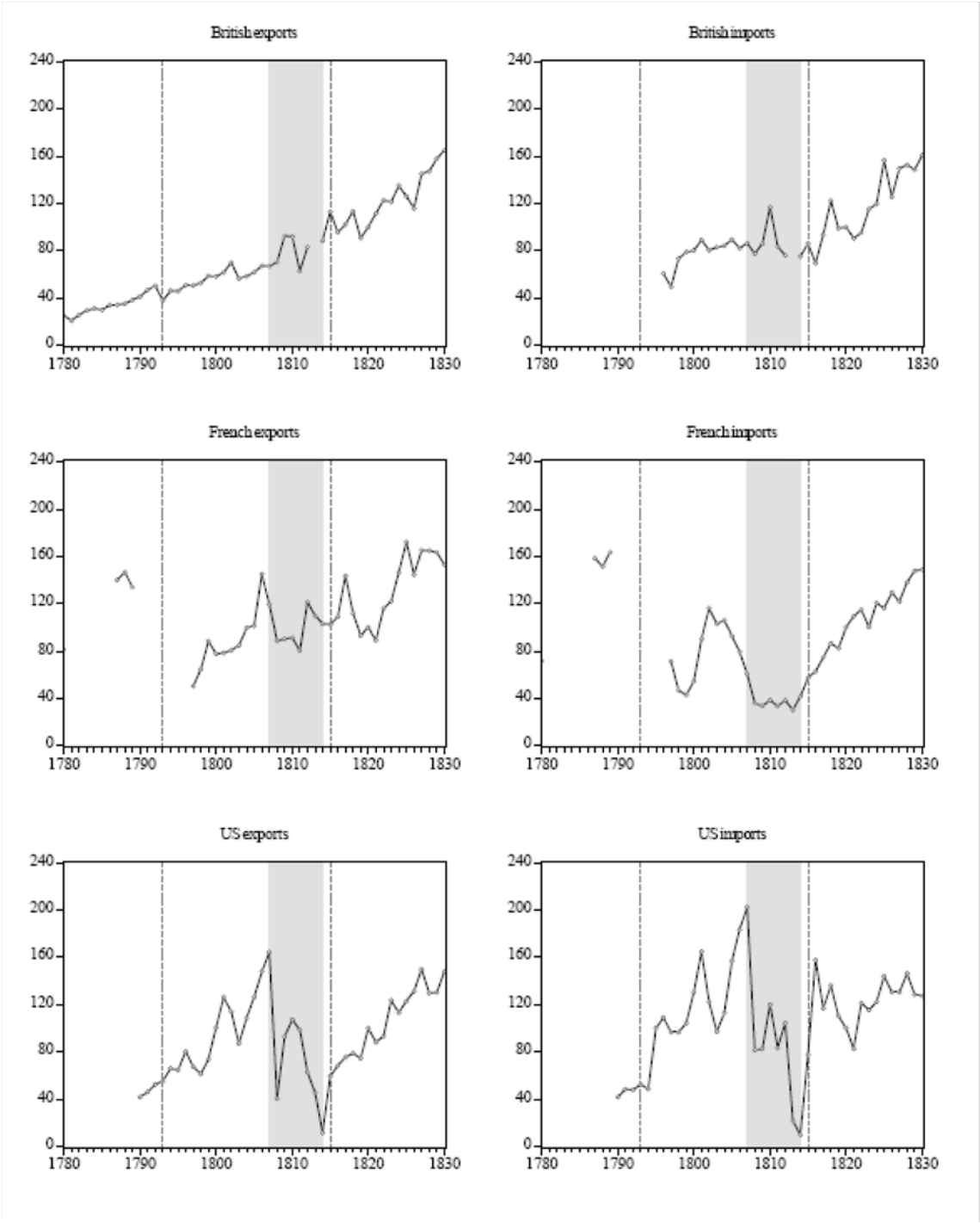
Figure 1. Volume of trade, 1780-1830 (1820 = 100)
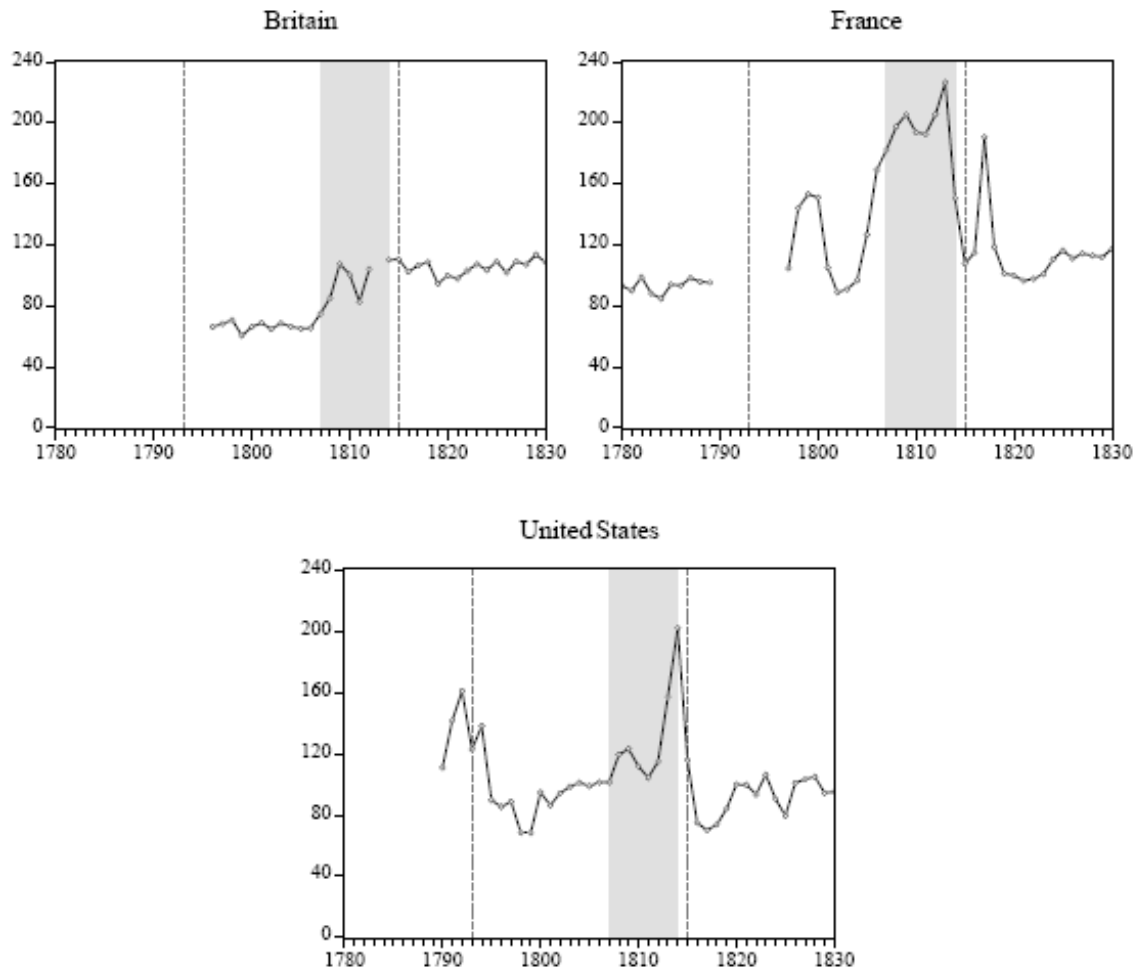
Source: see data appendix.
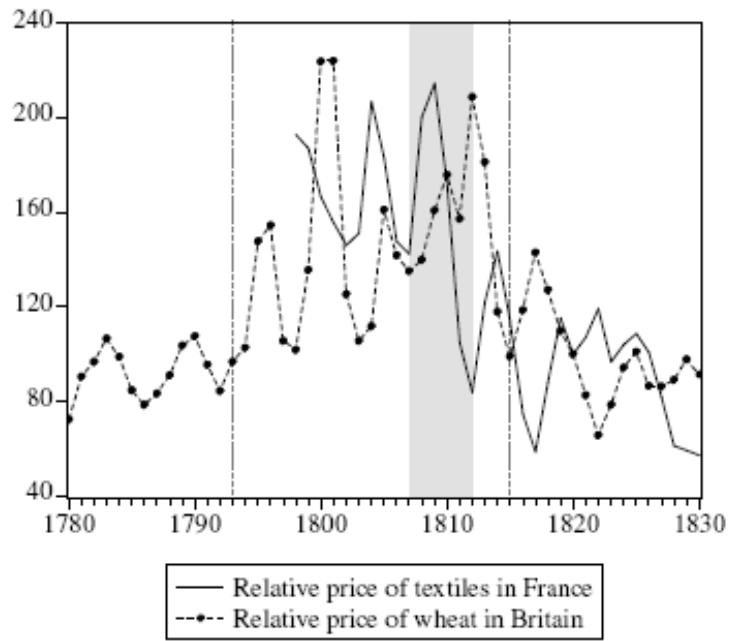
Figure 2. Relative wheat/textile prices in Britain and France, 1780-1830
(1820 = 100)

Source: O'Rourke (forthcoming), Figure 10.

**Figure 3. Relative raw cotton/textile prices in Britain and United States, 1780-1830
(1820 = 100)**

Source: data underlying O'Rourke (forthcoming).

Figure 4. Price of imports relative to exports, 1780-1830 (1820=100)
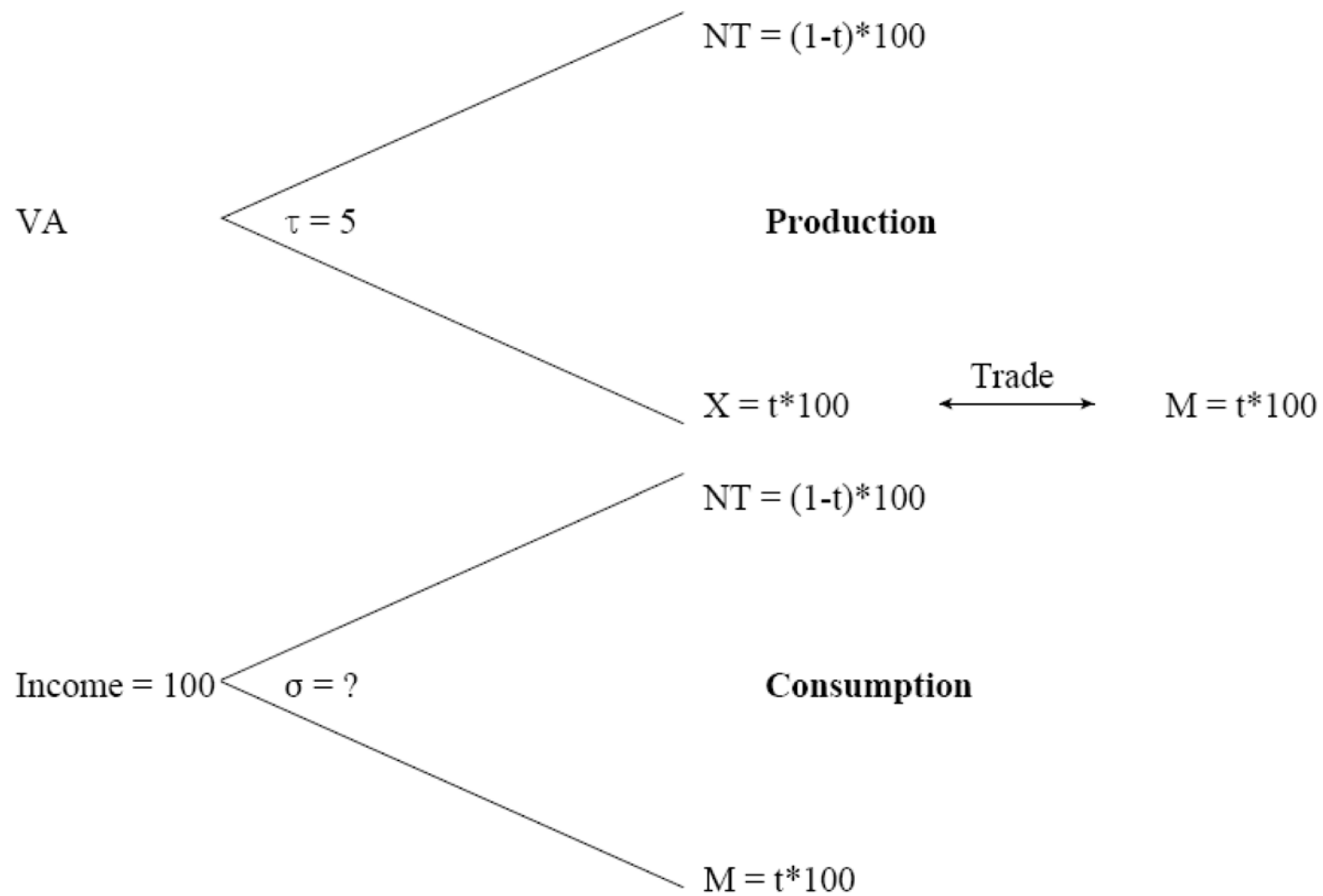
Source: see data appendix.

NT = (1-t)*100

VA   τ = 5   **Production**

Trade

X = t*100   ←——————→   M = t*100

NT = (1-t)*100

Income = 100   σ = ?   **Consumption**

M = t*100

Figure 5. Calibrating the CGE model

Data appendix

Data sources

<u>Trade volumes and terms of trade</u>

Britain. Imports: Imlah (1958), Table 8, pp. 94-98. Exports: 1780-1821, Cuenca Esteban (1997), Appendix Table 1, p. 901, spliced with Imlah's data for 1821-30.

France: 1780-1820: data underlying Cuenca Esteban (2004), graciously made available by the author. The price indices for 1716-86 rest on 11 price series with constant weights (Cuenca Esteban 2004 , p. 65). 1820-1830: Lévy-Leboyer and Bourguignon (1990), Tables A-III, A-IV.

United States: North (1966), pp. 221, 228-9, 233-4, 240-3.

MPS/GE code

The code below can be used to solve the CGE model described in the text. The code is in MPS/GE 'scalar' format, as described in Rutherford (1989). MPS/GE is now available as a GAMS sub-system, with input files typically being in 'vector' format, which is far more efficient for large models. Rutherford (1998, pp. 8-9) introduces the scalar notation in the context of a manual aimed at GAMS users. Rutherford (1999) provides an introduction to MPS/GE vector notation. As can be seen, the input code below is more or less self-explanatory. Note that trade is here handled by means of an artificial 'production sector' which converts exports into imports at a fixed rate (the terms of trade). The code first solves for a benchmark model in which all prices and the consumer's welfare are equal to 1. It then solves for a second model, labelled 'WAR,' which is identical with the first except that I have now imposed the negative terms of trade shock on the system. I have highlighted in bold the parameters which a user would have to edit in order to change the trade share, terms of trade shock, or elasticities of substitution or transformation.

```
$MODEL: BENCHMARK

$SECTORS:
PRODUCTION
TRADE 15.7

$COMMODITIES:
PX PM PNT GDP

$CONSUMERS:
REPAGENT

$PROD: PRODUCTION   t: 5
I: GDP     X: 100
O: PNT     X: 84.3
O: PX      X: 15.7
```

$PROD: TRADE
I: PX   X: 1
O: PM   X: 1

$DEMAND: REPAGENT   s: 0.7
E: GDP   X: 100
D: PNT   X: **84.3**
D: PM   X: **15.7**

$SOLVE:

$MODEL: WAR

$PROD: TRADE
I: PX   X: **1.119**
O: PM   X: 1

$SOLVE