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Tax Britannica: Nineteenth century tariffs and British national income *

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Abstract. The literature on British economic history presumes that Britain was a free trader after the repeal of the Corn Laws and that her tariff levels were thus below those which were optimal for maximizing utility. Presumably, if the optimal British tariffs had been positive and greater than the levels established by mid-century, a reduction to zero of all tariffs that remained would have lowered British welfare even further. In this paper, we use a simple computable general equilibrium model to simulate a drop in all British tariffs to zero. The resulting substantial net *increase* in British welfare suggests that British tariffs were much higher than would be consistent with an optimum tariff policy. More important, the size of British losses from her high tariff levels suggests that British policy was not consistent with the stance of an ideological free trader.

1. Introduction

Traditional accounts of commercial history have treated nineteenth-century Britain as the lone European free trader in the decades following the repeal of the Corn Laws (e.g. Kindleberger, 1975). Such a transformation was important on both political and ideological grounds. It is said to have encouraged reform in the institutions of international trade and in support of free markets. However, British moves toward trade liberalization seem to have been especially anomalous because Britain might have stood to lose from a move to lower tariffs. As the leader in world trade, Britain must have had substantial market power and if so, would have gained more in the short run by maintaining a positive optimal tariff. McCloskey first drew attention to this problem in a noted essay published some two decades ago (1980). Using purely hypothetical elasticity parameters and speculating as to the values of the most

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significant variables, McCloskey concluded that if the optimal British tariffs were positive, Britain would have paid a price for moving to free trade. However, the price was small in static terms, and whatever welfare losses were incurred were undoubtedly offset by the dynamic gains from moving to freer trade. About a decade after McCloskey's work, Irwin (1988) made much the same point with a simple model that sought to measure the welfare change associated with Britain's trade reductions; he, too, concluded that in going to free trade, Britain was moving away from the optimal tariff and that the nation had therefore suffered a loss in utility on the basis of static calculations. He conceded that his calculations seemed "to confirm the judgment that adverse terms of trade shifts would outweigh efficiency gains from a British tariff reduction" (Irwin, 1988: 1158), but repeated McCloskey's claim that these were static calculations that ignored the dynamic effects of free trade: in particular, the demonstration effect of British tariff reduction in terms of spurring other nations to move to free trade.

However, there are serious difficulties with the calculations on which these claims have been based. For one thing, more recent research points to Britain's having had substantially higher tariffs than had hitherto been suspected, tariffs which were not fully eradicated in the quarter-century after Peel's reforms had begun in the 1840s (Nye, 1991). For the most part, these took the form of extremely high tariffs on wine and brandy, coffee, tea, sugar, and tobacco. The persistence of these tariffs, especially on wine and brandy, is remarkable because these duties indicate a Britain unwilling to lower tariffs on her prime imports. Furthermore, the duties on wine and brandy go back to the beginnings of English mercantilism and struggles with France as far back as the late seventeenth century. Arguably, they were designed to be not only protective but indeed prohibitive. War with the French from 1689 to 1713 led to temporary prohibitions and, subsequently, permanent high tariffs designed to limit the import of wine and spirits and favor domestic beer and liquor as well as the production of friendly nations such as Portugal and Spain. This reduced the volume of French imports in the eighteenth century to five percent or less of their peak seventeenth century levels. (cf. Nye, 1991, and elaborated in Nye, 2004). Thus, Britain may have lowered some tariffs, but she was not a free trader after the 1840s.

In this paper we simulate a drop in all British tariffs to zero and demonstrate that British tariffs, even after the repeal of the Corn Law, were not only far too high to be consistent with the stance of a committed free trader, but even too high to be consistent with an optimum tariff policy.

Nineteenth-century Britain's stance as the leading free trader in history has become so embedded in our received wisdom that whole literatures in history and political economy have been constructed based on Britain's presumed ideological purity. But more recent research (Anderson and Tollison, 1985, and Nye, 1991 and 2004) suggests that the politics of trade reform was much more consistent with the cynical view of self-professed reform typical of work in public choice and the evolution of institutions. We speculate on the importance of this work for further analysis of political economy. The size of welfare losses is large enough, especially when held against comparable figures for France, that we are forced to reconsider the impact of these results on the political economy of trade and the history of trade reform. Indeed, such an analysis forces a reinvestigation of the problems of strategic theories of hegemonic trade and raises difficulties because of the subtlety required to understand the course of all political economic reforms.

2. Measuring protection

Traditional tariff indices have usually focused on one of three measures: (1) the nominal level of tariffs per class of goods, (2) weighted measures of average tariffs defined as total revenues divided by total value of imports (and various modifications to this basic idea) or (3) measures of effective protection on an item-by-item basis, where nominal tariff levels are corrected for tariffs on inputs used in production of these goods. All three suffer from a variety of theoretical and empirical problems. The first measure ignores the relative importance of a good in total trade, the second has serious problems with respect to trade weights, given the problem that an early prohibitive tariff might add little to the revenues received, and the third is not only problematic when used to create an overall index but also suffers because effective protection measures ignore the costs of tariff restrictions to the consumer.

The most widely cited recent attempt to create a more universal tariff measure is the *Trade Restrictiveness Index* (TRI) first promoted by Anderson and Neary (1994) and adopted by O'Rourke (1997) in his own contribution to the debate on whether nineteenth century France, rather than Britain, was the freer trader. The TRI – which is calculated within a computable general equilibrium (CGE) framework – is the first theoretically sound index because it is directly derived from an economic objective, in this case welfare maximization.

By explicitly modeling tariffs and trade in a general equilibrium framework, O'Rourke quantified and thereby clarified the terms of the debate. He demonstrated that the outcome of the debate hinges on the functional forms and calibration of preferences and technology; in particular, he showed that the degree of substitutability between beer and imported alcoholic beverages turned out to have a remarkable impact on the welfare effects of British tariffs. The question, thus, is no longer whether beer and wine are substitutes (and thus whether tariffs on wine should be included in a tariff index), but rather for what *range* of elasticities of substitution between both types of alcohol, France would indeed have been the freer trader.

Unfortunately, in order to compute a country's TRI, one must ignore the issue of market power and assume a small country whose decisions have no effect on world trade. As shown in the appendix, a large country's TRI will be either ambiguous or not defined at all (see also Dakhlia, 2002). Since the small-country assumption is evidently not ideal when studying how a country that loomed large in international commerce might have benefited from a positive economic tariff and its subsequent reduction, the TRI-based measure must be abandoned. We should however be careful not to toss out the baby with the bath water: we preserve the CGE framework since it offers an unusually rich context in which to interpret our sparse data. While we cannot derive an index *per se*, the framework will still allow us to track welfare effects of protectionism.

Specifically, we track the national welfare effects of a progressive counterfactual tariff reduction down to zero. This suffices for our purposes, since we merely wish to know whether British tariffs were higher or lower than those suggested by static welfare maximization.

3. The model

Our approach follows Anderson and Neary and O'Rourke by modeling the economy in a general equilibrium framework. The general equilibrium framework provides a particularly appropriate tool for performing comparative statics exercises in trade and for studying the static effects of policy changes and their impact on trade flows, allocation of goods, and welfare effects on consumers, since the interdependence among the various markets is at the heart of the measurement problem: a tariff imposed on wine, for example, will affect not only the demand for wine, but also the demand for beer and other goods. A partial equilibrium approach would capture only bits and pieces of a tariff's intricate effects.

A model should be sufficiently rich to shield itself from the Fogel critique (1967) and leave room for the data to matter. The downside of a rich and flexible model, of course, is that it may be too complex to allow for simple, closed-form solutions and comparative statics; thus the need for a *numerical*, computational approach. Moreover, the beauty of a *computable* general equilibrium approach lies in its direct focus on the welfare or utility of the representative consumer, thereby avoiding awkward approximations typical of partial equilibrium welfare analysis.

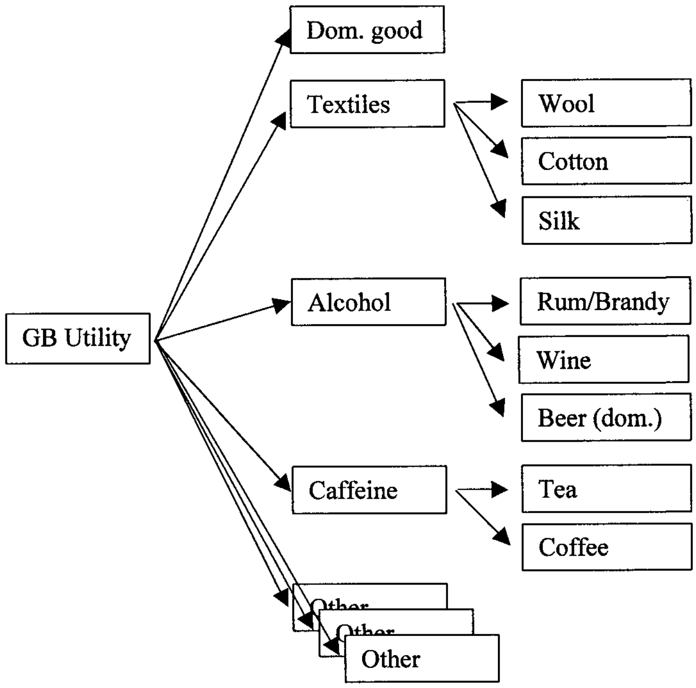

Figure 1. British two-level utility function

As in Anderson and Neary, we assume that each region has a representative consumer who values a large variety of imports as well as a generic, non-traded, domestic product. This specification conforms to the available records, which are rich on import and export data, but scarce on non-traded commodities. A region's consumer is endowed with non-traded inputs and receives all tariff revenue. Furthermore, she consumes her entire production of the non-traded good, while none of the exportables are consumed at home.

As in O'Rourke, a two-level nested CES utility function allows us to specify different elasticities of substitution *within* bundles of goods as well as *among* bundles. The maleability of nested CES offers an attractive compromise between realism on one hand and computational expediency on the other. The first utility level combines comparable consumption goods into bundles. Wine and brandy, for instance, which can be considered close substitutes, belong to the same bundle generically called alcohol. The second utility level then combines the various bundles such as alcohol and textiles. The assumed preference structures for Britain and France are represented by Figures 1 and 2.

Our model differs from Anderson and Neary and O'Rourke in two essential ways:

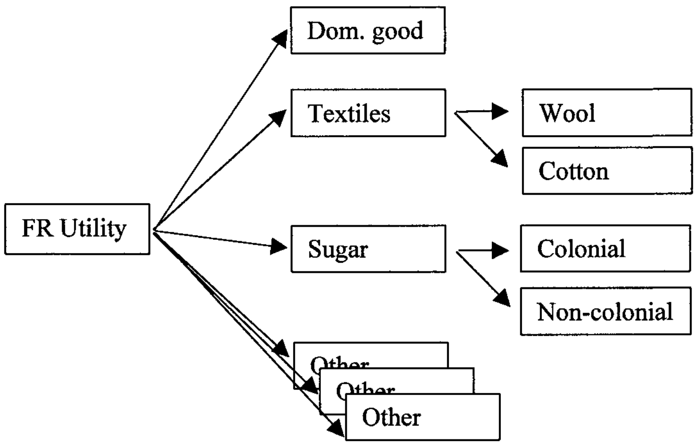

Figure 2. French two-level utility function

(1) Our world economy consists of *three* finitely-sized regions (Britain, France, and the rest of the world) instead of a single, price-taking country (facing an infinitely large "rest of the world"). While this forces us to drop the TRI as a convenient measure of protection, it also relaxes the assumption of a zero optimal tariff vector, thus acknowledging the issue of market power raised by McCloskey and Irwin.

(2) In addition to imported intermediate goods and a mobile, non-traded input, we include capital as a third type of input and assume that it is sector-specific: a brewery cannot be transformed into a steel mill. Our specific-factors model (Jones, 1971; Samuelson, 1971) stands in contrast to the one-factor model that is usually derived from basic Ricardian theory. As a consequence, falling tariffs can increase capital incomes in some sectors at the expense of others. Moreover, there are decreasing returns to labor. Imported inputs, capital, and labor enter a nested CES production function. Output supply and input demand functions are derived from profit maximization.

4. Data

From the *Tableau Décennal du Commerce*, we know what France exported to and what it imported from Britain. It also provides us with France's tariffs on imports. McCloskey (1980), on the other hand, provides British and French total import volumes and tariffs. British and French import and export figures with the Rest of the World are thus computed as the difference between both data sets. Tables 1 and 2 show French and English import figures and tariff rates for the most important commodities traded in the years 1841 and 1854

Table 1. Import/export data for 1841

British imports	From France	From RoW	Tariff	French imports	From Britain	From RoW	Tariff
wool fab.	6.95			wool. text.	0.465	0.285	50.0%
cotton fab.	2.7	270.5		cotton text.	19.47		50.0%
coffee		45.32	96.0%	coffee		26.3	100.8%
sugar		318.5	67.0%	for sugar		10	156.4%
cereals	7.91	204.9	6.5%	col. sugar		83.9	71.9%
wines	11.59	69.15	113.9%	fats/lard		5.2	
rum/brandy	19.283	69.39	206.6%	silk	7.79	52.21	
jewelry	0.56			wool	2	44.04	22.1%
leather gds	4.58			raw cotton	1.62	106.7	12.1%
eggs	4.89			coal	6.44	20.4	16.5%
silk fabric	28.64			hides/pelts	1.697	25.62	2.2%
tobacco		94.8	843.3%	flax/linen	27.9		
tea		186.3	114.1%	oleag.	2.79	34.77	3.3%
wood		115.7	14.0%	wood		39.2	
Other-FR	34.35		15.2%	copper/iron	14.9	0.91	
Other-RW		842.2	15.2%	livestock		10.6	21.8%
				Other-BR	7.74		76.9%
				Other-RW		397.3	13.5%

Sources. Tableau Décennal du Commerce, McCloskey (1980), Nye (1991)

respectively. We also note that by the mid-nineteenth century, British tariffs were evenly imposed on most countries and preference for Portugal's wines had ended.

Given the data's imperfections and incompleteness, trade among the three regions requires balancing: we do so by introducing an artificial commodity produced in France or in Britain (or, if necessary, in both) and exported to the Rest of the World. Finally, given the lack of data on domestic production and consumption, we are left to assume that each region produces a generic non-exportable good for domestic consumption. A region's expenditures on this generic domestic good is assumed to equal GDP plus intermediate imports (including tariff revenues) minus exports. Finally, we assume that the rest of the world produces and consumes the same goods as Britain and France and in proportional amounts. In our standard baseline calibration, we let Britain and France make up half the world's economy, and thus purposely bias their market power upwards.[1]

Table 2. Import/export data for 1854

British imports	From France	From RoW	Tariff	French imports	From Britain	From RoW	Tariff
coffee		22.18	52.8%	silk	44.45	77.85	0.0%
sugar		213.8	52.5%	wool	16.78	35.72	17.9%
wood		131.5	4.8%	raw cotton	0.66	99.14	14.3%
tobacco		24.95	479.0%	wood		57.2	0.0%
tea		100	119.5%	coal	8.85	56.65	10.2%
rum/brandy	8.94	24.26	201.8%	hides/pelts	1.98	36.12	1.6%
cereals	0.64	546.9	1.9%	livestock		21.1	3.8%
cotton fab.	9.92	437.6	0.0%	coffee		23.3	78.5%
wines	8.88	47.37	84.9%	flax/linen	1.61	21.09	0.0%
silk fabric	103.3			oleag.	1.85	15.95	14.6%
wool fab.	33.45			wool. text.	0.14	0.56	50.0%
leather gds	14.69			cotton text.	0.0018	0.7982	50.0%
Other	90.7	1531	8.1%	for. sugar		16.6	107.2%
				col. sugar		48.7	62.2%
				fats/lard		6.2	0.0%
				Other	56.558	427.14	8.0%

Sources. Tableau Décennal du Commerce, McCloskey (1980), Nye (1991)

In empirical work, it is often assumed that final demand is elastic, while intermediate demand is inelastic. Anderson's (1995) calibration, just to cite an example, specified elasticities of substitutions of 0.7 among input bundles and 2.0 among bundles of consumption goods. We made the same numerical assumption for our base case. Within bundles, we typically chose 3.0 among textiles, 5.0 between tea and coffee, 5.0 among various alcohols, and 8.0 between foreign and colonial sugar.[2] While these assumptions strike us as reasonable, we also ran our simulations over a wide range of alternative elasticities assumptions: between 0.1 and 2.0 among input bundles and between 0.5 and 4.0 among final consumption goods. We found that our results are rather robust to alternative specifications in the higher elasticity range. A final caveat: despite the quantitative – or, rather, numerical – nature of our simulations, we feel that their qualitative implications deserve most of the attention and interpretation. The shape of curves and their positions relative to other curves are more significant than are their absolute magnitudes.

5. Results

5.1. *The big picture*

Over a wide range of alternative calibrations, calculations that simulate a *unilateral* drop in all British tariffs show a substantial net *increase* in British welfare, suggesting that British tariff levels were significantly higher than would be consistent with an optimum tariff policy.[3] For our baseline case, we found that British tariffs in 1841 were roughly three times larger than the optimal tariff, leading to a static welfare loss for Britain of about 1.4%. For 1854, on the other hand, we find that while actual tariffs are significantly reduced, they are still almost twice the size of optimal tariffs, this despite our exaggerated assumptions on market power. Static welfare losses for Britain, however, have fallen to a negligible 0.13% of national income.[4] Thus, while Britain did indeed significantly reduce its tariffs, thereby greatly eliminating associated welfare losses, those tariffs were still too high to be consistent with a policy of free, unfettered, trade. Indeed the tariff levels still exceeded those that would have been consistent with an optimal tariff policy.

In comparison, French tariffs led to much smaller French static welfare losses, which, in 1841, represented less than 1% of income. Those tariffs were about 10 times the magnitude of optimal tariffs, reflecting, in part, France's smaller market power. In 1854, French tariffs fell to a very negligible 0.06% loss of welfare, even though, here too, tariffs were still about twice the size of optimal tariffs. We note that the French results were robust to quite severe respecifications of the tariff equivalents on cotton and woolen textiles, given the relatively small share of French trade that was taxed.

Chart 1 summarizes these findings by plotting welfare (the utility of the representative consumer) against percentage of the original tariff vector. The graph is best read from right to left: we start with 100%, the full norm of the historic tariff vector, and then observe changes in welfare as we scale the norm of the tariff vector down to 0%.

Issues of country size notwithstanding, readers familiar with O'Rourke's spectacularly high uniform tariff equivalents might wonder how his results, which are based on similar data, can be reconciled with our relatively small welfare effects. We speculate that the explanation lies in the high variance of British customs duties. In addition to having high levels of tariffs on a small but important set of imports, the highly discriminatory nature of these duties would distort British trade beyond what would seem indicated by the high levels alone. Hence, any uniform tax designed to mimic the welfare results of such a tariff profile would have to reflect both the effects of the tariffs themselves and the welfare losses due to the uneven imposition of customs duties. Since a uniform tax has little distortionary effect, even less so if the proceeds are returned to the consumer, it takes a very high uniform tariff indeed to obtain a small change in welfare.

5.2. *Sensitivity analysis*

As expected, the simulation results are sensitive to calibration, in particular to the specified elasticities of substitution.

First, according to our data, Britain was mainly an importer of consumption goods, whereas France's imports were dominated by inputs. Since we typically assume an elasticity of substitution of 0.7 among inputs and 2.0 among most consumption goods, this asymmetry clearly lowers Britain's optimal tariff relative to France. To see how much of our result rests on this asymmetry, we performed simulations with identical calibrations for both the supply and the demand side. Specifically, we assumed that *both* elasticities of substitution were equal to 1, which corresponds to Cobb-Douglas specifications for both tastes and technology.

As can be seen in Chart 2, increasing the elasticity of substitution among inputs from 0.7 to 1 and decreasing the elasticity of substitution among consumption goods from 2.0 to 1 somewhat diminishes Britain's potential gains from a counterfactual reduction of tariffs in 1841, even if those potential gains are still higher than France's potential gains. For comparison, the same change in elasticity assumptions has an even larger effect on 1841 France, whose potential benefit of trade liberalization is reduced by 75%.

More remarkably, in 1854, while still being far from being free-traders, both Britain and France appear to be practicing near-optimal tariff policies under the new elasticity assumptions. While Britain's tariffs are still slightly beyond their optimal level, France actually displays a touch of magnanimity.

Second, we perform a sensitivity analysis on the elasticity of substitution among (bundles of) consumption goods. Chart 3 shows the static welfare effects of a move to free trade for 1841 and 1854 Britain and for elasticities ranging from 0.5 to 4.0. The graphs are very similar between the two years, the main difference being the relative magnitude of welfare losses. As seen earlier, for an elasticity of substitution of 2.0 among consumption bundles, Britain's high tariffs cost her close to 1.4% of her static income in 1841, but only 0.13% in 1854. Increasing the elasticity of substitution from 2.0 to 4.0 dramatically increases the welfare cost of protection to over 2.4% of income in 1841 and to 0.35% in 1854. Decreasing the elasticity also lowers the welfare losses, but the critical result here is that the consumer's elasticity of substitution must be a low 0.5 before it can be claimed that 1841 British tariffs were close to welfare maximizing, but only below 1 to make the same claim for 1854. The premise behind McCloskey's argument thus begins to hold water if imports generally faced inelastic demands. We note furthermore that for an elasticity of substitution of 0.5, a free-trade policy would have cost Britain 1.7% of its welfare.

Third, we vary the elasticity of substitution among inputs and find our results to be particularly sensitive to this parameter. As can be seen in Chart 4, raising the elasticity from 0.7 (slightly inelastic) to 1.2 (slightly elastic) just about triples both 1841s and 1854s static welfare losses relative to optimal tariffs. Raising the elasticity to 2.0 pushes the welfare losses to an enormous 9% of income in 1841 and a smaller loss of only 1% in 1854. More fundamentally, even a reduction of that elasticity to an almost Leontief 0.1 still places the optimal tariff below the historic tariff for either year.

Fourth, we vary the size of the rest of the world. Our baseline case tends to exaggerate British (and French) market power by assuming that the rest of the world makes up only a modest half of the world's economy. By relaxing this assumption and increasing market share of the rest of the world to 70, 90, and 99%, our central claim that British tariffs were too high to be consistent with an optimal tariff policy is further reinforced. The simulation results are reported in Charts 5 and 6.

5.3. *The revenue story*

Irwin argued that Britain's high tariffs on select goods such as wines, rum, and brandy were levied not for protection but for revenue alone. As such, he claimed that, unless given a very small weight, their inclusion into a measure of protection such as a tariff index would be misleading. His rationale was that those goods had no close domestic substitutes and, in particular, that even high wine prices would have only a negligible effect on British beer consumption. However, this ignores the prohibitive effects of the tariff on certain classes of wine and spirits most likely to be in competition with domestic production of alcoholic beverages.[5]

It is thus natural to ask whether 1841 tariffs of about 115% on wines and over 200% on rum and brandy could *conceivably* have been so high as to be excessively prohibitive and not raise anywhere close to the potential revenues. Our simulations suggest, however, that for a range of plausible elasticities of substitution, those high tariffs were indeed still on the reasonable side of the Laffer curve. In particular, for an elasticity of substitution of 2.0 among alcohol imports and domestic beer, the vector of tariffs on alcohol was close to revenue-maximizing: in Chart 7, the solid tariff revenue curve is flat and almost reaches its maximum at 100% of historic tariffs on alcohols. Only for higher elasticities of substitution would the historic tariffs have been excessive.

Chart 8, finally, shows the *welfare* effects of these simulations. At an elasticity of substitution of 2.0, for which the tariffs are close to revenue-maximizing, the welfare losses remain non-negligible. While we thus agree with Irwin that tariffs – except for those on table wine – can be construed as revenue-maximizing, the associated utility loss suggests that the tariffs cannot be exempted from a protective role.

6. Conclusion

This paper has been motivated by the desire to sort out the various claims that have been made about the status of British trade policy in the 1800s.The view of Britain as a magnanimous market liberal, willing to sacrifice short-term static gains from higher tariffs in order to promote free trade at home and abroad, has been examined and rejected.

The use of a simple computable general equilibrium model has allowed for more refined calculations than seen in earlier writing based on partial equilibrium models. We found that British tariff levels even a decade or more after the abolition of the Corn Laws were still high in absolute terms (and indeed were high relative to those of important rivals like France). Moreover, calculations that simulated a drop in all British tariffs showed a significant net increase in British welfare suggesting that British tariff levels were higher than would be consistent with an optimum tariff policy. More important, the size of British losses from her high tariff levels makes it clear that British policy was not consistent with pure free trade. It confirms earlier work (Nye, 1991) that demonstrated how unusually high British tariff levels were compared both to British rhetoric and to French tariffs. It lays to rest the puzzle – examined by both McCloskey (1980) and Irwin (1988) – of a dominant Britain moving to a trade policy that was freer than that which would have been dictated by narrow self interest, a claim which served as the basis for an important subset of the work on hegemonic stability theory (cf. Keohane, 1984). The actual policies employed were, in practice, far more damaging to the welfare of the nation than has been suggested in the magnanimous view of Britain originally advanced by McCloskey (1980), but are now much easier to reconcile with an interest group explanation whose origins partly lie in historical decisions made a century and a half earlier (Anderson and Tollison, 1985; Nye, 2004). Finally, our results are consistent with a trade policy aimed at revenue maximization, but only if we ignore the prohibitive effects of the tariff on wine and treat them as *ad valorem* rather than as the specific tariffs they had always been in practice.

Notes

1. In 1854, for example, Britain imported 8.88 million francs (MF) worth of wine from France and 47.37 MF worth of wine from the rest of the world. In our standard calibration, we would thus assume that the rest of the world also imported 8.88 MF worth of wine from France and produced an additional 47.37 MF for its own consumption. Alternative specifications of market shares are explored as part of our sensitivity analysis.
2. Previous research based on partial equilibrium analysis specified price elasticities of demand, ε, rather than elasticities of substitution, σ. The two are, of course, related since the price elasticity depends on the CES elasticities of substitution as well as on a good's expenditure share s. The approximate relation is $\varepsilon \approx \sigma - \mathrm{s}(1 + \sigma)$, also shown in Table 3 in the appendix.
3. It is important to point out that we restrict our attention to equi-proportional reductions of the historic tariff vector. Our computed "optimal tariffs" are thus not global, but rather constrained to the segment connecting zero tariffs to the historic tariffs. As a consequence, we are likely to *underestimate* the welfare losses associated with protection.
4. To use modern examples for comparison, Krugman and Obstfeld (1997) report welfare costs of protection of 9.5% for Brazil 5.4% for Turkey, 5.2% for the Philippines, and 0.26% for the U.S.
5. We should point out that these revenue maximization calculations are somewhat misleading for wine and spirits because these goods were uniquely taxed by volume rather than *ad valorem*. Thus, our calculations ignore the prohibitive effect of British tariffs on the cheapest class of wines, which did not enter into British consumption at all after the eighteenth century. In contrast, the finest products of Burgundy and Bordeaux naturally received much lower tariffs on an ad valorem basis for a fixed tariff. Our inability to deal with the problem of specific tariffs on wine and brandy therefore leaves out the very important protective and distributional effects on the types of wines that were imported and on the specific protection of domestic beer.

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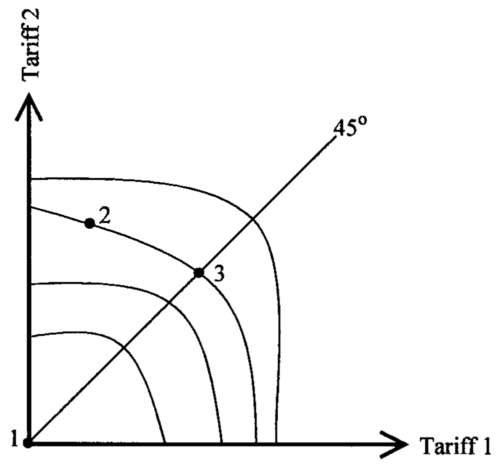


Figure 3. TRI existence and uniqueness for a small country

Appendix 1: TRI and large country

The *Trade Restrictiveness Index* is based on the concept of a *Uniform Tariff Equivalent* (UTE), which is illustrated in Figure 1. The graph shows a country's (or its representative consumer's) welfare level curves with respect to tariffs on two goods. For a small country, the optimal tariff, represented by point 1, lies at the origin. If the historic tariff structure is represented by point 2, then point 3 (on the 45 degree line) represents the uniform tariff that generates the same welfare loss as the historic tariff.

Things go wrong, however, if we drop the small country assumption. The intuition is shown in Figure 2. If a country is large, the optimal tariff vector, represented by point 1, lies in the interior of the positive orthant, with iso-welfare curves concentric around the optimum. We can now visualize three cases:

1. the actual tariff is given by point 2, whose welfare curve does not intersect the 45 degree line, hence the UTE is not defined;
2. the actual tariff is given by point 3, whose welfare curve intersects the 45 degree line twice at points 4 and 5, thus the UTE is not uniquely defined and hence ambiguous;
3. the actual tariff is given by point 6 with UTE at point 7. This last case, however, appears to be non-generic.

Appendix 2: Formal model

The world economy consists of three regions, Britain, France, and the rest of the world. We identify sectors of activity by indices $s, t \in \mathcal{S}$, with $\mathcal{S} = \{1, 2, \ldots, S\}$ representing the set of all industries. Regions are identified by indices $i, j \in \mathcal{W}$, with

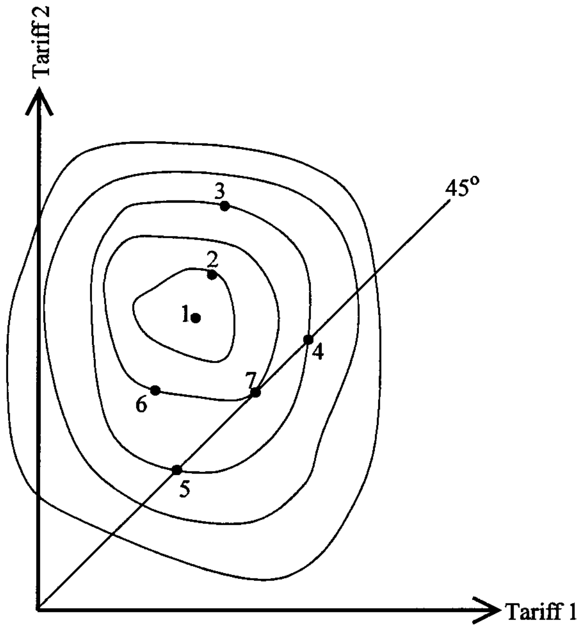


Figure 4. Nonexistence or non-uniqueness of a uniform tariff equivalent

$\mathcal{W}$ = {Br, Fr, RW}. To keep track of trade flows, we follow the usual practice that identifies the first two indices with, respectively, the region and the industry supplying the good and the next two with the client region and industry. Production uses three types of input: fixed capital, mobile labor, and imported intermediate inputs. Output consists of the non-traded good and exported goods. None of the exportables are consumed at home. Consumers are endowed with labor (a non-traded input) and receive all profits and tariff revenue. They consume imported final goods and their non-traded good.

Consumption

Each region i has a representative consumer who values a large variety of imports as well as a generic, non-traded, domestic product. This specification, also used by Anderson and Neary for their TRI computations, conforms to the available records, which are rich on import and export data, but scarce on non-traded commodities.

A two-level nested CES utility function allows us to specify different elasticities of substitution *within* bundles of goods as well as *among* bundles. The maleability of nested CES offers an attractive compromise between realism on one hand and computational expediency on the other. The first utility level combines bundles of consumption goods c_{jsi} into aggregates c_{ki}. Wine and brandy, for instance, which can be considered close substitutes, belong to the same bundle generically called alcohol. Formally, we shall partition the set $\mathcal{S}$ into bundles or "nests" $\mathcal{S}_k$, $k \in \mathcal{K} = \{1, 2, \ldots, K\}$, $K \leq S$. The second utility level determines the optimal composition of the consumption aggregates c_{ki}, such as alcohol and textiles. Formally, the consumer's preferences are thus:

$$C_i = \left(\sum_{k \in \mathcal{K}} \rho_{ki} c_{ki}^{\frac{\sigma_i - 1}{\sigma_i}} \right)^{\frac{\sigma_i}{\sigma_i - 1}}$$

where

$$c_{ki} = \left(\sum_{s \in \mathcal{S}_k} \sum_{j \in \mathcal{W}} \delta_{jsi} c_{jsi}^{\frac{\sigma_k - 1}{\sigma_k}} \right)^{\frac{\sigma_k}{\sigma_k - 1}},$$

and δ_{jsi} and ρ_{ki} represent benchmark expenditure shares.

The consumer maximizes C_i with respect to c_{jsi} and subject to

$$p_{ci} C_i \geq \sum_{j \in \mathcal{W}} \sum_{s \in \mathcal{S}} (1 + \tau_{jsi}) p_{jsi} c_{jsi},$$

where τ_{jsi} are tariff rates, p_{jsi} are prices, and σ_i and σ_k are elasticities of substitution.

Production

The representative firm of region i, sector s owns fixed, sector specific capital $\bar{K}_{is}$, while labor is assumed to be fully mobile. Hence, there are decreasing returns to labor. Material inputs, all imported, along with capital and labor enter a nested CES production function along the same principle as in the consumer's utility function. Output supply and input demands result from maximizing profit

$$\Pi_{is} = p_{is} Q_{is} - \sum_{j \in \mathcal{W}} \sum_{t \in \mathcal{S}} (1 + \tau_{jti}) p_{jti} x_{jtis} - w_i L_{is}$$

subject to

$$\Pi_{is} \geq 0,$$

and

$$Q_{is} = \left(\alpha_{Kis} \bar{K}_{is}^{\frac{\sigma_{is} - 1}{\sigma_{is}}} + \alpha_{Lis} L_{is}^{\frac{\sigma_{is} - 1}{\sigma_{is}}} + \sum_{k \in \mathcal{K}} \alpha_{kis} x_{kis}^{\frac{\sigma_{is} - 1}{\sigma_{is}}} \right)^{\frac{\sigma_{is}}{\sigma_{is} - 1}},$$

where

$$x_{kis} = \left(\sum_{t \in \mathcal{S}_k} \sum_{j \in \mathcal{W}} \beta_{jtis} x_{jtis}^{\frac{\sigma_k - 1}{\sigma_k}} \right)^{\frac{\sigma_k}{\sigma_k - 1}}.$$

Table 3. Own-price elasticities of demand

Elasticity of substitution	Expenditure share 0%	5%	10%	20%	40%	60%	80%	100%
0	0.00	–0.05	–0.10	–0.20	–0.40	–0.60	–0.80	–1.00
–0.1	–0.10	–0.15	–0.19	–0.28	–0.46	–0.64	–0.82	–1.00
–0.5	–0.50	–0.53	–0.55	–0.60	–0.70	–0.80	–0.90	–1.00
–1	–1.00	–1.00	–1.00	–1.00	–1.00	–1.00	–1.00	–1.00
–1.5	–1.50	–1.48	–1.45	–1.40	–1.30	–1.20	–1.10	–1.00
–2	–2.00	–1.95	–1.90	–1.80	–1.60	–1.40	–1.20	–1.00
–5	–5.00	–4.80	–4.60	–4.20	–3.40	–2.60	–1.80	–1.00
–10	–10.00	–9.55	–9.10	–8.20	–6.40	–4.60	–2.80	–1.00

Appendix 3: Tables and graphs

CHART 1
Base Case: Counterfactual unilateral reduction from 100% to 0% of a country's historical tariff vector. Effect on own Welfare.

	Brit 41	Brit 54	Fra 41	Fra 54
100%	0.000%	0.000%	0.000%	0.000%
95%	0.136%	0.024%	0.042%	0.007%
90%	0.267%	0.047%	0.089%	0.015%
85%	0.398%	0.068%	0.140%	0.022%
80%	0.526%	0.087%	0.191%	0.027%
75%	0.651%	0.102%	0.243%	0.034%
70%	0.774%	0.117%	0.303%	0.041%
65%	0.888%	0.125%	0.359%	0.046%
60%	0.996%	0.131%	0.425%	0.054%
55%	1.097%	0.131%	0.485%	0.058%
50%	1.186%	0.125%	0.550%	0.061%
45%	1.261%	0.110%	0.620%	0.063%
40%	1.319%	0.090%	0.686%	0.063%
35%	1.355%	0.058%	0.756%	0.061%
30%	1.364%	0.013%	0.816%	0.056%
25%	1.336%	-0.046%	0.872%	0.046%
20%	1.255%	-0.126%	0.919%	0.032%
15%	1.097%	-0.230%	0.947%	0.010%
10%	0.813%	-0.367%	0.952%	-0.019%
5%	0.306%	-0.550%	0.919%	-0.056%
0%	-0.715%	-0.806%	0.840%	-0.107%

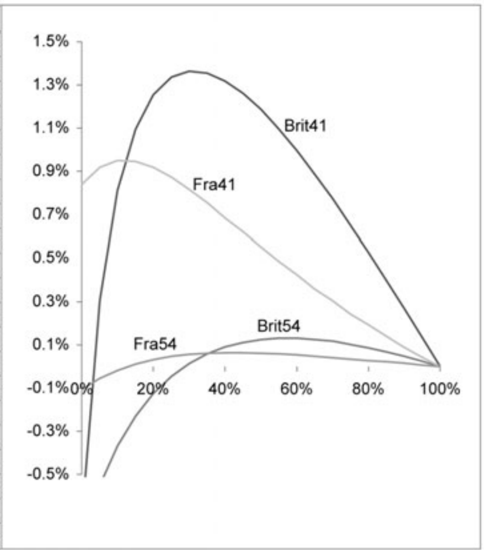
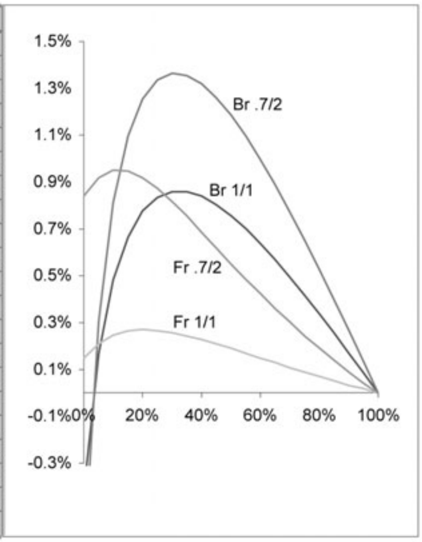


CHART 2
Using the same elasticities of substitution in consumption and production. Effect on Welfare

1841	Br 1/1	Br 0.7/2.0	Fr 1/1	Fr 0.7/2.0
100%	0.000%	0.000%	0.000%	0.000%
95%	0.086%	0.136%	0.019%	0.042%
90%	0.170%	0.267%	0.033%	0.089%
85%	0.256%	0.398%	0.051%	0.140%
80%	0.337%	0.526%	0.070%	0.191%
75%	0.418%	0.651%	0.089%	0.243%
70%	0.495%	0.774%	0.107%	0.303%
65%	0.568%	0.888%	0.131%	0.359%
60%	0.637%	0.996%	0.149%	0.425%
55%	0.701%	1.097%	0.168%	0.485%
50%	0.757%	1.186%	0.191%	0.550%
45%	0.804%	1.261%	0.210%	0.620%
40%	0.841%	1.319%	0.229%	0.686%
35%	0.860%	1.355%	0.243%	0.756%
30%	0.860%	1.364%	0.257%	0.816%
25%	0.835%	1.336%	0.266%	0.872%
20%	0.777%	1.255%	0.271%	0.919%
15%	0.665%	1.097%	0.266%	0.947%
10%	0.482%	0.813%	0.247%	0.952%
5%	0.167%	0.306%	0.210%	0.919%
0%	-0.423%	-0.715%	0.149%	0.840%



1854	Br 1/1	Br 0.7/2.0	Fr 1/1	Fr 0.7/2.0
100%	0.000%	0.000%	0.000%	0.000%
95%	0.005%	0.024%	-0.005%	0.007%
90%	0.008%	0.047%	-0.010%	0.015%
85%	0.009%	0.068%	-0.015%	0.022%
80%	0.009%	0.087%	-0.019%	0.027%
75%	0.008%	0.102%	-0.024%	0.034%
70%	0.003%	0.117%	-0.032%	0.041%
65%	-0.005%	0.125%	-0.039%	0.046%
60%	-0.016%	0.131%	-0.049%	0.054%
55%	-0.032%	0.131%	-0.056%	0.058%
50%	-0.050%	0.125%	-0.066%	0.061%
45%	-0.077%	0.110%	-0.078%	0.063%
40%	-0.112%	0.090%	-0.090%	0.063%
35%	-0.155%	0.058%	-0.105%	0.061%
30%	-0.210%	0.013%	-0.122%	0.056%
25%	-0.281%	-0.046%	-0.141%	0.046%
20%	-0.369%	-0.126%	-0.163%	0.032%
15%	-0.486%	-0.230%	-0.188%	0.010%
10%	-0.635%	-0.367%	-0.217%	-0.019%
5%	-0.837%	-0.550%	-0.251%	-0.056%
0%	-1.112%	-0.806%	-0.290%	-0.107%

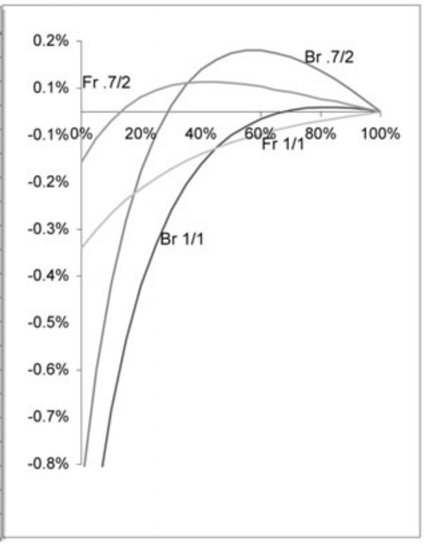
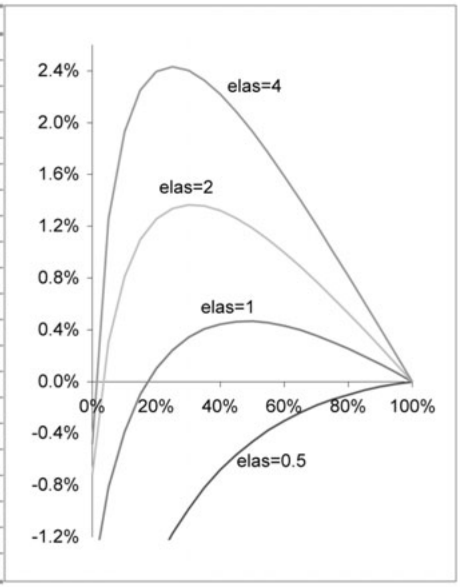


CHART 3
Varying the elasticity of substitution among consumption bundles for both Britain and France: Effect on Britain

1841	0.5	1.1	2.0	4.0
100%	0.000%	0.000%	0.000%	0.000%
95%	-0.017%	0.070%	0.136%	0.206%
90%	-0.039%	0.134%	0.267%	0.409%
85%	-0.067%	0.195%	0.398%	0.612%
80%	-0.100%	0.253%	0.526%	0.816%
75%	-0.139%	0.309%	0.651%	1.013%
70%	-0.184%	0.356%	0.774%	1.211%
65%	-0.239%	0.398%	0.888%	1.403%
60%	-0.301%	0.431%	0.996%	1.587%
55%	-0.376%	0.454%	1.097%	1.765%
50%	-0.462%	0.468%	1.186%	1.932%
45%	-0.562%	0.465%	1.261%	2.085%
40%	-0.679%	0.445%	1.319%	2.218%
35%	-0.818%	0.406%	1.355%	2.327%
30%	-0.983%	0.342%	1.364%	2.402%
25%	-1.172%	0.245%	1.336%	2.433%
20%	-1.403%	0.103%	1.255%	2.394%
15%	-1.676%	-0.097%	1.097%	2.252%
10%	-2.012%	-0.387%	0.813%	1.929%
5%	-2.435%	-0.816%	0.306%	1.255%
0%	-2.992%	-1.534%	-0.715%	-0.484%



1854	0.5	1.1	2.0	4.0
100%	0.000%	0.000%	0.000%	0.000%
95%	-0.027%	0.003%	0.024%	0.047%
90%	-0.057%	0.005%	0.047%	0.093%
85%	-0.088%	0.005%	0.068%	0.137%
80%	-0.123%	0.002%	0.087%	0.178%
75%	-0.161%	-0.003%	0.102%	0.216%
70%	-0.202%	-0.011%	0.117%	0.252%
65%	-0.246%	-0.024%	0.125%	0.282%
60%	-0.295%	-0.039%	0.131%	0.309%
55%	-0.348%	-0.061%	0.131%	0.330%
50%	-0.408%	-0.087%	0.125%	0.344%
45%	-0.475%	-0.120%	0.110%	0.350%
40%	-0.549%	-0.161%	0.090%	0.345%
35%	-0.632%	-0.211%	0.058%	0.330%
30%	-0.725%	-0.273%	0.013%	0.298%
25%	-0.831%	-0.347%	-0.046%	0.249%
20%	-0.951%	-0.438%	-0.126%	0.175%
15%	-1.090%	-0.550%	-0.230%	0.071%
10%	-1.250%	-0.688%	-0.367%	-0.077%
5%	-1.441%	-0.863%	-0.550%	-0.287%
0%	-1.668%	-1.088%	-0.806%	-0.596%

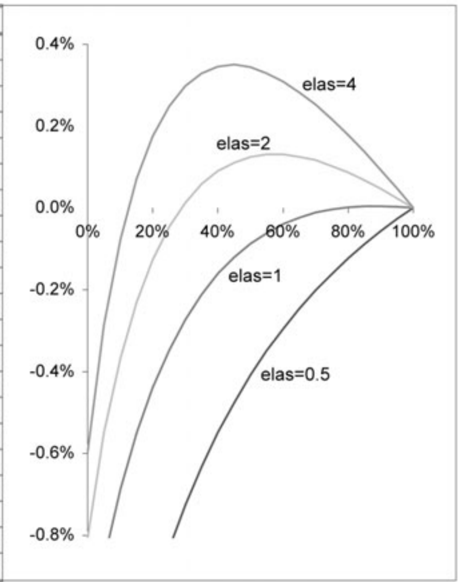
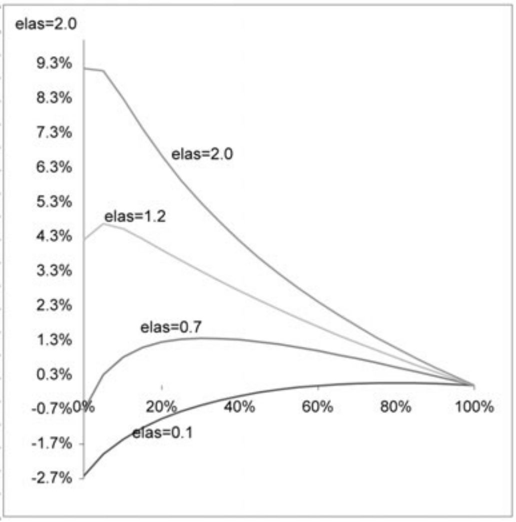


CHART 4
Varying the elasticity of substitution among input bundles for both Britain and France: Effect on Britain

1841	0.1	0.7	1.2	2.0
100%	0.000%	0.000%	0.000%	0.000%
95%	0.028%	0.136%	0.192%	0.251%
90%	0.047%	0.267%	0.390%	0.512%
85%	0.061%	0.398%	0.593%	0.788%
80%	0.067%	0.526%	0.799%	1.077%
75%	0.061%	0.651%	1.016%	1.383%
70%	0.050%	0.774%	1.236%	1.709%
65%	0.025%	0.888%	1.464%	2.054%
60%	-0.011%	0.996%	1.701%	2.419%
55%	-0.058%	1.097%	1.943%	2.811%
50%	-0.122%	1.186%	2.196%	3.229%
45%	-0.203%	1.261%	2.455%	3.682%
40%	-0.303%	1.319%	2.728%	4.169%
35%	-0.426%	1.355%	3.009%	4.701%
30%	-0.573%	1.364%	3.301%	5.286%
25%	-0.752%	1.336%	3.607%	5.929%
20%	-0.966%	1.255%	3.922%	6.644%
15%	-1.233%	1.097%	4.239%	7.440%
10%	-1.564%	0.813%	4.529%	8.300%
5%	-1.996%	0.306%	4.679%	9.104%
0%	-2.614%	-0.715%	4.214%	9.177%



1854	0.1	0.7	1.2	2.0
100%	0.000%	0.000%	0.000%	0.000%
95%	0.011%	0.025%	0.036%	0.049%
90%	0.020%	0.049%	0.073%	0.101%
85%	0.028%	0.069%	0.110%	0.155%
80%	0.032%	0.088%	0.147%	0.211%
75%	0.033%	0.106%	0.183%	0.270%
70%	0.032%	0.118%	0.219%	0.333%
65%	0.027%	0.129%	0.254%	0.397%
60%	0.017%	0.134%	0.287%	0.465%
55%	0.003%	0.136%	0.320%	0.536%
50%	-0.014%	0.129%	0.350%	0.610%
45%	-0.038%	0.117%	0.377%	0.686%
40%	-0.066%	0.096%	0.399%	0.765%
35%	-0.102%	0.065%	0.416%	0.844%
30%	-0.143%	0.020%	0.424%	0.922%
25%	-0.194%	-0.039%	0.421%	0.995%
20%	-0.254%	-0.118%	0.401%	1.057%
15%	-0.325%	-0.221%	0.355%	1.091%
10%	-0.408%	-0.358%	0.271%	1.080%
5%	-0.509%	-0.542%	0.123%	0.976%
0%	-0.634%	-0.798%	-0.140%	0.694%

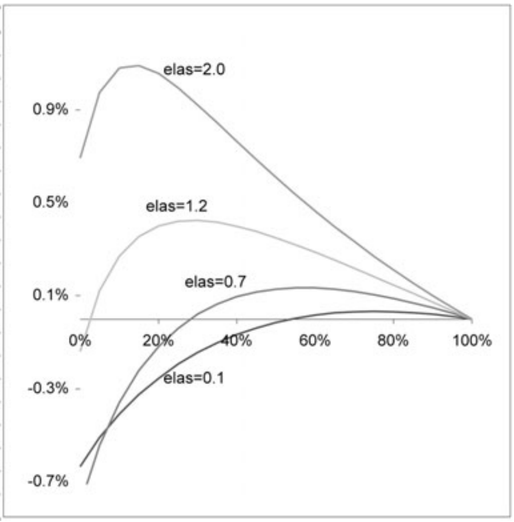
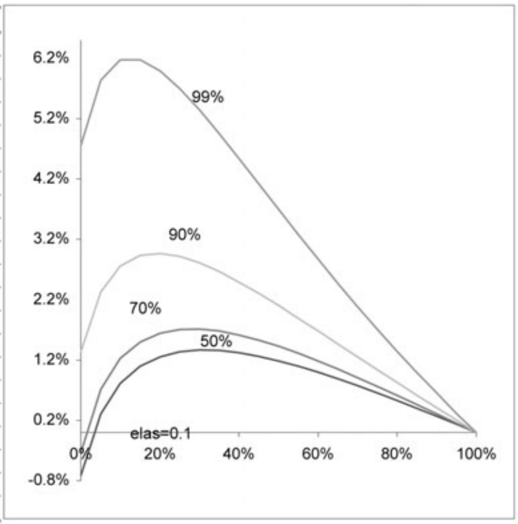


CHART 5
Varying the size of the Rest of the World
Effect on Britain

1841	50%	70%	90%	99%
100%	0.000%	0.000%	0.000%	0.000%
95%	0.136%	0.156%	0.203%	0.317%
90%	0.267%	0.309%	0.409%	0.649%
85%	0.398%	0.462%	0.615%	0.988%
80%	0.526%	0.612%	0.827%	1.342%
75%	0.651%	0.763%	1.038%	1.706%
70%	0.774%	0.907%	1.253%	2.082%
65%	0.888%	1.049%	1.467%	2.472%
60%	0.996%	1.183%	1.681%	2.870%
55%	1.097%	1.311%	1.893%	3.279%
50%	1.186%	1.425%	2.101%	3.696%
45%	1.261%	1.528%	2.302%	4.117%
40%	1.319%	1.614%	2.491%	4.537%
35%	1.355%	1.678%	2.664%	4.949%
30%	**1.364%**	**1.712%**	2.808%	5.344%
25%	1.336%	1.706%	2.917%	5.700%
20%	1.255%	1.645%	**2.967%**	5.993%
15%	1.097%	1.500%	2.934%	6.179%
10%	0.813%	1.227%	2.758%	**6.179%**
5%	0.306%	0.713%	2.330%	5.837%
0%	-0.715%	-0.337%	1.333%	4.757%



1854	50%	70%	90%	99%
100%	0.000%	0.000%	0.000%	0.000%
95%	0.044%	0.058%	0.080%	0.093%
90%	0.085%	0.115%	0.162%	0.189%
85%	0.125%	0.169%	0.244%	0.290%
80%	0.161%	0.222%	0.326%	0.394%
75%	0.194%	0.271%	0.408%	0.503%
70%	0.224%	0.315%	0.487%	0.617%
65%	0.248%	0.356%	0.566%	0.736%
60%	0.266%	0.391%	0.639%	0.859%
55%	0.279%	0.418%	0.708%	0.987%
50%	**0.285%**	0.437%	0.768%	1.118%
45%	0.282%	**0.448%**	0.820%	1.254%
40%	0.268%	0.446%	0.858%	1.389%
35%	0.243%	0.430%	0.880%	1.522%
30%	0.202%	0.401%	**0.883%**	1.649%
25%	0.145%	0.350%	0.859%	1.761%
20%	0.066%	0.274%	0.806%	1.848%
15%	-0.043%	0.170%	0.711%	**1.891%**
10%	-0.186%	0.024%	0.563%	1.864%
5%	-0.382%	-0.178%	0.345%	1.727%
0%	-0.654%	-0.464%	0.022%	1.421%

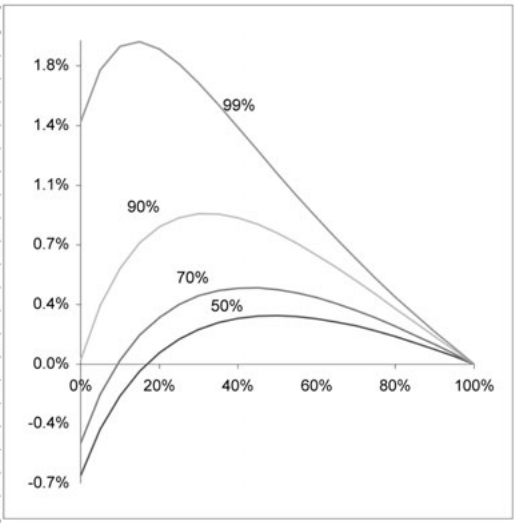
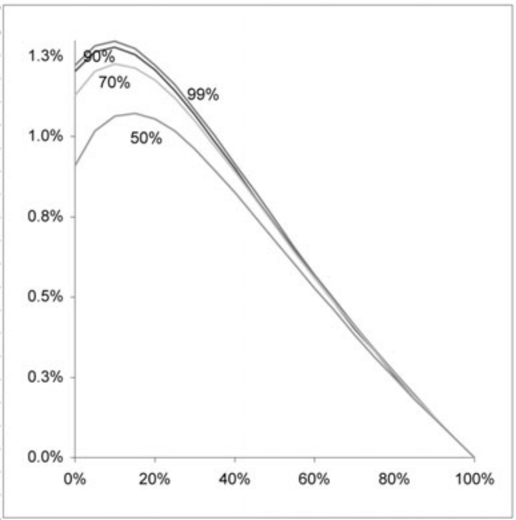


CHART 6
Varying the size of the Rest of the World
Effect on France

1841	50%	70%	90%	99%
100%	0.000%	0.000%	0.000%	0.000%
95%	0.061%	0.061%	0.061%	0.061%
90%	0.126%	0.126%	0.126%	0.121%
85%	0.191%	0.196%	0.191%	0.182%
80%	0.257%	0.266%	0.261%	0.247%
75%	0.331%	0.336%	0.331%	0.313%
70%	0.401%	0.411%	0.406%	0.383%
65%	0.481%	0.490%	0.481%	0.457%
60%	0.560%	0.569%	0.560%	0.527%
55%	0.644%	0.653%	0.639%	0.602%
50%	0.728%	0.742%	0.723%	0.676%
45%	0.812%	0.830%	0.807%	0.751%
40%	0.900%	0.914%	0.891%	0.826%
35%	0.984%	1.003%	0.970%	0.896%
30%	1.068%	1.082%	1.050%	0.961%
25%	1.143%	1.162%	1.120%	1.017%
20%	1.208%	1.222%	1.176%	1.054%
15%	1.255%	1.274%	1.213%	1.073%
10%	1.278%	1.297%	1.227%	1.064%
5%	1.264%	1.283%	1.204%	1.017%
0%	1.204%	1.222%	1.129%	0.910%



1854	50%	70%	90%	99%
100%	0.000%	0.000%	0.000%	0.000%
95%	0.015%	0.015%	0.017%	0.017%
90%	0.029%	0.029%	0.032%	0.034%
85%	0.044%	0.046%	0.049%	0.049%
80%	0.058%	0.061%	0.066%	0.066%
75%	0.073%	0.076%	0.080%	0.083%
70%	0.088%	0.093%	0.097%	0.097%
65%	0.100%	0.107%	0.112%	0.115%
60%	0.115%	0.122%	0.127%	0.129%
55%	0.127%	0.134%	0.141%	0.144%
50%	0.139%	0.149%	0.156%	0.156%
45%	0.151%	0.158%	0.166%	0.168%
40%	0.158%	0.168%	0.175%	0.175%
35%	0.166%	0.175%	0.183%	0.183%
30%	0.171%	0.180%	0.188%	0.185%
25%	0.171%	0.180%	0.188%	0.185%
20%	0.166%	0.178%	0.183%	0.178%
15%	0.156%	0.168%	0.173%	0.166%
10%	0.136%	0.149%	0.154%	0.144%
5%	0.110%	0.122%	0.127%	0.112%
0%	0.071%	0.083%	0.085%	0.068%

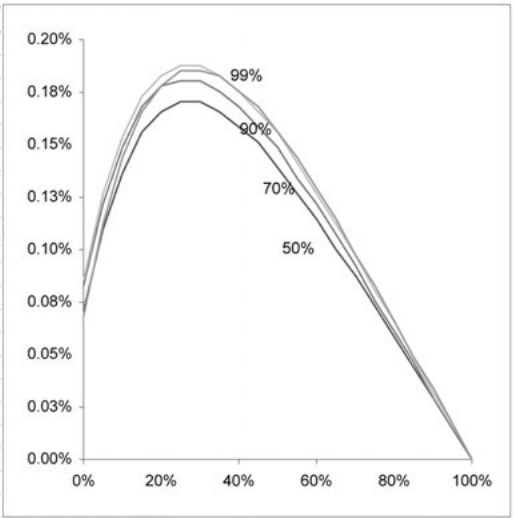
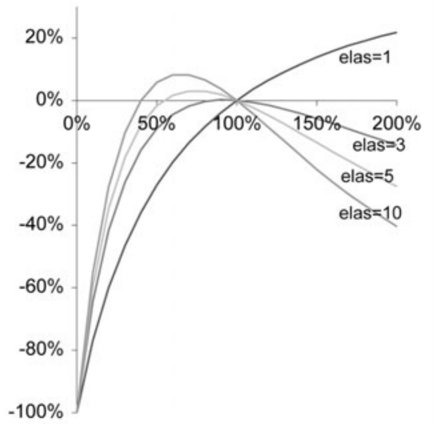


CHART 7
Laffer Curves: Tariff on alcohols and effect on British Revenue for various elasticities of substitution among alcohols, including domestic beer

1841	elas=1	elas=3	elas=5	elas=10
200%	21.8%	-14.4%	-27.6%	-40.3%
190%	20.5%	-12.7%	-24.9%	-37.1%
180%	19.1%	-10.9%	-22.2%	-33.7%
170%	17.5%	-9.2%	-19.4%	-30.1%
160%	15.8%	-7.4%	-16.5%	-26.2%
150%	13.8%	-5.8%	-13.5%	-22.1%
140%	11.6%	-4.2%	-10.6%	-17.7%
130%	9.3%	-2.8%	-7.7%	-13.2%
120%	6.5%	-1.6%	-4.9%	-8.7%
110%	3.5%	-0.6%	-2.2%	-4.2%
100%	0.0%	0.0%	0.0%	0.0%
90%	-3.9%	0.2%	1.9%	3.7%
80%	-8.4%	-0.4%	2.9%	6.5%
70%	-13.6%	-1.9%	3.0%	8.2%
60%	-19.8%	-4.6%	1.7%	8.2%
50%	-27.1%	-9.1%	-1.8%	5.7%
40%	-35.8%	-15.9%	-8.0%	0.0%
30%	-46.5%	-26.2%	-18.3%	-10.4%
20%	-59.9%	-41.6%	-34.6%	-27.7%
10%	-77.0%	-64.7%	-60.0%	-55.4%
0%	-100.0%	-100.0%	-100.0%	-100.0%



1854	elas=1	elas=3	elas=5	elas=10
200%	30.0%	-11.3%	-26.0%	-40.2%
190%	27.9%	-9.6%	-23.5%	-37.1%
180%	25.8%	-8.1%	-20.8%	-34.0%
170%	23.5%	-6.7%	-18.1%	-30.4%
160%	20.8%	-5.2%	-15.4%	-26.7%
150%	18.1%	-4.0%	-12.7%	-22.5%
140%	15.2%	-2.7%	-10.0%	-18.3%
130%	11.9%	-1.5%	-7.1%	-13.8%
120%	8.3%	-0.6%	-4.6%	-9.0%
110%	4.4%	-0.2%	-2.1%	-4.4%
100%	0.0%	0.0%	0.0%	0.0%
90%	-4.8%	-0.2%	1.7%	4.0%
80%	-10.0%	-1.3%	2.7%	7.1%
70%	-16.0%	-3.3%	2.5%	9.0%
60%	-22.9%	-6.5%	1.0%	9.2%
50%	-30.8%	-11.3%	-2.5%	6.9%
40%	-40.0%	-18.3%	-9.0%	1.3%
30%	-50.6%	-28.8%	-19.2%	-9.0%
20%	-63.8%	-44.0%	-35.4%	-26.3%
10%	-79.6%	-66.3%	-60.4%	-54.4%
0%	-100.0%	-100.0%	-100.0%	-100.0%

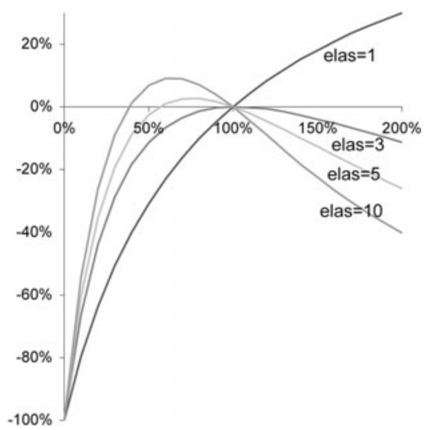
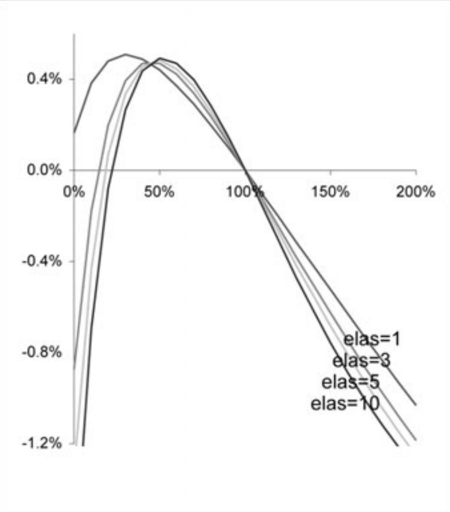


CHART 8
Tariff on alcohols and effect on British Welfare
for various elasticities of substitution among alcohols, including domestic beer

1841	elas=1	elas=3	elas=5	elas=10
200%	-1.033%	-1.186%	-1.253%	-1.311%
190%	-0.932%	-1.080%	-1.150%	-1.216%
180%	-0.832%	-0.974%	-1.041%	-1.116%
170%	-0.732%	-0.863%	-0.927%	-1.005%
160%	-0.629%	-0.746%	-0.807%	-0.888%
150%	-0.523%	-0.626%	-0.682%	-0.757%
140%	-0.420%	-0.504%	-0.551%	-0.618%
130%	-0.315%	-0.381%	-0.418%	-0.470%
120%	-0.209%	-0.253%	-0.278%	-0.315%
110%	-0.103%	-0.125%	-0.139%	-0.156%
100%	0.000%	0.000%	0.000%	0.000%
90%	0.103%	0.122%	0.136%	0.150%
80%	0.200%	0.239%	0.259%	0.287%
70%	0.292%	0.340%	0.367%	0.398%
60%	0.373%	0.423%	0.445%	0.470%
50%	0.443%	0.470%	0.484%	0.493%
40%	0.490%	0.470%	0.456%	0.437%
30%	0.509%	0.395%	0.337%	0.267%
20%	0.482%	0.200%	0.070%	-0.078%
10%	0.384%	-0.178%	-0.431%	-0.693%
0%	0.164%	-0.874%	-1.317%	-1.762%



1854	elas=1	elas=3	elas=5	elas=10
200%	-0.265%	-0.319%	-0.341%	-0.358%
190%	-0.240%	-0.290%	-0.312%	-0.334%
180%	-0.213%	-0.262%	-0.284%	-0.307%
170%	-0.188%	-0.232%	-0.252%	-0.278%
160%	-0.161%	-0.200%	-0.221%	-0.246%
150%	-0.134%	-0.169%	-0.186%	-0.211%
140%	-0.107%	-0.136%	-0.151%	-0.172%
130%	-0.080%	-0.102%	-0.114%	-0.132%
120%	-0.054%	-0.068%	-0.077%	-0.088%
110%	-0.027%	-0.035%	-0.038%	-0.044%
100%	0.000%	0.000%	0.000%	0.000%
90%	0.025%	0.033%	0.036%	0.041%
80%	0.050%	0.063%	0.071%	0.080%
70%	0.074%	0.091%	0.101%	0.110%
60%	0.096%	0.114%	0.123%	0.132%
50%	0.115%	0.129%	0.136%	0.139%
40%	0.129%	0.134%	0.131%	0.126%
30%	0.140%	0.120%	0.104%	0.082%
20%	0.142%	0.080%	0.041%	-0.006%
10%	0.131%	-0.002%	-0.077%	-0.166%
0%	0.099%	-0.155%	-0.290%	-0.443%