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Keywords: Tariff/growth relationship, protectionism, trade liberalization, cointegrated VAR
JEL Classification: F1; F4; N1; N7; O2

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Tariffs and Income: A Time Series Analysis for 24 Countries[1]

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[1] Some of this article was written during Paul Sharp's time as an academic assistant at the Robert Schuman Centre for Advanced Studies at the European University Institute as part of the ERC funded research programme 'Market integration and the welfare of Europeans' and while Markus Lampe was a post.doc. funded by the Department of Economics at the University of Copenhagen. Additionally, we would like to thank Marta Barros (Fundación Norte y Sur), Anna Dorthe Bracht (Statistics Denmark), Carsten Burhop, Nick Crafts, Giovanni Federico, Ingrid Henriksen, André A. Hofman, Katarina Juselius, Niels Framroze Møller, Silvia Nenci, Kevin O'Rourke, Karl Gunnar Persson, Ulrich Pfister, Jacob Weisdorf, Jeffrey G. Williamson, participants at the meeting on Tariffs in History, Madrid 13-14 May 2010 and participants at other seminars and conferences where we have presented, as well as two anonymous referees. Markus Lampe also thanks MCI project ECO2011-25713.

1. Introduction

Does trade liberalization promote economic growth, and hence increase per capita incomes? We suggest a new approach to this question which has spawned a multitude of studies with a wide range of methodologies and conclusions. This previous work rests largely on the results from panel data studies, but we argue that more can be learned with appropriate time series analyses (cointegrated VARs) for individual countries.[2] In doing so, we do not discount the importance of the panel data approach, which has some important theoretical implications. Rather, we question the way in which these results are presented and indeed used by policymakers.

As is well known, a central plank of the 'Washington Consensus' (see Williamson 1990, chapter 2) is the claim that import liberalization is growth promoting. But if a negative relationship is identified using the panel data approach, can this really be taken as an indication that *on the individual country level*, tariffs must be harmful for growth? Economic theory is in any case ambivalent about this question.

A recent example from the tariff-growth literature is given by Warcziag and Welch (2008), who find that countries that liberalize foreign trade have had 1.42 percentage point higher growth rates in comparison to before and to non-liberalizers.[3] What would they have to say about the experience of Japan after the war, where trade policy was actively used to promote growth?[4] Or should we expect to identify a tariff-growth relationship for the UK from the 1860s to at least the First World War, when tariffs were kept continuously at a very low level? Economic history presents its own challenges to the literature, with discussion of a 'tariff-growth paradox' and a positive relationship changing to negative after World War I.[5] Others, such as Nicholas

[2] Recent work has applied a similar approach to the aid-growth relationship (Juselius et al 2011).
[3] Warcziag and Welch actually use a version of the Sachs-Warner dummy (see below), not tariff rates, so they can only distinguish between economies defined as 'open' or 'closed'.
[4] Actually, the common knowledge that Japan *effectively* used trade protection to promote growth has been called into question recently (compare Lawrence 1993 to Beason and Weinstein 1996).
[5] See Clemens and Williamson (2004) and O'Rourke (2000), but also Schularick and Solomou (2011) who question the existence of a 'paradox'. The next section gives a more comprehensive literature review.

Crafts, have pointed out that the institutional environment in each country is a crucial determinant, and point to the East Asian experience as an illustration of this (Crafts 2004).

Another limitation of panel data is that it imposes a causal relationship from tariffs to growth. This assumption is not trivial. Most of today's rich countries embarked on modern economic growth behind protective barriers, but later liberalized. As Rodrik (2007, 217-8) states: 'The only systematic relationship is that countries dismantle trade restrictions as they get richer.'

We discuss the limitations of the panel data approach, and compare it to the advantages of estimating fully-specified country-specific cointegrated VAR models, which can allow for both positive and negative relationships between tariffs and growth, and can also give some indication as to the causality of the relationship (see Johansen 1996 and Juselius 2006). Appropriate time series analysis can help document these individual country level experiences and can better handle questions of endogeneity and parameter stability than can panel data. Using this approach, we point towards a true understanding of what underlies the measures of protection in each individual country, and we can demonstrate the successes and failures of individual experiences with tariff policy through history.

Since we cannot hope to demonstrate the heterogeneity we suggest with fully specified models in this paper, we make our point by estimating cointegrating relationships between average ad valorem equivalents of the tariff rates and GDP for a large number of countries. Our first task is to collect the best possible series of tariff and income measures. We then estimate simple two variable cointegrated VAR models. The cointegrating relationships can be considered a sort of robust correlation coefficient, since as is well known cointegration as a property is robust to the addition of other variables (Pashourtidou 2003). Our models also give an indication of the (Granger) causal relation, but these must be interpreted with caution, since they are more sensitive to the addition of other variables in a more fully specified model. Some heterogeneity is found, but generally the relationship was negative before the Second World War, with the causality from tariffs to GDP. Although also negative the relationship *after* the war was with reversed causality: countries liberalized as they grew richer. Some examples of successful tariff policy, and thus a positive relationship, are also identified, however.

2. Literature survey, theory and problems

While there is no sensible economic theory that gives the result that autarky is preferable to an open economy, there might be cases where selective protection can lead to higher growth rates than free trade. Rodríguez and Rodrik (2000, 267-72) give an overview of the relevant theories. Even the father of the Washington Consensus, Williamson (1990), concludes that one exception from the general rule of free trade might be the temporary protection of infant industries to widen the domestic industrial base and help the emergence of what has been called dynamic comparative advantages. These refer to economic activities in which a country does have a comparative advantage which under current circumstances cannot be made effective. If these 'dynamic' comparative advantages hold a potential for higher economic growth and domestic knowledge development with concurrent spillover effects than the apparent current ('static') comparative advantage, then temporary protection should increase incomes in the long run.

Still, the general case favors free trade. Standard neoclassical theory points to one-off income gains from reallocation after going from autarky to free trade. In the standard Solow-framework, however, it is unlikely that permanently higher growth rates result from the transition to free trade, since growth rates in that framework are determined by exogenous factors like total factor productivity growth. However, 'newer' endogenous growth theory has been able to explain productivity growth, and provided an argument for free trade, as trade barriers are likely barriers to the world technology pool, and hence retard domestic productivity growth. Via this, the level of protection has a negative influence on the level of economic growth.[6]

Empirically, first-generation cross-country growth models following the formulation of endogenous theory, aimed to explain 20- to 30-year averages (c. 1960-90) of growth rates by the development of production factors and trade policy over the period in question. A

[6] This result is of course again subject to qualifications. See Rodríguez and Rodrik (2000) and Bhagwati and Srinivasan (2001), among others. For a short and balanced update of the discussions on trade policy, growth and poverty see the review article by Athukorala (2011) on the book *Trade Liberalization and The Poverty of Nations* by Thirlwall and Pacheco-Lopez.

remarkable variety of proxies was used for trade policy, among which the so-called 'Sachs-Warner (1995) dummy' emerged as a favorite. It combined several features of trade policy (tariff rates, non-tariff barrier coverage, exchange rate black-market premium, presence of a socialist economy or state monopolies of major exports) into a 0/1-variable, according to which an economy was defined as 'open' (0) or 'closed' (1). In various studies, coefficients for this proxy could be estimated that pointed to a robust negative relationship between protection and economic growth (see, e.g., Sala-i-Martin 1997). However, in an influential paper, Rodríguez and Rodrik (2000) found most of these studies not to be robust due to unobserved country characteristics not controlled for, inadequate econometrics, and especially, bad trade policy measures. Most importantly, they argue, is that the Sachs-Warner dummy captures a wide range of economic distortions ranging from general macroeconomic instability to geographical location in Sub-Saharan Africa. They recommended the simple 'average tariff' (AVE), i.e. import duty revenue divided by import value because 'these measures in fact do a decent job of rank-ordering countries according to the restrictiveness of their trade regimes.'[7]

Since 2000, several studies dealing with economic growth after 1945 have actually investigated the tariff-growth relationship, using fixed effects panel methods (using mostly 5- to 10-year averages) and/or instrumental variable approaches to control for the potential reverse causality from economic growth/high incomes to the level of protection. Clemens and Williamson (2004) find that the relationship was negative after 1950, but positive before, confirming Vamvakidis (2002). Yanikkaya (2003) found that especially for developing countries the relationship was positive (1970-97). This result has been put into context by DeJong and Ripoll (2006) who show that the relationship is contingent on income: it is positive for (very) poor countries, and negative for (very) rich ones. Several other studies have established a negative, but insignificant or otherwise problem-ridden relationship between tariffs and growth, while actually arguing that what really matters is the tariff structure (Estevardeordal and Taylor 2008, Nunn and Trefler 2010) or the intensity of trade with technologically advanced countries (Madsen 2009).

[7] Rodríguez and Rodrik (2000), p. 316.

To economic historians, the findings of Vamvakidis and Clemens and Williamson are familiar. O'Rourke (2000) has established the term 'tariff-growth paradox' for his finding of a positive relationship between tariffs and growth for a sample of countries between 1870 and World War I. This finding has been confirmed by Jacks (2006) for a partially different set of countries, using more refined methods. However, also in economic history the empirical effect of trade policy has been recently questioned, since Schularick and Solomou (2011) have shown that more sophisticated econometrics and a bigger sample lead to a less clear identification of a relationship, which, if it exists at all, might be negative (see also Tena 2010).[8] At a disaggregated level, however, Lehmann and O'Rourke (2011) find that before 1914 tariffs on manufactured goods were growth-enhancing, while tariffs on agricultural commodities were likely harmful.[9]

If anything, this short literature review suggests that the sign and significance of the relationship between protection and economic performance is not clear, as can be seen from Table 1, which sums up the sums up the results of the literature on the tariff-growth relationship between 1995 and 2010.[10] We have tried to translate the results of all studies into the equivalent impact of a change in income of a 1 percentage point increase in the average tariff (from its mean, if necessary) after 30 years, an approximation of the 'long-term'. This increase in income can be the manifestation of a higher growth rate in growth regressions or of higher incomes in income regressions. We have calculated the effect on long-run changes in income because in the following we will use time-series data of tariffs and income. This relates directly to the statistical properties of the data, as explained below. Apart from this, tariff reductions might lead to one-time gains from reallocation and thus higher short-term growth rates, which however might not necessarily lead to higher total factor productivity growth and 'steady-state' income growth rates in the long run. In other words, the effects of liberalization might be 'static' rather than 'dynamic', in which case the one-time gains should be easier to

[8] Results from Irwin (2002a) and Clemens and Williamson (2004) suggest that the coefficient varies for different samples.

[9] This finding confirms a new kind of 'tariff-growth paradox', since the results are more or less diametrically opposed to those of Estevardeordal and Taylor, who find for the period since the 1970s that liberalizing tariffs on imported capital goods and intermediate inputs increased growth rates significantly.

[10] Including the papers by Foreman-Peck (1995) and Jones (2000) who estimate the relationship in for income levels.

trace in levels than in growth rates. There is now also a discussion in growth economics, following Hall and Jones (1999) and Jones (2000), about the use of levels in growth regressions.

Although we have of course made an effort to calculate them correctly, the figures in Table 1 should be taken with a grain of salt, since the authors use different methods, ways of estimating elasticities, control variables, sample sizes, etc., and the transformation of these into a common framework might involve misunderstandings as well as assumptions about their sample mean (which we reconstructed from our data if not given). We have not included the results of the recent study by Schularick and Solomou (2011) in this table, since their aim is actually to show how little robust the tariff-growth relationship is for the period of the first globalization. Their coefficients for *log(1+tariff rate)* on *log(GDP per capita)* range from -2.9 to +0.5 (but insignificant in both cases) for the main specifications reported in the body of their paper.

Table 1: Implied effect of a 1-percentage point higher tariff on income at the end of a 30-year period.

Study	Effect of a 10%-point increase in tariffs on income in a 30 year-period	Significant (at 5%)?	Period	N
Foreman-Peck (1995), pp. 463-64	-1.75%	yes	1860-1910	70
Harrison and Hanson (1999), T. 2	-1.75% (min) -0.69% (max)	yes (min) / no (max)	1970-89	73
Rodrik and Rodríguez (2000), T. IV.1 (SW replication)	-3.94%	no	1970-89	71
Jones (2000), T. 1	-1.70% (average minus worst)	3 of 4 (at 10%)	1970-89	71
O'Rourke (2000), T. 6/ 7	+1.29% (min) +4.73% (max)	no (min) yes (max)	1875-1914	70
Vamvakidis (2000), T. 1	-0.60% (min) -1.49% (max)	yes (min) no (max)	1970-90	54
Vamvakidis (2000), T. 2	0	No	1950-70	34-43
Vamvakidis (2000), T. 3	+1.82% (max)	Yes	1920-40	20-22
Yanikkaya (2003), T. 4	+1.27% (min) +2.00% (max)	No (min) Yes (max)	1970-97	83/52
Clemens and Williamson (2004), T. 1	+0.61% (min) +2.89% (max)	yes	1869-1913	307/ 142
Clemens and Williamson (2004), T.2 (max)	+0.07% (min) +2.51% (max)	No (min) Yes (max)	1919-1938	130/ 106
Clemens and Williamson (2004), T.4 (max)	-0.40% (min) -2.32% (max)	No (min) Yes (max)	1950-99	204/ 222
Jacks (2006), T. 3	+0.75% (min) +6.67% (max)	yes	1875-1914	70
DeJong and Ripoll (2006), T. 4 (upper panel)	-0.37% (min) +1.59% (max)	No (min) No (max)	1975-2000	200/ 60
Trefler and Nunn (2010), T. 4 (1) (min.)	+0.003%	No	ca. 1972-2000	63
Athukorala and Chand (2007), T. 2	-0.51%	Yes	1870-2002	TS Australia
Athukorala and Chand (2007), T. 2	-0.45%	Yes	1901-49	TS Australia
Athukorala and Chand (2007), T. 2	-0.32%	No	1950-2002	TS Australia
Estevadeordal and Taylor (2008), T. 2	-0.68% (?) (min) -1.55% (?) (max)	No (min) Yes (max)	1975-89/ 1990-2004	75
Madsen (2008), T. 2/8	+0.006 (max) -0.99% (min)	No (min) Yes (max)	1875-2006	432
Madsen (2008), T. 5	-2.88%	Yes	1915-1951	128
Madsen (2008), T. 4	-0.55%	Yes	1956-2006	176
Tena (2010), T. 2	-0.68%	Yes	1870-1913	38

Sources: Own calculations from the figures given in the cited articles.

Although there might be a majority of papers hinting at the relationship being negative, sign and significance vary greatly over time and between studies, as well as with per capita income (DeJong and Ripoll 2006).

For long-term studies (covering at least 100 years, Madsen 2008 and Athukorala and Chand 2007) in our table, the income change after 30 years ranges from -0.99% to approximately 0; for the period before World War I, the range is -1.75% to +6.67%, while for periods after 1950 results range between -2.32% and +2.89% if we only take significant results from other studies into account.

This might be a consequence of the panel data approach of growth regressions, which estimates average coefficients over individual country experiences and their processes in different periods. We argue that such 'average' coefficients, whether unconditional or conditional on time-invariant country-fixed effects, might have the right sign and even be statistically significant, but they still must not necessarily be (or are unlikely to be) true for all countries in the sample, a necessary condition for the strict prescription of 'Washington medicine'.

Other issues result from sample selection and inclusion of different control variables. Also, a lot of information is lost by averaging over 5- to 30-year periods.[11] Most seriously, perhaps, while instrumental variable approaches can 'filter out' potential one-way causality, they do not look at the growth/income-tariffs relationship, which might also exist: Economic growth could actually lead to decreasing tariff levels because tariffs become fiscally less important and are replaced by revenues from a wider tax base (Kubota 2005). The first argument in this direction concerns collection costs. Economic historians are familiar with the observation that economic growth normally is concurrent with the commercialization of society, a modernization of the state and increasing claims of citizens for participation in politics and public services. Tilly (1993, 87-91) developed the argument that economic development on the one hand broadens the tax basis and on the other hand introduces new instruments of revenue raising, away from tributes and rents (even enforceable in kind) and flow taxation (such as customs and road tolls) towards

[11] This is reportedly done to avoid 'business cycle contamination' in the assessment of steady-state outcomes.

taxation of stocks and incomes. These require a more capable bureaucracy, but also allow more efficient and equal taxation (see also Kubota 2005, Aidt and Jensen 2009). Maschke (2008) has shown empirically that even for a country as developed as the late 20th century United States, raising one dollar of governmental revenue in alternative taxes is 3 to 5 cents more expensive than generating it via customs revenue. Baunsgaard and Keen (2010) find that the ability of recovering tax revenues from trade liberalization by other sources (taxation, VAT, etc.) is much less clear than for rich and middle income countries, which clearly can more than offset the (small) losses in trade tax revenue due to liberalization (the former were already dependant on this revenue to only a very small degree in 1975). Hence, there is reason to believe that governments of poor countries face more severe fiscal constraints and less revenue raising capability than the leaders in rich countries. Hence, the scope for trade liberalization increases as countries grow richer. This growing richer might of course be caused (partially) by intelligent trade policy, as the liberalization might cause further increases in income.

A second argument would be more ideologically framed and emphasizes the argumentative power of the pro-free trade arguments since the Anti-Corn Law League and the Cobdenite movement in Britain up to the Washington Consensus and the idea of a politically and economically united Europe, in fact ideologically close to Cobden's original ideas. In this sense, Irwin (2002b, 226) nicely sums up the convictions of many politicians in today's richer countries, when he states that 'today protectionism is taken as a sign of weakness'.[12]

3. The data

To show the viability and potential of our approach, we assembled a new dataset for one of the key variables in question, trade protection, for the largest possible number of countries (24)[13] and years (1865-2000 whenever possible), while we use the best-practice collection of GDPs per capita Barro and Ursúa (2006), who assembled a dataset of real income per capita indices for the largest number of countries possible, improving the series collected and homogenized

[12] This, of course, has not always led to coherent free trade policy, as examples like quotas for agricultural products, voluntary export restraints and the multi-fiber agreement demonstrate.

[13] These 24 countries are not randomly drawn, but determined by data availability: Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK, Canada, USA, Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay, Australia, India, and Japan.

by Maddison (2006). We use their dataset without modification, except the extension of Argentina's time series backwards to 1865 (from 1875) using estimates reported in Ferreres (ed., 2005, p. 231).

We follow Rodríguez and Rodrik (2000) in using the import-weighted average ad valorem tariff (AVE), calculated as the ratio of customs duty revenue to total imports for domestic consumption, as the best available measure of trade policy restrictiveness. However, we do not necessarily share their belief that AVEs are adequate to compare different countries at one point in time, especially in the late 19th and early 20th century, when import duties were used in different countries in very different ways, some – like the United States – explicitly protecting manufacturing, some – like Latin American countries – more or less desperately looking for revenue, and some trying to appease non-competitive national producers like French agriculture, thereby causing individual idiosyncratic mixes of defensive and infant industry protection and revenue generation (see e.g. Lehmann and O'Rourke 2011, Tena 2010). Especially countries with low taxation capabilities and/or weak central governments tended to generate considerable amounts of income from tariffs on consumption goods of low income elasticity (tobacco, sugar, alcoholic beverages, coffee, tea, etc.), which can cause an upward bias in the level of protection measured through AVEs (see e.g. Irwin 1993, Tena 2006). Therefore, we conclude that the central criticism to AVE, that it uses import values as weights across commodities and therefore puts low weights on highly protected goods and even ignores prohibitive tariffs, while it puts high value on duties imposed to generate much revenue (Irwin 2010, p. 111), is most problematic when there is a difference in the structure of tariffs and imports across countries.[14] However, in the same country these differences should matter much less and therefore make AVE a more homogeneous and reliable measure of trade policy restrictions.

As an empirical underpinning of this assumption we can invoke Irwin (2010), who calculates a theoretically better grounded and more reliable simplified Trade Restrictiveness Index (TRI;

[14] AVE also does not take into account the structure of protection as 'effective tariffs' would do (Corden 1966), by which it likely understates true protection. A measure that takes these points into account is the TRI, whose calculation for a fairly extensive sample of countries over a large time-span is unfeasible at the present state.

Andersen and Neary 2005, Kee, Nicita and Olarreaga 2009) for the United States between 1867 and 1961 and compares it to the US AVEs. He finds that the correlation coefficient between both is 0.92, while the levels of his TRI are 75% higher. Our data on both components of the AVE, customs revenues and import volumes, comes from a variety of national sources. By this, we considerably improve the existing best-practice dataset assembled by Clemens and Williamson (2004), which we used as a basis for our research.[15] The main problem with that dataset, apart from data gaps in their AVE time series, lies in the large break observed for many countries between the tariff levels at the end of their pre-1950 and the beginning of their post-1950 series. We therefore revisited their pre-1950 sources and added large amounts of data from other sources, detailed in Appendix 2, to ensure that both customs revenue and import volume series were consistent over time. We draw our data from authors who are especially interested in the assessment of long-run trends in the economy of their particular country therefore ensuring that the series we use are as comparable over time as they possibly can be. Nevertheless, for some countries, notably the United Kingdom, France and Italy, we have not been able to find coherent series over time, and were therefore obliged to chain series with different levels.[16] The results obtained with the series for Italy and the UK are not satisfactory, which might be due to the quality of the data.

To make our results comparable to those of the cross-country studies discussed above, we also estimate an illustrative model for 'the world', which is actually a weighted average of the 24 countries in our sample.[17] We also calculate an analogous weighted average of the O'Rourke (2000) sample. The weights are each country's GDPs in 1990 International Geary-Khamis dollars from Maddison (2006). Note, however, that we provide the world results for illustrative purposes only. Because we find considerable heterogeneity in individual country's experiences, results for the average are clearly *not* key results of our study.

[15] We are very grateful to Jeffrey G. Williamson for supplying this data.

[16] For the UK, we have been able to trace the source of the considerable difference between both series: Excises on a number of goods were included in the collected duties and cannot be separated from them, since the rates also included a protective element in some cases (see e.g. Customs and Excise (1949)). See also Lloyd (2008), app. III, who discusses the problem in detail for the Australian beer excises.

[17] The idea for 'the world' was inspired by the work of Nenci (2011).

4. Our econometric approach

Our approach thus focuses on time series analysis of yearly data for individual countries and a world average. We make use of the cointegrated VAR model and the methodology suggested by Juselius (2006).[18] Due to our approach we are able to use all available data points and do not have to average over several periods to be able to identify long run relationships. Previous research using cointegration methods in this field has focused on single countries and short time periods, and normally uses the rate of trade (or just imports) to GDP as a measure of liberalization, an indicator that is clearly inadequate as a proxy for trade policy, since governments cannot control imports directly (except in a state-run economy).[19]

The variables used in the subsequent analysis are *y*, which is the natural logarithm to the level of GDP per capita, and *ave* which is the ad valorem equivalent. We wish to emphasize again that we are *not* suggesting that these are fully specified models, and that we are presenting robust estimates of the tariff-income relationship for the countries we look at. Indeed, as Pashourtidou (2003) has demonstrated, omitted relevant variables will make it less likely to identify cointegration and will bias the adjustment coefficients (thus making it difficult for us to conclude anything about causality here). Nevertheless, any cointegrating relationships found are robust to omitted variables, which allows us to say something about the heterogeneity between our countries for those where we do find cointegration. A fully specified model would include other relevant determinants of GDP, such as factors of production, real exchange rates, terms of trade, measures of institutional quality, etc.

Thus, in order to model the long-run relationship between income and AVEs the following model is estimated:

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

[18] The results were obtained usingOxMetrics 6.20.

[19] See e.g. Ahmed (2003) for Bangladesh, Dutta and Ahmed (2004) for Pakistan, Sharma and Panagiotidis (2005) for India. See also Ghatak, Milner and Utkulu (1995) for Turkey, who use proxies similar to Sachs and Warner. To our knowledge, the only study that uses tariff rates to explain income growth is a working paper by Athukorala and Chand (2007) for Australia (1870-2000). They use Hendry's 'general to specific' method which is different from our approach.

where $X_t = (y_t, ave_t)'$ and t is the trend.

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

The model assumes that the residuals are iid and normally distributed (Juselius 2006). We thus report in Appendix 1 the PcGive tests for (no) autocorrelation up to second order and for normality. The most serious misspecification occurs in the case of autocorrelation which, however, is only a problem for Italy and the UK in the first period, countries where we know the data is particularly poor.

The analysis also relies on the choice of a lag-length of 2 in the model in equation (1) being correct. Using information criteria, it is found that *k*=2 lags are in fact sufficient to characterize the systematic variation in the model in both periods in all cases. Moreover, the model assumes constant parameters, and since there is strong evidence of the relationship changing around about the interwar period, the sample is split in two: 1865 (or later if the data was not available) to 1913 and from 1950 to 2000. We initially tried including the World War and interwar years in one of the periods, but these years proved rather difficult to model due to a very large number of outliers.[20] After each estimation we used recursive estimation (both forwards and backwards) to check the stability and robustness of the estimates.

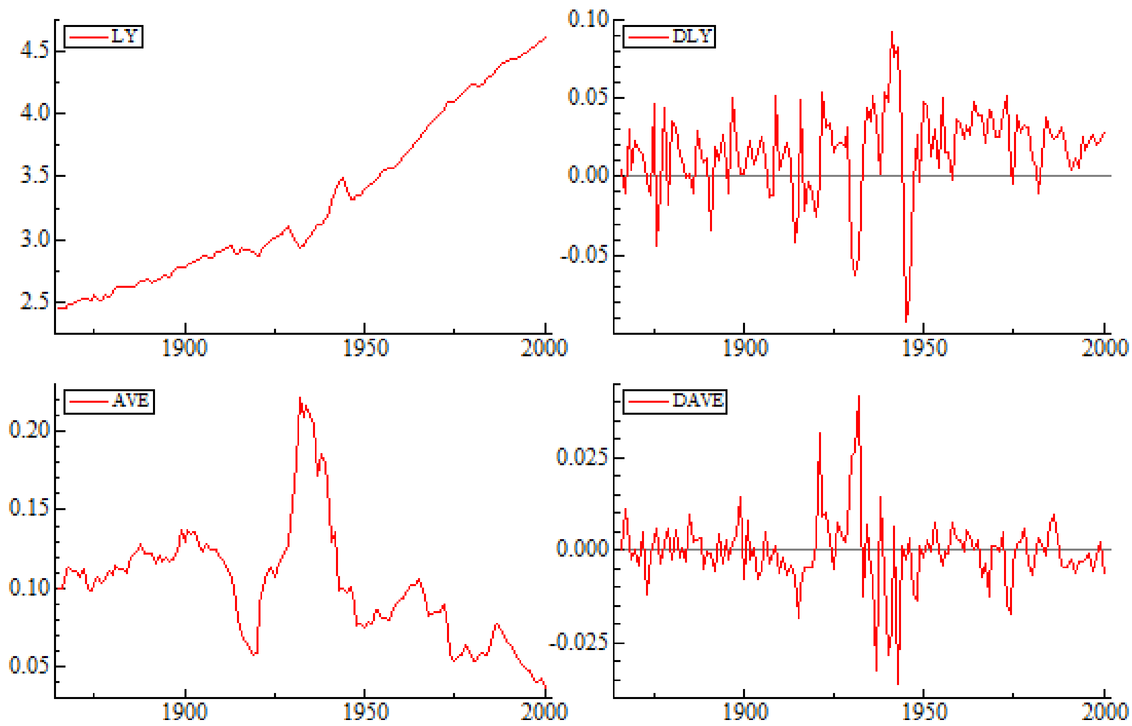
A crucial step in the analysis is to determine the number of equilibrium relationships, *r*. Since we only have two variables, we expect $r = 1$ if there is any causal relationship between the variables. We found early on that growth of GDP per capita appears in almost all cases to be an I(0) stationary process, while AVEs seem to be an I(1) non-stationary process. This implies that there can never be a cointegrating relationship between GDP growth and levels of AVEs. We

[20] It might have been interesting to estimate the interwar period separately, but unfortunately this would provide us with too few data points for a useful estimation.

thus look for a cointegrating relationship between (log) levels of GDP per capita and levels of AVEs.

For illustrative purposes, Figure 1 gives the levels and differences of *y* and *ave*. The first differences of *y* (growth rates) are clearly stationary I(0), highlighting the point made above, whereas *ave* appears to be I(1). Also apparent from Figure 1 is the great instability of the variables during the World Wars and the interwar period, thus justifying the exclusion of these years.

Figure 1: Graphs of the levels and differences of *y* and *ave* for 'the world', 1865-2000



Source: See Appendix 2.

Since the usual trace test is biased towards stationarity with limited samples, we also make use of other methods for determining the number of cointegrating relationships. More specifically, we make use of graphs of the cointegrating relations, we look at the roots of the Companion matrix, and we plot recursive graphs of the trace test statistics (see Juselius 2006 for more on determining the cointegration rank). In most cases, an assumption of one unit root seems appropriate and is justified in as much as it allows for greater ease of interpreting the estimation results (Johansen 2006).

5. Results

As mentioned before, we perform the above analysis for the 24 countries we have data for, plus an average for 'the world' and for the original O'Rourke (2000) ten-country-sample. Since we have two periods, but for three countries (Colombia, Mexico and Peru) it is impossible to analyze the first period due to lack of data, we estimate a total of 49 models. We cannot of course report all our results here, but a summary of the results illustrating the countries with each causal relation[21] is given in Tables 1 and 2. Here we have also included those with no significant cointegrating relationship, because it is difficult to identify cointegration with few observations, so the results might give some indication of what might be identified had we more years of data. We have also highlighted those results where there is misspecification of the residuals: one star indicates that the residuals are very non-normal (i.e. a high number of outliers), and two stars indicate that there is autocorrelation. We could control for these using dummies or extra lags, but to keep the results as comparable as possible we have chosen not to do so. The full cointegrating relationships we identify are reported in Appendix 1.[22]

Interestingly, for both 'the world' and the O'Rourke sample, the sign is clearly negative in both periods (although this is clearer for the second). This is perhaps what we should expect: despite potential country level benefits from protecting certain industries or sectors of the economy, for the world as a whole increasing tariffs is a zero-sum game. However, the causality is not

[21] Note that causality can be in both directions, even with only one cointegrating relationship. This implies that both variables adjust in order to reestablish equilibrium in the event of a change to one of them.

[22] Even more detailed results, including standard errors and the results of the various specification tests described above are available on request.

always clear, and for the second period it seems that it points in the other direction, consistent with the statement by Rodrik and the theoretical arguments given above above.

Referring to the magnitude of the coefficients on tariffs in our results, except a few outliers commented on below, we find them in the fat part of the distribution of results obtained in the studies mentioned in the literature review above using the panel approach (assuming again that our long run estimates are comparable with their changes over 30 years). In relation to this is should be remembered that the panel estimates are in a sense averages for all countries, so some outliers are to be expected.

Table 1: Results for period until 1913

Sign	Negative			Positive		
Causality	$ave \rightarrow y$	$y \rightarrow ave$	$ave \leftrightarrow y$	$ave \rightarrow y$	$y \rightarrow ave$	$ave \leftrightarrow y$
Countries	**France**, **Italy****, **Canada**, **India***, **Japan**	**Denmark,** Argentina	**Netherlands**, **Sweden***, **Uruguay**, **Australia**	Belgium, Germany, **Norway**, Switzerland, UK**, **US**, **Chile**	Portugal, Spain	**Brazil***

Note: Colombia, Mexico and Peru were not estimated due to short time series. See also notes to Table 2.

Table 2: Results for period 1950-2000

Sign	Negative			Positive		
Causality	$ave \rightarrow y$	$y \rightarrow ave$	$ave \leftrightarrow y$	$ave \rightarrow y$	$y \rightarrow ave$	$ave \leftrightarrow y$
Countries		**Belgium***, Denmark*, **France**, **Netherlands**, Norway*, Portugal, **Sweden**, Canada*, Chile*, **Colombia**, **India**, Japan	**Germany**, **Italy**, **UK**, **US**, **Uruguay**	**Spain**, **Switzerland**	Argentina*, Brazil, Mexico, **Australia***	**Peru**

Notes: Relationships highlighted in bold are statistically significant at the 5% level. One star (*) denotes potential problems with autocorrelation in the residuals, and two stars (**) denotes potential problems with non-normality in the residuals (see Appendix 1).

Again, we emphasize that care must be taken in interpreting these results. Even if we were able to estimate the 'true' model, they would depend on at least two factors: what countries choose to do with their tariffs, and whether or not they succeeded in this. So for example, a country might choose infant industry protection and thus expect a positive relationship. But if they were not successful, we will not identify this.[23]

Then, due to the limitations of our simple two variable model, failure to find a significant cointegrating relationship does not imply that none existed, as explained above. In particular,

[23] This might be the case for Australia and its insignificant Latin American counterparts in the second period, where we see that they put up tariffs as they get richer, but do not seem to reap any fruits from this.

the causal relationships are very tentative. It might be noted at this point that some countries have very poor data (particularly France, Italy and the UK), which makes it more difficult to identify a relationship. Clearly, however, we can already here observe considerable heterogeneity in the experiences of these countries. The main direction for the first period was negative, and mostly involved causality from tariffs to income (including two-way relationships). The positive relationship between tariffs and income is only identified for the US, Chile, Norway and possibly Brazil.

The result for the US is perhaps particularly worth noting, since it actually shows the tariff-'growth' paradox in the first period. The US has often been taken as the model case of a industrialization paradigm involving institutional and transport integration of the national market, banking, education and protectionist trade policy at an early stage (see e.g. Allen 2011, pp. 78-90), a model which - in the words of Robert C. Allen (2011, p. 114) – 'proved less and less fruitful as time went by'.

The second period, despite also seeming to be mostly associated with a negative relationship, displays reverse or two-way causality for all countries in that part of Table 2, thereby providing relatively more evidence for the income-tariff side of the relationship than for its more prominent incarnation, the tariff-income relationship. However, one might ask why not all of these countries did not experience an increase in income due to this additional move to free trade. We believe that a part of the answer lies in the generally low levels of protection in these countries, and therefore very low deadweight losses from existing tariffs (cf. Irwin 2010).[24] The most important channel for liberalization to lead to better economic performance is trade, and trade at the aggregate level might not have been seriously affected by tariffs during most of our period for the said countries. Therefore, on the one hand, we agree with a large body of recent literature (e.g., Nunn and Trefler 2010, Estevardeordal and Taylor 2008, Lehmann and O'Rourke 2008, Tena 2010) that at any level of protection, it matters what you protect, and on the other

[24] However, notice that this argument cannot explain everything, since for the US we find two-way causality, while for India, the country with the highest average tariff in the second period we only find higher (lower) incomes causing lower (higher) tariffs.

hand, we believe that liberalization from higher levels of protection should have stronger effects on income than from already very low levels.

Some apparently problematic results also warrant attention: the results for Sweden, the Netherlands and Australia in the first period and for Germany, Italy, Spain and Switzerland in the second period show very high coefficients for the causal relationships from AVEs to tariffs. We believe that for most of these – all except Spain and Switzerland in the second period – this is, together with the sometimes very low adjustment parameters, an indication that although we detect two-way causality the prevalent causal relationship is from income to tariffs (see also footnote 21 above). For Spain and Switzerland it is interesting that their high coefficients are for a positive tariff to income relationship, although we have no real explanation for this. In the case of Spain we observe that *ave* levels are relatively low in the 1950s (around 6%), when macroeconomic distortions and non-convertibility of the peseta led to low effective levels of openness of the economy, while *ave* levels increased in the 1960s after the Stabilization and Liberalization Plan of 1959 was put into practice (see Prados de la Escosura et al 2012), thereby highlighting one of the possible shortcomings of the *ave* measure.

Finally, it is tempting to attempt more formal generalizations of the results (sorting them according to certain criteria), but we have so few observations and a large number of 'boxes' countries can end up in, making this impossible. The fact that in our first step we cannot identify channels through which income and tariffs might interact underlines another of our central suspicions: that the historical circumstances and institutional, geographical and economic backgrounds of each country matter. This is best illustrated by our finding of a negative coefficient for India before independence, which indicates that lower (higher) tariffs (statistically) caused higher (lower) incomes, by roughly 0.7% for every 1%-point change in the tariff level. This finding is apparently at odds with classical Indian historians like Dadabhai Naoroji, R.C. Dutt or their interpretation by Nehru, who state that railroad penetration and low tariffs[25] (in part due to Lancashire lobbying) since at least the 1870s destabilized the Indian economy, reinforced the disappearance of handloom weavers (a point also made by Marx) and

[25] In our dataset, 4.4% on average between 1872 and 1900, but increasing to 15% in the early 1920s and more than 30% in the 1930s.

pushed India into a low-growth specialization in agriculture (see Bagchi 1976, Clingingsmith and Williamson 2004). However, a lecture of the influential post-1947 research contributions by K.N. Chaudhuri, John McLane, Sunanda Sen, Amiya K. Bagchi and others collected in Balachandran (2005) shows that a large part of the classical story, the 'wealth drain' of quasi-tributes siphoned off via an export surplus and dysfunctional monetary policy and financial development, is largely unrelated to the tariff level. Recent research on de-industrialization on the one hand (Clingingsmith and Williamson 2004) and technology transfer to India on the other (Roy 2009) adds additional layers to this already complex history, as does the post-war result referred to above.

6. Conclusion

We have argued for a new approach to understanding the tariff-growth/income relationship. We demonstrate that time series analysis can better describe the actual impact of tariffs on an individual economy, which can then be interpreted in terms of political motivations, institutional settings, and the like.

As we have repeatedly stressed, our results are tentative, but we see a number of promising avenues for future research. Most obviously, the lack of evidence for the tariff-growth paradox could be investigated further. Then, particular cases such as the United States and India before the First World War might be taken up again within more fully specified models to investigate the robustness of our findings. For the second period, it is tempting to look more closely at the prevalent finding of 'reverse causality' in the post-war years, again within more fully specified models, in an attempt to falsify the Washington Consensus.

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Appendix 1: Full results

Cointegrating relation

(Bold typeface indicates that the parameter is significant at the 5% level; where there is no clear causal relation, both variables are normalized on)

Tests

(P-value in square brackets. AR: PcGive/OxMetrics Vector AR 1-2 test; N: PcGive/OxMetrics Vector Normality test; J: Johansen cointegration test for r=1, i.e. one cointegrating relationship)

Averages

World 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.34} \\ \mathbf{-0.08} \end{bmatrix} [\{y + 0.57ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.05} \\ \mathbf{-0.19} \end{bmatrix} [\{ave + \mathbf{1.76}y - \mathbf{0.02}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 0.75072 [0.6467]

N: Chi^2(4) = 8.4448 [0.0766]

J: [0.67]

World 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.16} \\ \mathbf{0.37} \end{bmatrix} [\{ave + 0.04y + 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.38455 [0.9257]

N: Chi^2(4) = 1.1771 [0.8818]

J: [0.83]

O'Rourke Sample 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.36} \\ -0.04 \end{bmatrix} [\{y + 0.44ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.9201 [0.0699]

N: Chi^2(4) = 5.6201 [0.2294]

J: [0.83]

O'Rourke Sample 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.16} \\ 0.03 \end{bmatrix} [\{ave + \mathbf{0.30}y - 0.01t\}_{t-1}] + \cdots$$

AR: F(8,76) = 1.0809 [0.3856]

N: Chi^2(4) = 6.7707 [0.1485]

J: [0.60]

Europe

Belgium 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.34} \\ 0.01 \end{bmatrix} [\{y - 0.97ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.7994 [0.0912]

N: Chi^2(4) = 13.046 [0.0111]*

J: [0.31]

Belgium 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.31} \\ -1.69 \end{bmatrix} [\{ave + \mathbf{0.11}y - \mathbf{0.00}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 2.7956 [0.0091]**

N: Chi^2(4) = 7.5584 [0.1092]

J: [0.98]

Denmark 1865-1913

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.51} \\ -0.32 \end{bmatrix} [\{ave + \mathbf{0.26}y - \mathbf{0.00}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.1602 [0.3350]

N: Chi^2(4) = 8.2110 [0.0841]

J: [0.55]

Denmark 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.44} \\ 0.49 \end{bmatrix} [\{ave + 0.00y + 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.54201 [0.8212]

N: Chi^2(4) = 35.509 [0.0000]**

J: [0.51]

France 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.33} \\ -0.03 \end{bmatrix} [\{y + \mathbf{3.45}ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 0.52281 [0.8356]

N: Chi^2(4) = 7.0053 [0.1356]

J: [0.87]

France 1950-2000

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.20} \\ 0.03\end{bmatrix} [\{ave + \mathbf{0.36}y - 0.01t\}_{t-1}] + \cdots$$

AR: F(8,76) = 1.1822 [0.3210]

N: Chi^2(4) = 7.8736 [0.0963]

J: [0.04]

Germany 1865-1913

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.53} \\ -0.01\end{bmatrix} [\{y - 0.52ave - \mathbf{0.01t}\}_{t-1}] + \cdots$$

(beta *ave* sig at 10%)

AR: F(8,72) = 1.1303 [0.3538]

N: Chi^2(4) = 6.8634 [0.1433]

J: [0.89]

Germany 1950-2000

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.09} \\ \mathbf{-0.03}\end{bmatrix} [\{y + \mathbf{6.79}ave - \mathbf{0.01t}\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.19} \\ \mathbf{-0.59}\end{bmatrix} [\{ave + \mathbf{0.15}y - \mathbf{0.00t}\}_{t-1}] + \cdots$$

AR: F(8,76) = 2.0031 [0.0572]

N: Chi^2(4) = 5.9708 [0.2013]

J: [0.03]

Italy 1865-1913

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.32} \\ \mathbf{0.15}\end{bmatrix} [\{y + \mathbf{0.61}ave - \mathbf{0.01t}\}_{t-1}] + \cdots$$

AR: F(8,72) = 3.2768 [0.0031]**

N: Chi^2(4) = 42.511 [0.0000]**

J: [0.94]

Italy 1950-2000

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.10} \\ \mathbf{-0.04}\end{bmatrix} [\{y + \mathbf{5.16}ave - \mathbf{0.03t}\}_{t-1}] + \cdots$$

or

AR: F(8,76) = 0.67551 [0.7115]

N: Chi^2(4) = 18.240 [0.0011]**

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.19}\\ \mathbf{-0.50}\end{bmatrix}[\{ave + \mathbf{0.19}y - \mathbf{0.00}t\}_{t-1}] + \cdots$$

J: [0.20]

Netherlands 1865-1913

$$\begin{bmatrix}\Delta y_t\\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.31}\\ \mathbf{-0.01}\end{bmatrix}[\{y + \mathbf{23.05}ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.32}\\ \mathbf{-7.07}\end{bmatrix}[\{ave + \mathbf{0.04}y - \mathbf{0.00}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 0.66028 [0.7244]

N: Chi^2(4) = 4.8817 [0.2996]

J: [0.84]

Netherlands 1950-2000

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.13}\\ -0.46\end{bmatrix}[\{ave + \mathbf{0.18}y - \mathbf{0.00}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 1.5327 [0.1601]

N: Chi^2(4) = 4.6039 [0.3304]

J: [0.49]

Norway 1865-1913

1865-1938:

$$\begin{bmatrix}\Delta y_t\\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.32}\\ 0.09\end{bmatrix}[\{y - \mathbf{1.61}ave - \mathbf{0.02}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.0965 [0.3758]

N: Chi^2(4) = 4.9877 [0.2886]

J: [0.16]

Norway 1950-2000

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.33}\\ -0.07\end{bmatrix}[\{ave + 0.04y + 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.98025 [0.4580]

N: Chi^2(4) = 65.077 [0.0000]**

J: [0.80]

Portugal 1865-1913

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.18}\\ 0.07\end{bmatrix}[\{ave - 0.16y + 0.00t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.6009 [0.1397]

N: Chi^2(4) = 2.7068 [0.6080]

J: [0.56]

Portugal 1950-2000

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix}=\begin{bmatrix}\mathbf{-0.21}\\ 0.78\end{bmatrix}[\{ave+0.05y+0.00t\}_{t-1}]+\cdots$$

AR: F(8,76) = 0.58981 [0.7833]

N: Chi^2(4) = 0.87037 [0.9288]

J: [0.74]

Spain 1865-1913

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix}=\begin{bmatrix}\mathbf{-0.33}\\ 0.13\end{bmatrix}[\{ave-0.24y+0.00t\}_{t-1}]+\cdots$$

(beta *ave* sig at 10%)

AR: F(8,72) = 1.0992 [0.3740]

N: Chi^2(4) = 9.4897 [0.0500]*

J: [0.42]

Spain 1950-2000

$$\begin{bmatrix}\Delta y_t\\ \Delta ave_t\end{bmatrix}=\begin{bmatrix}\mathbf{-0.09}\\ -0.01\end{bmatrix}[\{y-\mathbf{8.20}ave-\mathbf{0.04}t\}_{t-1}]+\cdots$$

AR: F(8,76) = 1.3708 [0.2230]

N: Chi^2(4) = 11.506 [0.0214]*

J: [0.16]

Sweden 1865-1913

$$\begin{bmatrix}\Delta y_t\\ \Delta ave_t\end{bmatrix}=\begin{bmatrix}\mathbf{-0.37}\\ \mathbf{-0.12}\end{bmatrix}[\{y+\mathbf{5.56}ave-\mathbf{0.02}t\}_{t-1}]+\cdots$$

or

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix}=\begin{bmatrix}\mathbf{-0.67}\\ \mathbf{-2.08}\end{bmatrix}[\{ave+\mathbf{0.18}y-\mathbf{0.00}t\}_{t-1}]+\cdots$$

AR: F(8,72) = 0.75273 [0.6450]

N: Chi^2(4) = 27.422 [0.0000]**

J: [0.86]

Sweden 1950-2000

$$\begin{bmatrix}\Delta ave_t\\ \Delta y_t\end{bmatrix}=\begin{bmatrix}\mathbf{-0.07}\\ -0.36\end{bmatrix}[\{ave+\mathbf{0.19}y-\mathbf{0.00}t\}_{t-1}]+\cdots$$

AR: F(8,76) = 0.99676 [0.4456]

N: Chi^2(4) = 9.4344 [0.0511]

J: [0.51]

Switzerland 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.47} \\ -0.00 \end{bmatrix} [\{y - 2.77ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.6177 [0.1348]

N: Chi^2(4) = 12.368 [0.0148]*

J: [0.89]

Switzerland 1950-2000

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.15} \\ -0.02 \end{bmatrix} [\{y - \mathbf{3.45}ave - \mathbf{0.02}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.99249 [0.4488]

N: Chi^2(4) = 17.553 [0.0015]**

J: [0.15]

UK 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.44} \\ 0.01 \end{bmatrix} [\{y - 0.07ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 3.0289 [0.0055]**

N: Chi^2(4) = 9.4978 [0.0498]*

J: [0.55]

UK 1950-2000

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.36} \\ \mathbf{-0.08} \end{bmatrix} [\{y + 1.42ave - \mathbf{0.02}t\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.11} \\ \mathbf{-0.52} \end{bmatrix} [\{ave + \mathbf{0.70}y - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.93098 [0.4962]

N: Chi^2(4) = 24.729 [0.0001]**

J: [0.29]

North America

Canada 1870-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.21} \\ -0.03 \end{bmatrix} [\{y + \mathbf{1.95}ave - \mathbf{0.03}t\}_{t-1}] + \cdots$$

AR: F(8,62) = 1.2292 [0.2974]

N: Chi^2(4) = 4.9420 [0.2933]

J: [0.58]

Canada 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.38} \\ -0.46 \end{bmatrix} [\{ave + 0.03y + \mathbf{0.00t}\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.41928 [0.9061]

N: Chi^2(4) = 36.434 [0.0000]**

J: [0.86]

USA 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.17} \\ 0.08 \end{bmatrix} [\{y - \mathbf{1.53}ave - \mathbf{0.02t}\}_{t-1}] + \cdots$$

AR: F(8,72) = 2.0652 [0.0505]

N: Chi^2(4) = 16.180 [0.0028]**

J: [0.59]

USA 1950-2000

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.25} \\ \mathbf{-0.07} \end{bmatrix} [\{y + 0.90ave - \mathbf{0.02t}\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.06} \\ \mathbf{-0.22} \end{bmatrix} [\{ave + \mathbf{1.11}y - \mathbf{0.02t}\}_{t-1}] + \cdots$$

AR: F(8,76) = 1.1399 [0.3469]

N: Chi^2(4) = 16.636 [0.0023]**

J: [0.42]

Latin America

Argentina 1865-1913

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.32} \\ 0.07 \end{bmatrix} [\{ave + 0.13y - 0.00t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.0581 [0.4019]

N: Chi^2(4) = 4.9259 [0.2950]

J: [0.28]

Argentina 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.22} \\ 0.12 \end{bmatrix} [\{ave - 0.42y - 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 1.3021 [0.2554]

N: Chi^2(4) = 36.801 [0.0000]**

J: [0.76]

Brazil 1870-1913

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.19} \\ \mathbf{0.21}\end{bmatrix}[\{y - \mathbf{1.92}ave + 0.00t\}_{t-1}] + \cdots$$

AR: F(8,62) = 1.1160 [0.3651]

N: Chi^2(4) = 26.425 [0.0000]**

J: [0.49]

or

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.40} \\ \mathbf{0.36}\end{bmatrix}[\{ave - \mathbf{0.52}y - 0.00t\}_{t-1}] + \cdots$$

Brazil 1950-2000

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.27} \\ 0.17\end{bmatrix}[\{ave - 0.01y - 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.61117 [0.7658]

N: Chi^2(4) = 9.6073 [0.0476]*

J: [0.79]

Chile 1865-1913

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.32} \\ 0.09\end{bmatrix}[\{y - \mathbf{1.61}ave - \mathbf{0.02}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 1.0965 [0.3758]

N: Chi^2(4) = 4.9877 [0.2886]

J: [0.16]

Chile 1950-2000

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.33} \\ -0.07\end{bmatrix}[\{ave + 0.04y + 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.98025 [0.4580]

N: Chi^2(4) = 65.077 [0.0000]**

J: [0.80]

Colombia 1950-2000

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.59} \\ 0.06\end{bmatrix}[\{ave + \mathbf{0.38}y - 0.01t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.69781 [0.6924]

N: Chi^2(4) = 16.463 [0.0025]**

J: [0.91]

Mexico 1950-2000

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.25} \\ \mathbf{0.09}\end{bmatrix}[\{ave - 0.01y + 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.51552 [0.8413]

N: Chi^2(4) = 8.5363 [0.0738]

J: [0.76]

Peru 1950-2000

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.11} \\ \mathbf{0.18}\end{bmatrix}[\{y - \mathbf{1.51}ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.26} \\ \mathbf{0.17}\end{bmatrix}[\{ave - \mathbf{0.66}y + \mathbf{0.00}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 1.9620 [0.0628]

N: Chi^2(4) = 8.7381 [0.0680]

J: [0.75]

Uruguay 1870-1913

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.52} \\ \mathbf{-0.13}\end{bmatrix}[\{y + 0.99ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.12} \\ \mathbf{-0.52}\end{bmatrix}[\{ave + \mathbf{1.01}y - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,62) = 1.5391 [0.1623]

N: Chi^2(4) = 18.214 [0.0011]**

J: [0.65]

Uruguay 1950-2000

$$\begin{bmatrix}\Delta y_t \\ \Delta ave_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.20} \\ \mathbf{-0.23}\end{bmatrix}[\{y + \mathbf{1.41}ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

or

$$\begin{bmatrix}\Delta ave_t \\ \Delta y_t\end{bmatrix} = \begin{bmatrix}\mathbf{-0.32} \\ \mathbf{-0.28}\end{bmatrix}[\{ave + \mathbf{0.71}y - \mathbf{0.00}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.82623 [0.5821]

N: Chi^2(4) = 15.424 [0.0039]**

J: [0.64]

Asia/Australia

Australia 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.18} \\ \mathbf{-0.04} \end{bmatrix} [\{y + \mathbf{5.98}ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,72) = 0.80695 [0.5986]

N: Chi^2(4) = 13.912 [0.0076]**

J: [0.86]

or

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.26} \\ \mathbf{-1.06} \end{bmatrix} [\{ave + \mathbf{0.17}y - \mathbf{0.00}t\}_{t-1}] + \cdots$$

Australia 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.77} \\ 0.03 \end{bmatrix} [\{ave - \mathbf{0.29}y + \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 1.2860 [0.2635]

N: Chi^2(4) = 39.039 [0.0000]**

J: [0.62]

India 1872-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-1.22} \\ -0.08 \end{bmatrix} [\{y + \mathbf{0.66}ave - \mathbf{0.01}t\}_{t-1}] + \cdots$$

AR: F(8,58) = 1.6345 [0.1349]

N: Chi^2(4) = 27.104 [0.0000]**

J: [0.56]

India 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} \mathbf{-0.23} \\ 0.00 \end{bmatrix} [\{ave + \mathbf{1.44}y - \mathbf{0.03}t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.72342 [0.6703]

N: Chi^2(4) = 16.199 [0.0028]**

J: [0.61]

Japan 1865-1913

$$\begin{bmatrix} \Delta y_t \\ \Delta ave_t \end{bmatrix} = \begin{bmatrix} \mathbf{-1.11} \\ 0.11 \end{bmatrix} [\{y + \mathbf{1.07}ave - \mathbf{0.02}t\}_{t-1}] + \cdots$$

AR: F(8,62) = 0.85916 [0.5554]

N: Chi^2(4) = 0.82110 [0.9356]

J: [0.73]

Japan 1950-2000

$$\begin{bmatrix} \Delta ave_t \\ \Delta y_t \end{bmatrix} = \begin{bmatrix} -0.07 \\ \mathbf{0.73} \end{bmatrix} [\{ave + 0.01y - 0.00t\}_{t-1}] + \cdots$$

AR: F(8,76) = 0.92927 [0.4976]

N: Chi^2(4) = 16.486 [0.0024]**

J: [0.09]

Appendix 2: Data sources for the calculation of AVEs

This appendix lists, country by country (in alphabetical order) the sources for Customs Revenue ('Revenue') and Import values ('Imports'), both normally in current prices in local currency units (LCU), indicating in parenthesis for which years data is retrieved from this source, and giving the specific reference to a page or table number, and, if necessary to distinguish between different series in our source, the denomination of the series we choose. Where either imports or revenues were reported in a currency different from LCU, this is also noted in parentheses and an additional source for the exchange rate is given with the corresponding detail information. If we directly used a source for AVEs, this source (e.g. Clemens and Williamson 2004) is mentioned. The full bibliographic reference for each title is given in the reference list at the end. In those cases where we connect series from different sources over time, we provide a short discussion of how they connect in overlapping years. We also mention how small data gaps have been bridge by interpolation in specific cases.

Argentina: *Revenue*: Ferreres (ed., 2005), Table 6.1.1 (derechos de importación). *Imports*: Ferreres (ed., 2005), T. 8.1.1 (importaciones, cif, in US$). *Exchange rate*: Ferreres (ed., 2005), T. 7.2 (dólar de importación).

Australia: *Revenue*: Vamplew (ed., 1987), Series GF 357 (1865-1900); Mitchell (1995), Table G.6 (1901-1903). *Imports*: Vamplew (ed., 1987), Series ITFC 23 (Aggregate Imports, Australian Colonies, only overseas trade, not between them; -1900); Mitchell (1992), Table E.1 (1901-1903). *AVE*: 1904-, Lloyd (2008).

Belgium: *Revenue*: Mitchell (1992), G.6 (-1969, 1913-1919, 1956-64 geometrically interpolated), IMF (2005, 2009a) (1972-91; 1970/71 geometrically interpolated between Mitchell and IMF), 1992-2000 extrapolated using figures for Netherlands; *Imports*: Horlings (2002) (-1990, 1914-1918 geometrically interpolated), IMF (2009b) (1991-2000).

Brazil: *AVEs*: Clemens and Williamson (2004) dataset (1870-1900); *Revenue*: OxLAD (1901-2000), *Imports*: Mitchell (1993), E1 (1901-1947, in LCU), OxLAD (1901-2000, in US$); *Exchange rate*: IMF (2009b).

Canada: *Revenue***:** Urquhart, Buckley and Leacy, (ed., 1983), Series G479 (-1975), IMF (2005, 2009a) (1976-); *Imports*: Urquhart, Buckley and Leacy, (ed., 1983), Series G384 (-1975), IMF (2009b) (1976-).

Chile: *AVEs*: Jofré/Luders/Wagner (2000), Table 3 (-1999); IMF (2009a, 200b) (2000).

Colombia: *AVEs*: Clemens/Williamson (2004) dataset (1910-11); *Revenue*: OxLAD (Mitchell 1993) (1912-2000); Imports: OxLAD (1912-2000, in USD); Exchange rate: OxLAD (1912-1949); CEPAL (2009) (1950-2000).

Denmark: *AVEs*: Clemens/Williamson (2004) dataset (1865-1896); *Imports*: Johansen (1985), Table 4.2 (1897-1980), Mitchell (2005), E1 (1981-87), OECD (2012), DNK.BPDBTD01.NCCU (1988-2000); *Revenue*: Mitchell (1992), G9 (-1964), OECD (2009) (1965-97), Danmarks Statistik (2012), Table 5.2 (1998-2000). Values coincide in overlapping years.

France: *AVEs*: Lévy-Leboyer and Bourgouignon (1990), T. A-VI (-1913); *Revenue*: Mitchell (1992), G6 (-1988; used until 1964), OECD (2009) (1965-); *Imports*: Mitchell (2005), E1. AVEs from Mitchell and OECD were not consistent (level in 1965: 0.23 vs. 0.61); so they were chained in 1965 forward (based on Mitchell-levels).

Germany: *Imports*: Bondi (1958), p. 124, 145 (1865-1871), Deutsche Bundesbank (1976) (1872-1913, 1925-1943, 1948-49), 1914-1924 interpolated and converted into current prices with import price index (Statistisches Reichsamt 1926, p. 263) and exchange rate to Gold dollar (Holtfrerich 1980), Mitchell (2005), E1 (1950-1970), OECD (2012), DEU.BPDBTD01.NCCUSA (1971-2000); *Revenue*: Kaiserliches Statistisches Amt (1889), p. 184 (1865-1878), Caasen (1953), Table 1.a/b (1872-1944); Mitchell (1992), G6 (1920-21, 1946-64), OECD (2009) (1965-97), Statistisches Bundesamt (2012), VGR-STE-22 (1998-2000); *AVEs* 1944-47 linearly interpolated; for revenues 1872-1878 we used averages between both sources (which diverged by c. 10%).

India: Revenue: Mitchell (1995), G.6 (1872-1988), World Bank (2008) (1989-2000); Imports: Mitchell (1995), E.1 (1872-1988), World Bank (2008) (1989-2000).

Italy: *Revenue*: Mitchell (1992), G.6 (-1942; 1947-1974), Liesner (1989), T. It.9 (1974-85), OECD (2009) (1974-2000), IMF (2005, 2009a) (1974-99). *Imports*: Mitchell (2003), E.1. Revenue data was not consistent between Mitchell, OECD and IMF until 1974, and Liesner, OECD and IMF after 1975.

Concerning revenue, Liesner's and Mitchell's figures are identical except for rounding until 1974, but a major break occurs in Liesner's figures between 1974 and 1975. Values after 1974 are unweighted averages of those obtained from using Liesner, OECD and IMF Revenue data, which diverge considerably, with the 1974 Mitchell figures. AVE's 1943-46 are geometrically interpolated.

Japan: *AVEs* 1865-67: Clemens and Williamson database (connects perfectly), *Revenue*: Mitchell (1992), G.6 (1868-1926), Japan Statistics Bureau (2008), Series 05-06 (Customs duties) (1927-). *Imports*: Mitchell (1995), E.1 (1868-1943, 1945-76), Japan Statistics Bureau (2008), Series 18-2-a (Value of Japan Imports) (1977-). Connects perfectly. Imports in 1944 are from Ohkawa and Shinohara (1979), Table A31. Import value for 1945 is interpolated using the Barro/Ursúa (2006) GDP per capita figure.

Mexico: *AVEs*: Clemens and Williamson database (- 1948); *Revenue*: Mitchell (1993), G.6 (1949-74), IMF (2005, 2009a) (1972-2000). In 1972-74 the mean of Mitchell and IMF, which diverged very little, was used. *Imports*: Mitchell (1993), E.1 (1949-1978), IMF (2009b) (1979-2000). AVEs before and after 1948 connect perfectly.

Netherlands: *Revenue*: Mitchell (1992), G.6 (-1941, 1943-64), OECD (2009) (1965-2000); *Imports*: Smits, Horlings, van Zanden (2000), H.1 (-1913), Mitchell (1992), E.1 (1914-1920, chained in 1913, 1940-43, chained in 1939), Centraal Bureau voor de Statistiek (2009), (1921-39, 1944-2000). *AVEs* in 1942, 1944, 45 have been geometrically interpolated. Mitchell and OECD revenue figures are identical for 1955 and 1960, but the 1964 figure in Mitchell is equal to the OECD's in 1965 (no OECD values for 1964 available). We have not shifted any of the series.

Norway. *AVEs*: Clemens/Williamson (2004) database (-1995); IMF (2009a, 2009b) (1996-2000). Clemens and Williamson's figures proved to be coherent when connected in 1950 and also were virtually identical to figures calculated from Mitchell (1993) and IMF sources.

Peru: *Revenue*: OxLAD (1900-2000); Imports: OxLAD (1900-2000, in US$); Exchange rate: OxLAD (-1949), CEPAL (2009) (1950-).

Portugal: *AVE*: Lains (2007), T. 3 (-1958), Valério (coord., 2001), Table 10.1 (1959-1998), IMF (2009a, 2009b) (1999-2000).

Spain: *Revenue:* Tena (2007), T. 7, col. 18 (-1935), Mitchell (1992), G6 (1939-1964), OECD (2009) (1965-); *Imports:* Tena (2007), T.3, col. 4 (1865-2000). Sources for revenue are very similar in the years when the series were connected, but diverge in later years.

Sweden: *Revenue*: Mitchell (1992) (-1972; deducting 2.7% until 1950 for coffee tax); OECD (2009) (1972-1989); IMF (2005, 2009a) (1990-2000). In overlapping years, differences in the sources are small. *Imports*: Edvinsson (2005), Table F.

Switzerland: *Revenue*: Mitchell (1992), G6 (-1885), Ritzmann-Blickenstorfer (1996), L.3 (1886-1960), *Imports*: Ritzmann-Blickenstorfer (1996), L2, H4, L54 (mean of Bairoch and Bernegger export volume indices [L2] rebased to 1885 and multiplied with wholesale price index [H4], replicates existing single year estimates for 1875/7 [in 1876] and 1879 [L54] very closely), Ritzmann-Blickenstorfer (1996), L3 (1886-1961); the resulting AVEs figures coincide perfectly with Clemens/Williams (2004) after 1952, whose AVEs were used for 1961-97; 1997-2000 have been calculated from IMF (2009a, 2009b).

United Kingdom: *Revenue*: Mitchell (1992), 581-584 (-1964), OECD (2009) (1965-), *Imports:* Mitchell (1992), pp. 451-454 (-1965), IMF (2009b) (1965-). Levels do not coincide, chained in 1964 at the OECD/IMF level (0.059 vs. 0.352 following Mitchell).

USA: *Revenue*: Sutch/Carter (general eds., 2006), Series Ea589 (-1999), *Imports*: Sutch/Carter (general eds., 2006), Series Ee369 (-1999). 2000: IMF (2009a, 2009b).

Uruguay: *AVEs*: Clemens and Williamson (2004) database (-1899, rebased to our 1900 figures); *Revenue*: OxLAD (1900-68, 1972-2000), Mitchell (1993), G6 (assuming that customs revenues were the same share of total revenues as in previous years). Imports: OxLAD (-1931, 1937-2000, in US$), Mitchell (1993), E1 (1932-36, in US$). Mitchell's import values were used for 1932-36 because OxLAD data caused implausible structural breaks in the AVE series. *Exchange rates*: OxLAD (1900-2000).

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