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Trade Policy and Long-term Economic Development: Historical Evidence from Australia's Colonies in 19th Century

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Abstract

In our studies, historical data on neighboring colonies of New South Wales and Victoria in 19th century are used to shed new light on an issue which has intrigued economic historians and economists: How is trade policy linked to long-term economic growth?

It is found that Victoria's higher protection restricted productivity growth directly, but stimulated it indirectly through the revenue effects of promoting greater infrastructure and a consequentially-larger population base.

Keywords: Colonial Australia; Trade policy; Aggregate productivity; Time-series analysis

The Setting and our Approach

Why did more-protectionist Victoria (abbreviated as Vic thereafter) develop faster in the later nineteenth century than freer-trade New South Wales (abbreviated as NSW thereafter)? Historians have mused over this question; and many economists have been reluctant to accept higher trade protection as a growth-creating agent. Economic theories of this issue tell us little: protection (or increased protection) can either retard or accelerate long-term economic development, when allowance is made for its effects on factor supply (including foreign factors acquired by the protecting country) and productivity growth, through research and development. But contemporary statistical techniques used widely in economics today enable us to shed new light on an old puzzle after some detailed assembly of data.

We focus on economic growth and especially `productivity growth'. Seminal economic-history studies associated with Rostow, Madison, and Denison all emphasize productivity growth, as did Australia's comprehensive Vernon report released in 1965. Trade policy theories are not directed to giving any insights into economic growth. And the economic growth literature makes few if any links to trade protection. But the growth literature does contain the Schumpeterian notion that, by limiting rivalry, productivity growth can and predictably will be enhanced [1].[1]

The importance of the above notion is that restrictions on free-market competition, like Victoria practiced in the later nineteenth century, can foster long-term higher growth rates. Indeed, we have historical affirmation from other countries showing that market intervention can limit competitive rivalry and enhance economic development. For instance,

`Germany and the United States, engaging in government-subsidized internal improvements, in particular, increasingly began to overtake Britain in the production of basic commodities like steel and pig iron' [2].

Moreover, the few empirical studies which examine this link using time-series data may not have sufficiently resolved such historical precedents. For example, a long-series empirical study by Clemens et al. tested a number of common hypotheses for explaining the lack of persistent correlation between tariffs and growth, without statistically conclusive results. Similar, a recent contribution by Greasley et al. [3] finds no clear relationship between primary-sector intensity and output growth, using multi-country data for many decades. The scene is thus set for a fresh look at this epoch and this issue that has fascinated economic historians and been largely ignored by economists. We use tools of statistical research designed to find linkages relating to long spans of data that are familiar to economic historians.

Colonial Australia lacked the skills, capital, and natural endowments for agriculture beyond self-sustenance, and even that was a struggle. But there was a stream of visiting sea vessels from 1820s to 1840s that needed supplies. As such, small-scale and inefficient land grants were given to migrants and ex-convicts to take advantage of this momentary comparative advantage. Like protection as applied by Victoria especially, purposive interference with free-market forces characterized the approach to economic policy.

Manufacturing developed rapidly in the South-Eastern colonies of NSW and Vic after 1850s gold rushes. Vic adopted significant and widespread protection against imports from 1860s, under the prominent advocacy of newspaper baron David Syme. In 1890s the different approaches to protection between these two colonies became a debating issue delaying Federation. The faster growth of Vic compared with NSW has encouraged many casual inferences that protection fostered faster development of industry: debates that rage today and form history can reveal genuinely relevant insights. This case study is a good natural experiment: few real differences then existed as between the two colonies considered, other than the protectionist policy stance of Vic.

This paper revisits this intriguing issue, using reconstructions of long series of data [4] and modern time-series econometrics. During this time, the Australian colonies shared a dominant economic policy objective of producing manufactures themselves [5]. An overview of the adjacent colonies is given in Table 1, followed by a comparison of protective tariff rates in the period considered Table 1.

[1]As in the massive literature contained in and associated with Kamien and Schwartz (1982)

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Factors	NSW	Vic
Population	825446	909021
City density (persons/km^2)	4.3376	4.5247
Output ($'000)	13800	13000
Manufacturing workers	32862	35060
Factory numbers	2396	2313
Private capital ($'000)	5915	5272
Public capital ($'000)	17600	16300

Average values across the years 1861-1900 inclusive. Monetary units converted to 1890 equivalent values. Table figures are primarily sourced from Butlin (1964), supported by a collection of other records as stated in the Appendix, unless explained otherwise.

Table 1: Comparison of NSW and Vic 1861-1900: average statistics.

Durable Items	NSW		Vic	
	1876	1893	1876	1893
Boots and shoes	Nil	10%	3-25d†/doz	4-60d†/doz
Gloves	Nil	10%	10%	20%
Hats and caps	Nil	10%	20%	36d/doz
Millinery	Nil	10%	10-20%	25%
Apparel and slops	Nil	10%	20%	35%
Blankets	Nil	10%	10%	35%
Fancy goods	Nil	10%	10%	10-15%
Floorcloth and oilcloth	Nil	10%	10%	20%
Furniture	Nil	10%	20%	40%
Carriages	Nil	15%	20%	$50
Carts	Nil	15%	20%	20%
Harness and saddlery	Nil	10%	20%	45%

Selected tariff schedule of major imports NSW and Vic during the years 1876 and 1893.

Source: Selections of tariff schedule derived from Butlin (1964).

†240d = 1£

Table 2: Sample of major tariffs during colonial Australia.

We notice from Table 1 that the mean tariff rate in NSW in was 8.9%; it was higher at 11.4% in Vic, using our definition of revenue-based tariff rates. This is not a massive difference, compared with inferences made by economic historians. We thus question the simplicity of this case comparison as presented by more contemporary academic observers, notably Sinclair [6]. That literature focuses on large and rapid changes in the tariffs applying to specific products that had strong political ties to lobby groups. But these product types constituted a small part of manufacturing, itself a small part of the economy. More narrowly-defined tariff rates are given in Table 2, which highlights some of the more pronounced tariff-rate differences Table 2.

This paper is organized into five further sections. Section 4 provides a brief overview of existing literature on this topic, including reflections from economic historians and any available insights from economists linking trade policy and long-term development. Section 6 describes the meaning and sources of the statistics we used in our research, emphasizing data properties and limitations. Section 5 describes the research methods we have used. Section 7 contains our analysis and results. Section 8 provides some discussion, our findings and some areas of potential further investigation by both historians and economists.

A Survey of Relevant Literature

The first significant research on the Vic-NSW development comparison arose in the nineteenth century itself [7]. This study used limited descriptive statistics. The purpose was to demonstrate that the 'freer-trade' policy of NSW was more beneficial than Vic's protectionist regime. While Powers did not define his measure of 'beneficial', he did define 'free trade' to mean 'tariffs for revenue only' [8].[2] This assumption differs greatly from the modern definition of free trade, meaning the absence of all trade barriers: it shows the need for care when examining historical data.

This practice has not always been followed. For example, the authoritative W.A. Sinclair, made his own evaluation of the effects Vic tariffs [9], considering only the changes that would have occurred had there been no tariffs, wrongly representing the moderate protection reality in NSW. Sinclair was, however, careful to frame his comments in terms of cause-and-effect relationships that tariffs had on production levels. Sinclair was not able to examine the interaction between tariffs, tariff revenue, public works expenditure, and productivity effects, which is our central objective here. He did not, moreover, use an econometric approach capable of filtering out other influences on economic development as we have sought to do.

Historians, Patterson and Butlin et al. [5,10] were antecedents to whom Sinclair often referred. Patterson recognized that most of the differences in tariff income between NSW and Vic were explained by the differences in land sales, which constituted another major source of revenue. The overriding consideration was still the immediate developmental needs of a new land rather than with long-term considerations such as productivity growth.

Butlin's extensive work [10], emphasizes data interpretation in an historical context. Butlin provide a large and varied set of results to be used in many studies as primary data, including this one. Butlin posited a relationship between the availability of investment capital and economic cycles the colonies faced at this time [11]. He found that reduced financial support from England required alternative sources of revenue. Hence, the change in productivity caused by a change in tariff rates may be more accurately described as a strong side-effect of that motive.

Later accounts of the development of industry in Victoria imply a protection-development linkage that became the accepted version of this period of history. As an example, the Centenary Edition of The Victorian Year Book, published in 1973, gives this account:

'At first the (Victorian general industry protective) tariff was low: 10 per cent on certain manufactured goods. In 1871, the tariff was raised to 20 per cent for finished manufactures, including boots, clothing, textiles, leather goods and iron and steel goods. Six years later the tariff was raised again and duties of 30 and 40 per cent measures were imposed on some commodities' (p.323).

The authors then infer that high and increased protection was associated with the fuller development and evolution of industry, compared with NSW:

'...by 1891 nearly 25 per cent more people were employed in secondary industry in Victoria than in the more populous New South Wales' (p.323).

The authors then document the firms, industries and towns that experienced this nineteenth century Victorian manufacturing development. But there is no attempt to link this development to protection specifically (pp.323-6). In another place, the writers state:

"Victoria did in fact lead other states in the development of (textiles, clothing, footwear and carriage building, against British and other

[2] "We must have revenue," they often said, "and the duties we propose will provide the sums we require. Incidentally, they may be of use to some of our industries." '. (Mills 1925)

overseas competition) and in the replacement of consumer goods by raw materials and capital goods as its major overseas imports. However, it is an open case whether these developments would have occurred in any case, since the population attracted by the gold discoveries already provided a sizeable local market and a readily available workforce." ... "Perhaps the most that can be said is that industrial development in Victoria was somewhat accelerated by protection."

In the four decades since these accounts were written, little solid statistical or other analysis has been made to check these cursory inferences and strong assertions. A recent study on the links between trade-openness, foreign direct investment, and long-term economic growth, Pradhan et al. [12] struggles to find any theory-based foundations for their work, while citing several empirical papers upon which they advance in a ten-country comprehensive study of recent data. As neither trade policy theory nor economic development gives any rigorous specification for the study we are making, the inspiration for our study must therefore come from less fully-specified theory, from observations and inferences at the time and since, and from empirical studies, by economists and economic historians and observers of the day.

Since 1960s there has been a resurgence of interest in analyzing tariff history, using more advanced econometric techniques. For example, an ambitious attempt to evaluate of overall social and economic welfare effects of iron and steel tariffs in nineteenth-century United States by Irwin [13] involved estimating linking coefficients. However, without sufficient information to deal with the interplay between import quantity, import price and the price-sensitivity of the supply of the foreign good(s), Irwin concedes that his approach remains a static comparative exercise [14]. A more relevant study was also conducted by Tena, who compared the effects of tariffs on the growth of Gross Domestic Product (GDP) in many nations [15] using a specification to separate tariff effects from other influences. Tena attributes the lack of statistically-significant results to the sparseness of his dataset, but this might not be the main problem.

Another contemporaneous paper [16] measures the change in Australian GDP from 1870 to 2002, amazingly with data available through all thirteen decades. The authors find a weak but statistically-significant negative relationship between tariffs and growth of around 0.28%. Concurrently, they noticed many qualitative disruptions throughout the period, inevitably these are caused by historical changes, which the authors handle by adding dummy variables that have no economic interpretation.

Our approach in this study captures multiple influences on productivity growth, which are consistent with the enumeration of explanatory factors found in the more-applied economics literature. Our choice of explanatory variables is supported by the Denison method embraced in Matthews [17] and more recently by Australia's National Office for the Information Economy [18].

Our Method

The simplest approach in econometric analysis is to begin with a testing equation. By convention, the measure for productivity is placed at the left and the candidate factors explaining it are place at the right. We selected variables that are causally linked to economic development according to the likelihood that the factor will influence the statistical estimates for tariff rate effects, the main independent variable, as well as being important to manufacturing in the colonies.

We start with a conceptual relationship between production rates and our cited dependent variables, for each colony in turn. Denote t as the time index of each variable. We write:

$$Y_t = f(trate_t; pub_t; fac_t; work_t; pri_t; city_t) \quad (1)$$

Where,

Y_t stands for output

$trate_t$ stands for tariff rates

pub_t stands for public capital

fac_t stands for establishments

$work_t$ stands for workers

pri_t stands for private capital and

$city_t$ stands for city density

We now state the derivation of each variable. Detailed empirical reasons for variable definitions are included in Appendix 1 for the interested reader.

Subject variable: production per worker

Our subject variable is total manufacturing output in 1890-adjusted dollars, divided by the total number of workers.

Main explanatory variable: Tariff rates

We define tariff rates as total customs revenues divided by the monetary value of imports.

Public capital expenditure

Public capital investment is assumed to be an externality: rather than measuring it on a per-worker or per-person basis, we compute capital investment using public capital expenditure data. The view of Sinclair is taken, that the primary incentive was to foster railroads, judging by the large share they consume. We estimate the accumulated stock of public capital investments in railroads in each year t, defined as follows:

$$Pub_t = pub_{t-1} + (New\ capital - Replacement\ Outlays_t) \quad (2)$$

Additionally, we know that the obvious revenue motive for imposing high tariff rates was to finance public works. The most important government initiative of this sort was railroad construction, lead to indirect benefits for manufacturing. Therefore, we attempt to estimate the hypothetical level of capital stock if income from tariffs were removed. We denote this value as $\widehat{pub_t}$, computed as follows:

$$\widehat{pub_t} = \widehat{pub_{t-1}} + MAX(total\ public\ capital\ investments, 0) * percentage\ of\ public\ capital\ investments\ in\ railroads - average\ maintenance\ cost * 2.5\% * \widehat{pub_{t-1}} \quad (3)$$

The 2.5% is the average maintenance cost, derived as follows:

$$\frac{\sum_1^T pub_t}{Replacement\ Outlays_t} * \frac{1}{T} \quad (4)$$

Economies of scope: number of factories

The total number of factories captures both scale economies effect at the firm level and scope between firms. If the infant-industries argument holds, productivity should increase when the sector is shared amongst fewer, larger firms.

Economies of scope: number of workers

Total number of workers in manufacturing, directly taken from sources.

Economies of scope: private capital accumulation

Private capital accumulation is defined as the total capital accumulated, in dollar amounts, during each year for each factory. This requires the assumption that the benchmark value of factory capital was close to zero before the 1860s, when growth really began to take off.

External factor: city density

City density is a measure of urban population. Most manufacturing activity occurs in urbanized areas of the colonies so this measure makes more sense than overall population levels of the entire colony. A higher population creates a price support for manufacturers due to consequential demand-side externalities; the price support created by increased tariff rates was thought to translate to factories being able to hire more workers.

The production function

As the number of data points in our study is limited, we use a modified Cobb-Douglas production relationship, which is commonly used for studies where prior information does not indicate any specific functional form for the function.

$$Y_t = (1+trate_t)^{\beta_1}(pub_t)^{\beta_2}(fac_t)^{\beta_3}(work_t)^{\beta_4}(pri_t)^{\beta_5}(city_t)^{\beta_6} \quad (5)$$

The main properties and limitations are documented in Hoover [19].

By specifying tariff rates as $(1+trate_t)$, our working assumption is that tariffs provide a price effect, and that small price changes are associated with an approximately constant own-price elasticity of demand, leading to the convenience of the log-log specification. If the tariff rate is applied directly, low tariff percentages will drive the log value to a large negative number. That would then imply that, at very low tariff rates, marginal changes would have a very large impact, when in reality small percentages from near zero should not have a very high percentage effect.

We now divide both sides of the equation by the number of workers to obtain the subject variable as production per worker, we can get a log-log model in the following form,[3]

$$Y_t = \beta_0 + \beta_1 ln(1+trate_t) + \beta_2 ln(pub_t) + \beta_3 ln(fac_t) + (\beta_4 - 1) ln(work_t) + \beta_5 ln(pri_t) + \beta_6 ln(city_t) + \varepsilon_t \quad (6)$$

Where,

y_t denotes the log of output per worker

ε_t denotes $N(0,\Sigma^{-1})$ iid errors.

Econometric modifications

In addition to the basic model, we will introduce three modifications. The first refinement relates to data integrity issues raised by Butlin [9]. One of his objections was that data during the early years of the Statistical Registers could be inaccurate. This limitation is potentially most serious in relation to the first two years of this study [9]. Outliers do not always invalidate results and they can never be excluded arbitrarily. For this study, the years 1861 and 1862 are excluded as outliers because Vic was still at her early stages, and the underlying phenomenon would have been uncharacteristic.

The second modification, which closely related to the first one is the treatment of the final years of the data, during the recession of the 1890s. Global recessions are external shocks that affect small-scaled economies such as Australia during the colonial-era. This study will add a dummy variable for the years 1893-1900 to prevent shocks in the underlying economic parameters of the respective colonies from distorting estimates for the other years.

Our third and final refinement we introduce is a statistical justification of the variables included in the model. This means sifting through the list of variables to select those that best explain productivity growth, striking a middle-ground between excluding important variables and over-fitting the model. This study will do so by estimating the above regression model using all possible combinations of the listed variables we have specified above. At the next stage, the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) scores are computed. These scores are a measure of information lost when each variable is excluded. The five variables being tested are: worker count, factory count, total private capital, city density and the recession dummy variable. They are included and excluded in turn for a total of 2^5=32 total combinations, presented in Table 3. AIC and BIC scores for all combinations of dependent variables are included in Appendix 2 Table 3.

Production per worker is the dependent variable, while tariff rates and public capital are always included because both are central to this study. Factory count and the recession dummy appear almost everywhere and are also included. The number of workers variable is excluded because it is not a significant factor for NSW. Only factors relevant for both colonies are included for comparison. As for the private capital and city density variables, both of them appear in the same specifications. The decision is to include private capital and omit city density because the latter depended a lot more on interpolation to fill the gaps. The need to exclude one is due to their high correlation with each other and with population in general. Estimation results using all available variables are included for reference as a robustness check.

Data and Variables

Manufacturing output, workers

Output in sterling terms is taken from Butlin [10], who estimated output as five times the value of total wages. Total workers in manufacturing data are taken from the source above except NSW workers in 1861/62. Those two years were not available so it is assumed that the percentage growth of workers is the same as during the years 1863/64, extrapolated backwards. The same is done for Victoria in 1861 using 1862/63; Butlin stated that the figure of 3830 was `clearly incomplete'. NSW during 1891 is taken from government statistics. Figure 1.

Variables in best model						
Statistic	**Dataset**	**Workers**	**Factory**	**Private capital**	**City density**	**Recession**
AIC	NSW		Y	Y	Y	Y
BIC	NSW			Y	Y	Y
AIC	Vic	Y	Y	Y	Y	Y
BIC	Vic	Y	Y			Y
AIC	dummy	Y	Y			Y
BIC	dummy		Y			Y
AIC	pooled	Y	Y	Y	Y	Y
BIC	pooled	Y	Y	Y	Y	Y

Variables included in the `best' specification as defined by scores of the AIC and BIC exogeneity tests. A total of 32 combinations were estimated by ordinary least-squares; tariff rates are the primary variable and always included. `Y' indicates that the specification includes that variable. Information scores for each combination of dependent variables are included in Appendix 2.

Table 3: Variables included for the best model based on AIC/BIC exogeneity tests.

[3]This is possible because $Var(\beta_4-1)=Var(\beta_4)$; all tables will display estimates of β_4.

The movement of production per worker in the two colonies, summarized in Figure 1, seems to have mirrored each other. This may well reflect common external factors that impinged on both these colonies. This is particularly evident during 1872/83 in NSW, when indices of production per worker increased from 387 to 421, closely coinciding with the increase enjoyed by Vic the year before, when production per worker rise from 344 to 386. Again, in the recession two decades later, NSW production per worker fell from 436 to 408 during 1892/93, with Vic following similarly a year later, dropping from 385 to 339. Alternatively, NSW simply have converted less of its primary sector into manufacturing, hiring only the best workers. It would be difficult for a regression estimate to distinguish between these effects.

Private capital, public capital, tariffs

Private capital formation is taken from p.282 of Butlin [10]. For NSW 1861-85, Butlin found that no data are available and hence he extrapolated backwards using techniques based on `three-year recursive running averages'. Public capital figures are taken from Butlin [10] at pp.348-67. Tariff rates on an ad-valorem basis are unavailable so they were computed. Total imports were taken directly from Statistical Registers, as well as customs & duties collected from 1891-1900 for NSW and for 1865-1900 for Victoria. Those for NSW during 1861-90 were taken from Patterson [5]; Victorian data 1861-64 were manually tallied from the `interchange' section of the Statistical Registers by aggregating the `duty collected' at the foot of each page Figure 2.

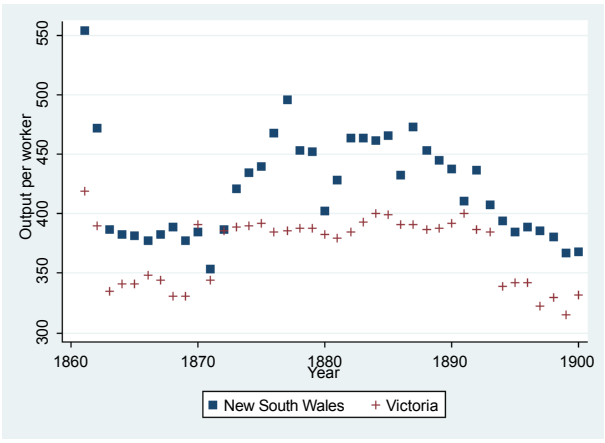

Figure 1: Output per worker, 1861-1900.

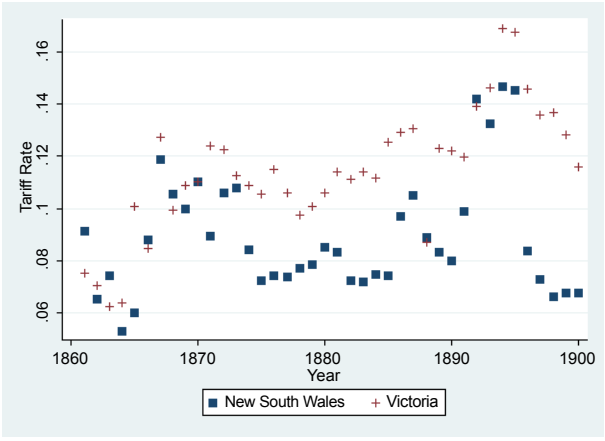

Figure 2: Annual average tariff rates, 1861-1900.

Movements in tariff rates, as shown in Figure 2, tended to coincide inversely with large apparent reductions in production per worker, in both colonies. In NSW, the tariff rates increased from 9.89% to 14.20% during 1891/92, a year before the colony saw a drop in production per worker. Similarly, in Vic there was a surge from 14.65% to 16.91% in the same year. Paradoxically, the temporal closeness between the movements of these two variables actually reduces the strength of the anti-tariff arguments made in earlier comparative studies, which state that protectionist measures do not pay in the long run. A more probable explanation is that recessions fuel populist sentiment for higher protection; but this does not establish how tariffs affect manufacturing output Figures 3 and 4.

Establishments (factories)

A Number of establishments for the years 1861-64 are taken from their respective Statistics Registers, shown in Figures 3 and 4. The bases between the colonies were not exactly the same. For NSW the 1861/62 figures only include `old settled districts' and for 1863/64 excluded machines `Connected with or dependent upon agriculture'. 1861/62 figures from Victoria include `breweries' and `Mills for Grinding and Dressing Grain'. Establishment figures 1891-1900 uses 1895 Statistical Registers as they are in line with Butlin's figures. Numbers from 1865-90 are taken from Patterson [5]. Both the 1861-64 numbers and Patterson's sources exclude isolated machines as establishments.

Population

Census dates did not coincide with the beginning of the year so linear extrapolation was performed according to the actual day of the year between the gaps. Before 1896, the numbers were taken from Keltie et al. [20]. The 1883 figure for NSW does not have a date so it is assumed to be mid-year, as consistent with other Victoria estimates. The 1891 census taken in NSW also does not have a date, so the customary date of 1 April is assumed. After 1896 the figures are taken from Coghlan [21].

City density

City density is highly incomplete and only a few points were available, hence the collinearity problem with population when used for regression analysis. First, city population censuses were taken during the years 1861/71/81/91 in the two colonies as well as `percentage of the total colonial population' figures. They are available in McCarty et al. [22]. Percentages between census dates were first filled in by linear interpolation, and then multiplied by colony population data. We use colony population instead of interpolated city population as a check: we found estimated city populations were all monotone around the census `nodes', confirming that the basis for counting population in both sources was consistent. Land area in hectares was available from Spearritt [23] for the years 1901/21/31 and extrapolated backwards; it also estimated for the year 1821 in Phillips [24].

Analysis and Results

We present out results in two parts. The first half will present our main findings. The second half contains variations in estimation strategy that serve as robustness checks for the interested reader. Tables of exact sources by year and a complete listing of variable values are listed in Appendix 3 for readers interested in replication.

Main estimation results

Parameter estimates of the colonial production function and their corresponding t-values are listed in Table 4. Four sets of regression

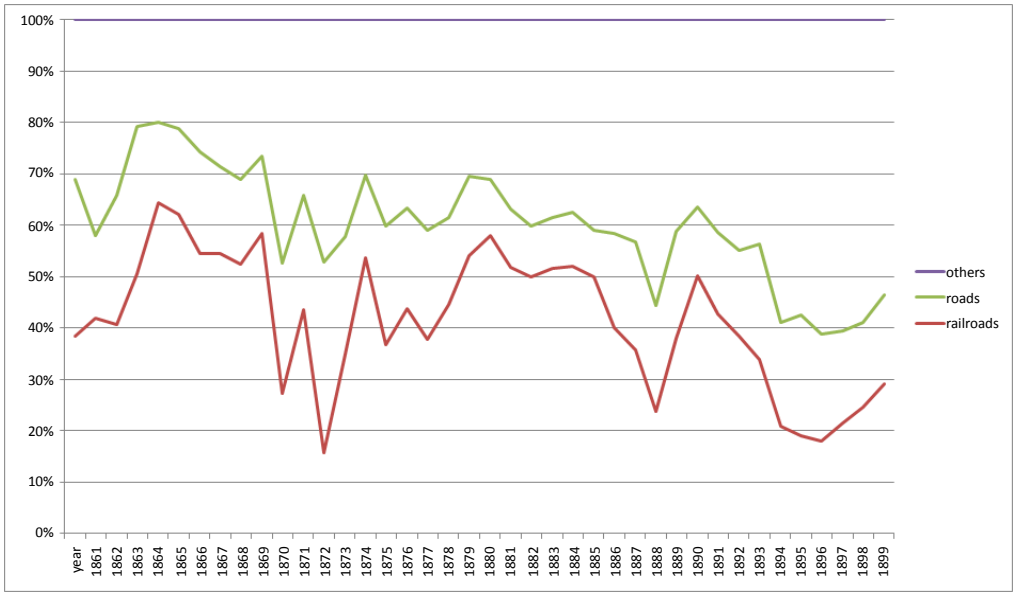

Figure 3: Railroad Expenditures of NSW, 1861-1900.

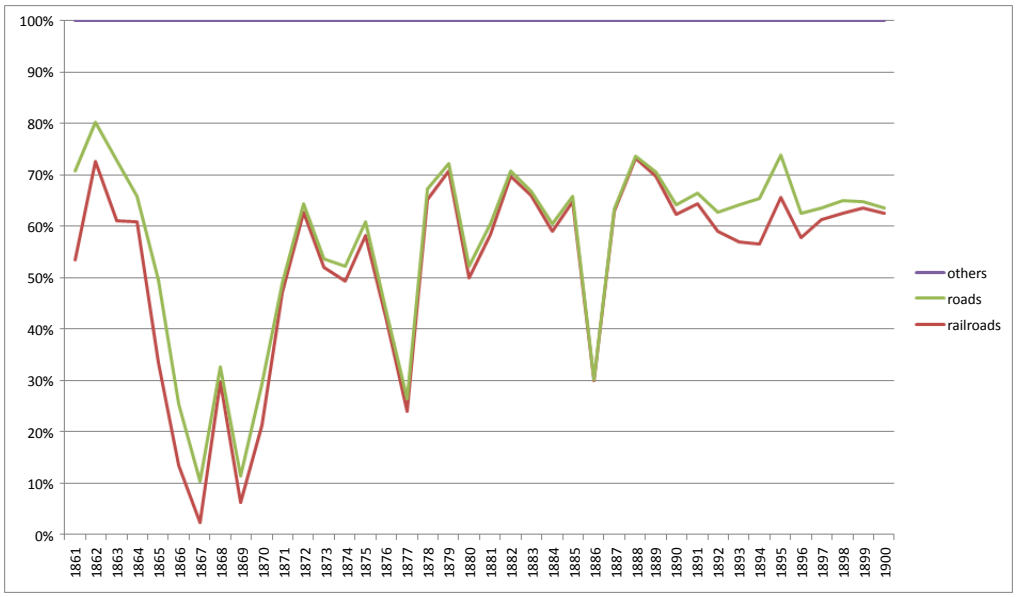

Figure 4: Railroad Expenditures of Vic, 1861-1900.

estimates are presented: NSW only, Vic only, colony dummy variable, and pooled regression Table 4.

Both Patterson and Butlin believed, with some significant justification, that the income motive was more important than trade-related concerns such as prices and competition. The results here are consistent with their hypothesis, as tariff rates do not have much direct effect on manufacturing productivity at all. Parameter values for tariff rates for the first three specifications are close to zero and are not statistically significant. The fourth specification, the pooled regression, displays a large and statistically significant negative value of -1.7161 but this is probably a misspecification because the effect reduces to -0.1063 once a colony dummy variable is added. Historically Vic did have higher tariff rates and lower productivity. However, in order to claim that tariff rates are detrimental to productivity, the same effect must be observed within each colony itself. Neither the parameter values of -0.0342 for NSW and 0.5259 for Vic are statistically significant and both are much smaller than the pooled-regression estimate.

The two variables that do have significant effects are total factory count and the Australian recession of the 1890s. Recessions are global historical events beyond the control of the colonies and are simply external factors to control for. For the number of factories parameter, the Vic-only regression specification obtained an estimate of 0.2038 while the dummy model had a significant value 0.1997. The factory number coefficient for the other two regressions is smaller but is still positive. These results are consistent with the presence of external economies of scale, a benefit that a protective tariff is meant to foster.

Variable	NSW only	Vic only	Colony dummy	Pooled
log(tariff rate)	-0.0342	0.5259	-0.1063	*-1.7161
	(0.1097)	(1.2543)	(0.4161)	(5.6703)
log(public capital)	-0.0803	0.0081	0.0083	-0.0109
	(1.6632)	(0.3706)	(0.6261)	(0.5681)
log(factory)	0.0605	*0.2038	*0.1997	0.0623
	(0.6647)	(2.6785)	(3.8553)	(0.6839)
log(private capital)	0.1346	-0.0418	-0.0303	0.0500
	(1.6478)	(1.6857)	(1.8442)	(1.4860)
Recession dummy	*-0.1340	*-0.1425	*-0.1309	*-0.1269
	(6.3724)	(5.1640)	(7.0812)	(3.9979)
Colony dummy			*-0.1187	
			8.2790	
(Constant)	*4.8321	*4.8052	*4.8462	*5.0953
	(30.1593)	(22.5390)	(42.4383)	(27.1627)
R^2	0.6894	0.7243	0.7886	0.5991
Adj R^2	0.6409	0.6812	0.7702	0.5705
Durbin-Watson	1.2860	2.0701		

Parameter estimates and standard errors of the log-production-function regression estimate, between the total output per work and the explanatory variables as listed here.

The figure on top is the parameter estimate and the value below is the t-value.

For the colony dummy, NSW=0 and Vic=1.

Recession dummy equals 1 for the years 1893-1900 inclusive, 0 otherwise.

*indicates 95\% significance level.

Table 4: Parameter estimates of log-log regressions on output per worker 1863-1900.

The actual effectiveness of protective tariffs in fostering economies of scale will be discussed further shortly.

Another claim propounded by both Vic and NSW is that tariffs were needed for infrastructure development. Specifically, tariffs will raise money for railroads for supporting the manufacturing sector. A preliminary way to test this effect is to construct a hypothetical scenario where tariff income, as computed by tariff rate times manufacturing output. This amount is removed from public capital investment values and the model is estimated again in Table 5.

There is little evidence that public capital, even at the reduced level, promotes manufacturing productivity. Parameter values are not significant for the colony-only specifications and even negative at -0.0314 for the dummy specification. These results do not support the notion that tariff-supported infrastructure development accelerates manufacturing development.

Robustness check 1: correlation between explanatory variables

Co-relationship between explanatory variables is a common concern in time-series regression analysis. Admittedly, with fragmented historical data, the possibilities for measuring and correcting for this problem are limited. Causality may be a close analogue, tested by running a vector-autoregression (VAR) model followed by a Granger causality test. This is done separately for the two colonies: NSW in Table 6 and Vic in Table 7. The pooled version does not seem relevant to most of this study Table 6.

The first significant causal relationship we found is the correlation between the recession dummies and tariff rates specifically for NSW. The significance levels are 1.3% for tariffs to recession and 3.2% for recession to tariffs; the lower the significance level, the stronger the relation. Importantly, a similar causal relationship is not observed in Vic, even though the Vic reaction of raising tariff rates in the face of recession is well documented Table 7.

Variable	NSW only	Vic only	colony dummy	pooled
log(tariff rate)	-0.2416	0.5094	-0.0658	*-1.6221
	(0.1097)	(1.2543)	(0.4161)	(5.6703)
log(public capital)	-0.0099	-0.0007	0.0074	0.0137
	(1.6632)	(0.3706)	(0.6261)	(0.5681)
log(factory)	0.1186	*0.2197	*0.2031	0.0337
	(0.6647)	(2.6785)	(3.8553)	(0.6839)
log(private capital)	0.0369	-0.0427	*-0.0316	0.0415
	(1.6478)	(1.6857)	(1.8442)	(1.4860)
Recession dummy	*-0.1435	*-0.1344	*-0.1321	*-0.1495
	(6.3724)	(5.1640)	(7.0812)	(3.9979)
Colony dummy			*-0.1159	
			(8.2790)	
(Constant)	*4.745	*4.8385	*4.8586	*5.0596
	(30.1593)	(22.5390)	(42.4383)	(27.1627)
R^2	0.6622	0.7230	0.7903	0.6065
Adj R^2	0.6094	0.6797	0.7721	0.5784
Durbin-Watson	1.1314	2.0347		

Parameter estimates and standard errors of the log-production-function regression estimate using hypothetically reduced levels of public capital investments as a result of a reduction in tariff income. See the methods section for computational details.

Table 5: Change in marginal effects after hypothetical reductions in public capital expenditures.

A cursory glance at the results in the tables might suggest that it was in fact NSW that responded to populist sentiments by raising tariffs. It is possible that because Vic already started with higher tariff rates, they may not have had much scope to raise them further. The significance here is that estimated marginal effect of tariff rates reinforces the observation that the colonies in fact had similar ideas about tariff policy.

Robustness check 2: unobserved determinants of number of factories

The parameter estimate for the number of factories, as shown in Table 4, stands out in importance and deserves a second check for correlation with other variables. In particular, the driving force of private capital in increasing the number of factories may be important. According to results in Table 4, this relationship exists for both NSW (1.4%) and Vic (0.9%). On the surface this is unsurprising because more factories obviously require more capital. However, the fact that there is a positive relationship between private capital and factory count then naturally leads to question of why private capital is not dropped altogether as an explanatory variable. An obvious concern is that including two endogenous parameters causes inflated parameter estimates.

A simple way to assess this is to set the number of factories as the dependent variable. The results are listed in Table 8. The most notable finding here is actually the non-result between tariff rates and number of factories. All the parameter values are negative but not significant. In table 4 above it was shown that there are significant positive relationships between total factory count and productivity, supporting the notion that external economies of scale should be fostered. But despite the relationship between factory count and productivity, there is no evidence suggesting that a protective tariff is an effective means to foster external economies of scale: benefits of size that accrue to others. Indeed, the slightly negative parameters suggest that it may even be detrimental Table 8.

Subject Variable	Excluded variable	X^2 statistic	Deg. Freedom	(Prob)
log(output per worker)	log(tariff rate)	0.171	1	0.679
log(output per worker)	log(public capital)	1.980	1	0.159
log(output per worker)	log(factory)	4.861	1	*0.027
log(output per worker)	log(private capital)	0.016	1	0.899
log(output per worker)	Recession dummy	2.390	1	0.122
log(output per worker)	(constant only)	18.642	5	*0.002
log(tariff rate)	log(output per worker)	1.135	1	0.287
log(tariff rate)	log(public capital)	1.558	1	0.212
log(tariff rate)	log(factory)	0.680	1	0.410
log(tariff rate)	log(private capital)	0.004	1	0.953
log(tariff rate)	Recession dummy	6.224	1	*0.013
log(tariff rate)	(constant only)	8.473	5	0.132
log(public capital)	log(output per worker)	2.682	1	0.101
log(public capital)	log(tariff rate)	10.892	1	*0.001
log(public capital)	log(factory)	2.219	1	0.136
log(public capital)	log(private capital)	0.264	1	0.608
log(public capital)	Recession dummy	0.129	1	0.719
log(public capital)	(constant only)	17.722	5	*0.003
log(factory)	log(output per worker)	0.903	1	0.342
log(factory)	log(tariff rate)	0.103	1	0.749
log(factory)	log(public capital)	2.031	1	0.154
log(factory)	log(private capital)	2.428	1	0.119
log(factory)	Recession dummy	0.587	1	0.444
log(factory)	(constant only)	5.218	5	0.390
log(private capital)	log(output per worker)	3.929	1	*0.047
log(private capital)	log(tariff rate)	0.108	1	0.743
log(private capital)	log(public capital)	5.236	1	*0.022
log(private capital)	log(factory)	6.060	1	*0.014
log(private capital)	Recession dummy	4.106	1	*0.043
log(private capital)	(constant only)	11.843	5	*0.037
Recession dummy	log(output per worker)	0.002	1	0.963
Recession dummy	log(tariff rate)	4.624	1	*0.032
Recession dummy	log(public capital)	0.470	1	0.493
Recession dummy	log(factory)	10.674	1	*0.001
Recession dummy	log(private capital)	6.036	1	*0.014
Recession dummy	(constant only)	23.250	5	*0.000

Vector-auto-correlation (VAR) estimate of log-production function with lag of 1, followed by Granger causality test between each variable, for NSW.

Table 6: Robustness: Vector-Autoregression and Granger causality, NSW.

Subject Variable	Excluded variable	X^2 statistic	Deg. Freedom	(Prob)
log(output per worker)	log(tariff rate)	0.954	1	0.329
log(output per worker)	log(public capital)	1.215	1	0.270
log(output per worker)	log(factory)	16.309	1	*0.000
log(output per worker)	log(private capital)	6.178	1	*0.013
log(output per worker)	Recession dummy	23.268	1	*0.000
log(output per worker)	(constant only)	60.333	5	*0.000
log(tariff rate)	log(output per worker)	3.693	1	0.055
log(tariff rate)	log(public capital)	1.601	1	0.206
log(tariff rate)	log(factory)	1.048	1	0.306
log(tariff rate)	log(private capital)	0.330	1	0.566
log(tariff rate)	Recession dummy	2.240	1	0.134
log(tariff rate)	(constant only)	9.620	5	0.087
log(public capital)	log(output per worker)	0.730	1	0.393
log(public capital)	log(tariff rate)	1.658	1	0.198
log(public capital)	log(factory)	7.259	1	*0.007
log(public capital)	log(private capital)	2.744	1	0.098
log(public capital)	Recession dummy	0.501	1	0.479
log(public capital)	(constant only)	29.538	5	*0.000
log(factory)	log(output per worker)	0.073	1	0.786
log(factory)	log(tariff rate)	1.283	1	0.257
log(factory)	log(public capital)	0.259	1	0.611
log(factory)	log(private capital)	2.659	1	0.103
log(factory)	Recession dummy	0.044	1	0.834
log(factory)	(constant only)	3.320	5	0.651
log(private capital)	log(output per worker)	0.003	1	0.954
log(private capital)	log(tariff rate)	5.941	1	*0.015
log(private capital)	log(public capital)	1.334	1	0.248
log(private capital)	log(factory)	6.740	1	*0.009
log(private capital)	Recession dummy	0.053	1	0.819
log(private capital)	(constant only)	18.842	5	*0.002
Recession dummy	log(output per worker)	0.213	1	0.644
Recession dummy	log(tariff rate)	2.954	1	0.086
Recession dummy	log(public capital)	7.069	1	*0.008
Recession dummy	log(factory)	2.201	1	0.138
Recession dummy	log(private capital)	0.514	1	0.474
Recession dummy	(constant only)	11.781	5	*0.038

Vector-auto-correlation (VAR) estimate of log-production function with lag of 1, followed by Granger causality test between each variable, for Vic.

Table 7: Robustness: Vector-Autoregression and Granger causality, Vic.

We include both private capital and number of factories for two reasons. First, there is no obvious sign that the inflation in parameter estimates is serious. The estimate for private capital is not significant anyway. The second reason is that available capital per factory can vary, so the variables are measuring different things. Inflation-adjusted capital per factory increased during this time period, while factories in NSW also had more capital available than the ones in Vic.

Robustness check 3: autocorrelation of dependent variables

The next issue we need to address is autocorrelation. The Durbin-Watson statistics in Tables 4 and 6 do not suggest a strong presence of autocorrelation, but an additional check can be conducted by running the same model using an autoregressive specification of order 1, presented in Table 9.

Parameter estimates for the explanatory variables did decrease in magnitude and are no longer significant, which may seem to suggest that the majority of significant results are actually autocorrelation. However this is not the case because the autocorrelation parameter is not significant for the colonies either. The autocorrelation score is positive but not significant for NSW; it is close to zero for Vic. Hence, there is little evidence of misattribution for previously observed effects in the explanatory variables. A time-series specification does not bring any tangible gains and can be safely ruled out.

Time lags between certain explanatory variables and productivity may also exist. This could be driven by differences in accounting dates between the variables or actual time gaps for changes in explanatory variables to take effect. This can be measured by estimating the model using first differences Table 10.

Overall results for the first-differences model as listed in Table 10 are more difficult to evaluate because the standard errors are much higher, reducing significance levels. The good news is that number of factories consistently remains a statistically significant factor for productivity in both the NSW (1.6957) and Vic (1.3234) data points. On the other hand, the large positive relationship between tariff rates

Variable	NSW only	Vic only	Colony dummy	Pooled
log(output per worker)	0.1399	0.7198	*0.5978	0.1194
	(0.6113)	(1.8379)	(2.8063)	(0.6930)
log(tariff rate)	-0.6229	-1.1697	-1.1382	-0.3571
	(0.7241)	(1.0840)	(1.8444)	(0.6004)
log(public capital)	-0.1465	0.0894	0.0564	0.0865
	(1.9275)	(1.8354)	(1.2405)	(1.7473)
log(private capital)	*0.5788	*0.2882	*0.3154	*0.3102
	(6.1087)	(6.2032)	(6.1687)	(5.6779)
Recession dummy	*-0.1306	-0.0529	-0.0821	*-0.1818
	(2.1267)	(0.6075)	(1.6364)	(5.0591)
Colony dummy			*0.1255	
			(3.3524)	
(Constant)	0.4981	-2.2145	-1.4904	0.9610
	(0.4474)	(1.0426)	(1.3166)	(0.9780)
R^2	0.9593	0.9679	0.9573	0.9482
Adj R^2	0.9529	0.9629	0.9536	0.9445
Durbin-Watson	1.6396	1.4504		

Parameter estimates of the log-production function, with the subject variable switched from output-per-worker to total number of factories.

Table 8: Robustness: Number of factories as the subject variable.

Variable	NSW only	Vic only
log(tariff rate)	0.0111	0.6440
	(0.0101)	(0.5993)
log(public capital)	-0.0449	0.0094
	(0.4840)	(0.2579)
log(factory)	0.0696	0.2081
	(0.3470)	(1.9219)
log(private capital)	0.0818	-0.0448
	(0.7386)	(0.8578)
Recession dummy	*-0.1246	*-0.1465
	(2.0311)	(3.0738)
(Constant)	4.9887	4.7848
	(7.4528)	(15.7768)
AR(1)	0.4285	-0.0645
	(1.5373)	(0.2995)

Parameter estimates of log-production function with autocorrelation model of order 1.

Table 9: Robustness: Estimate using autoregressive specification of order 1.

Variable	NSW only	Vic only
log(tariff rate)	2.5389	1.4621
	(1.5423)	(0.5752)
log(public capital)	0.0308	0.1612
	(0.1993)	(1.8045)
log(factory)	*1.6957	*1.3234
	(5.6772)	(4.6501)
log(private capital)	-0.5110	*-0.4670
	(1.9520)	(3.9400)
Recession dummy	-0.0206	-0.1685
	(0.1961)	(1.2988)

Parameter estimates of log-production function using the first-differences specification.

Table 10: Robustness: Estimate using first-differences specifications.

and productivity in the first differences model is very different than that of Table 4. We recall that the only difference is a slight change of specification using the same set of variables. What this means is that, once again, there may be insufficient evidence to link high tariff rates to any perceived reduction in trade and development.

Robustness check 4: validity of excluding variables

The decision to include a recession-years dummy variable is based on historical knowledge, not any statistical deduction or tests for structural breaks. To justify the validity of doing this, the same model as Table 4 is estimated again by removing this dummy variable. The important results as shown in Table 11 remain the same. Tariff rates still do not have significant effects on productivity, while the number of factories still do, with parameters for the latter ranging from around 0.25 to 0.45 in all four specifications. The new anomaly here is the compounded negative relationship between public capital and productivity. There is no clear reason for why this effect should exist or that it was hidden by including a recession year dummy. The more likely scenarios would be that public capital projects were initiated during the recession years. Hence including the recession dummy variable is the better specification decision Table 11.

The exclusion of a number of available variables from the analysis also demands support. The choice of variables in the main model depended entirely on comparisons using AIC/BIC likelihood statistics. The statistical justification is sufficient, but regression results estimated from including all available variables is included in Table 12 for completeness anyway Table 12.

We preserve the core findings from Tables 4 and 5; namely, the weak results from tariff rates and the stronger result from external economies of scale. The difference here is that the total number of workers and an estimated city density are also included. The significant effects of the number of workers are not surprising as it is very closely related to the number of factories. Accurate estimates of city density are not available, making this a tenuous addition in the first place. More importantly, it is credible to infer that they are very highly correlated with population, workers and number of factories. Adding them all will cause major endogeneity problems.

Discussion and Conclusion

It is often asked why the two colonies of NSW and Vic performed so similarly while practicing such different trade policies between 1860 and 1900. Part of the paradox stems from placing the labels `free trade' and `protectionist' on these two colonies. Both colonies actually had reasonably similar tariff levels; the main difference was that Vic made

Variable	NSW only	Vic only	Colony dummy	Pooled
log(tariff rate)	0.2035	-0.4327	-0.2339	*-1.8112
	(0.3617)	(0.7554)	(0.5677)	(4.6329)
log(public capital)	*-0.1090	*-0.0560	*-0.0397	*-0.0570
	(2.1848)	(2.2687)	(2.9132)	(3.4687)
log(factory)	*0.3118	*0.4202	*0.4191	*0.2775
	(3.0445)	(4.6617)	(6.9758)	(3.5381)
log(private capital)	0.0427	*-0.0834	*-0.0890	-0.0084
	(0.5144)	(2.6813)	(4.2699)	(0.3275)
Colony dummy			*-0.1165	
			(6.3982)	
(Constant)	4.7109	4.8876	4.8097	5.0554
	(23.7915)	(19.161)	(36.4959)	(26.9897)
R^2	0.5275	0.5311	0.6752	0.4925
Adj R^2	0.4702	0.4743	0.6520	0.4639
Durbin-Watson	0.9600	1.0572		

Parameter estimates of log-production function using ordinary least-squares (OLS) estimates, without recession dummy variable.

Table 11: Robustness: Estimates removing recession-years dummy.

Variable	NSW only	Vic only	Colony dummy	Pooled
log(tariff rate)	0.4473	0.1659	-0.1942	*-1.4302
	(1.2487)	(0.3766)	(0.8133)	(5.1668)
log(public capital)	*-0.2601	0.0535	0.0219	*0.0892
	(2.2844)	(0.7995)	(0.8831)	(2.2492)
log(factory)	0.1533	*0.4167	*0.2552	*0.2365
	(1.5738)	(2.5551)	(3.8820)	(2.2720)
log(workers)	*1.1038	*0.8172	*0.9242	*0.7375
	(7.8118)	(7.4357)	(14.5538)	(10.7828)
log(private capital)	0.1468	-0.0417	-0.0240	0.0691
	(1.8202)	(1.6967)	(1.1569)	(1.8052)
log(city density)	*0.4221	-0.0514	0.0303	-0.1081
	(2.1391)	(0.3384)	(0.4015)	(1.0420)
Recession dummy	*-0.1323	*-0.1319	*-0.1333	*-0.1371
	(5.5167)	(3.9149)	(7.4156)	(4.8838)
Colony dummy			*-0.1097	
			(7.3735)	
(Constant)	*5.1280	*4.4299	*4.8429	*4.6716
	(25.3477)	(6.6710)	(32.1512)	(20.3583)
R^2	0.7382	0.7629	0.7940	0.6774
Adj R^2	0.6771	0.7076	0.7694	0.6442
Durbin-Watson	1.7199	2.3654		

Parameter estimates of log-production function using OLS estimates with all variables, including the total number of workers and city density that were excluded previously from the AIC/BIC criteria.

Table 12: Robustness: Regression results including all variables.

demonstrable duty-rate increases on many prominent items to appease protectionist sentiments. While Vic exhibited a large and impressive list of dutiable imported products, covering many pages in the records, collectively they did not generate much additional tariff revenue. The chief imports to Vic remained alcohol, sugar and agricultural products, all of which had strong externality effects on manufacturing. On analysis, the tariff policies for those products were very similar in both colonies.

We have shown that the effect of tariff rates on productivity was statistically insignificant. This finding advances beyond existing economic theory, which is simply silent on this important matter. Of great importance is our proof of the presence of the external economies of scale in the manufacturing sector. In relation to Vic, we have found a proven benefit in fostering larger external economies of scale for the manufacturing sector. However, there is insufficient evidence to conclude that protective tariffs have any significant effect towards development. Proponents of protection in Victoria at the time have clearly, in terms of our findings, exaggerated the pro-productivity and pro-development benefits of Vic's protectionist policies over four decades. Again, NSW's freer-trade proponents cannot in retrospect and on our analysis lay claim to have fostered longer-term development with their more libertarian trade policy. Our central finding is that forces other than international trade policy seem to have been central in the evolution of spectacularly productivity growth and very rapid economic development in the major Australian colonies, especially for the later nineteenth century.

References

1. Kamien M, Schwartz NL (1982) Market Structure and Innovation.
2. Palen MW (2010) Protection, Federation and Union: The Global Impact of the McKinley Tariff upon the British Empire, 1890-94. The Journal of Imperial and Commonwealth History 38:395-418.
3. Greasley D, Madsen JB (2010) Curse and Boon: Natural Resources and Long-Run Growth in Currently Rich Economies. Economic Record 274: 311-328.
4. Williamson JG (2003) Was It Stolper-Samuelson, Infant Industry or Something Else? World Trade Tariffs 1789-1938. NBER Working Papers.
5. Patterson GD (1968) The tariff in the Australian colonies 1856-1900.
6. Sinclair WA (1976) The process of economics development in Australia.
7. Mills S (1925) Taxation in Australia.
8. Powers P, Fred (1888) The Australian Tariff Experiment. The Quarterly Journal of Economics 3:87-98.
9. Sinclair WA (1971) The Tariff and Economic Growth in Pre-Federation Vic. The Economic Record 117:77-92.
10. Butlin NG (1962) Australian Domestic Product, Investment and Foreign Borrowing 1861-1938/39.
11. Butlin NG (1964) Investment in Australian Economic Growth.
12. Pradhan RP, Bagchi TP, Chowdhury K, Norman NR (2012) Growth, Foreign Investment and Trade-Openness Interactions in Ten OECD Countries: A Panel-VAR Approach. *International Journal of Banking, Accounting and Finance* 4:273-293.
13. Irwin DA (2000) Did Late-Nineteenth-Century U.S. Tariffs Promote Infant Industries? Evidence from the Tinplate Industry. Journal of Economic History 60:335-360.
14. Irwin DA (1998) Higher Tariffs, Lower Revenues? Analyzing the Fiscal Aspects of The Great Tariff Debate of 1888. Journal of Economic History 58:59-72.
15. Tena A (2007) Tariff Structure and Institutions in the Late 19th Century. New Perspectives on the Tariff Growth Paradox.
16. Athukorala PC, Chand S (2007) *Tariff-Growth Nexus in the Australian Economy, 1870-2002: Is there a Paradox?*
17. Matthews RCO (1969) Why Growth Rates Differ. Economic Journal 79:261-268.
18. National Office for the Information Economy (2004) Productivity Growth in Australian Manufacturing.
19. Hoover KD (2001) The Methodology of Empirical Macroeconomics.
20. Keltie JS, Martin F (1861-1900) The Statesman's Year-Book 1861-1900.
21. Coghlan TA (1902) A statistical account of the seven colonies of Australasia.
22. McCarty JW, Schedvin CB (1978) Australian Capital Cities: Historical Essays.
23. Spearritt P (1999) Sydney's century: a history. UNSW Press, Sydney.
24. Phillips M (1909) A colonial autocracy: NSW under Governor Macquarie, 1810-1821 (King, London).
25. Eilon S, Gold B, Soesan J (1976) Applied productivity analysis for industry.

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