Trade, the staple theory of growth, and fluctuations in colonial Singapore, 1900–1939

Keen Meng Choy · Ichiro Sugimoto

Abstract Our paper enquires into the nexus between trade, growth, and fluctuations in the British colony of Singapore during the early 20th century. Hitherto, little quantitative economic history has been written on this great entrepôt of Southeast Asia due to a lack of data. We overcome this limitation by utilizing the GDP series recently constructed for the pre-war period by Sugimoto (2009). This comprehensive dataset enables us to explore the relevance and applicability of the staple theory of export-led growth to colonial Singapore through cliometric analyses. The results suggest that foreign trade had acted both as an engine of growth and a source of economic instability.

Keywords Entrepôt trade ∙ Staple theory ∙ Economic fluctuations ∙ Colonial Singapore

JEL Classification N15 ∙ O47 ∙ E32 ∙ C22

1 Introduction
‘The commercial growth of Singapore’, the historian Wong Lin Ken has remarked, ‘is written in its statistics.’ The very absence of reliable statistics for the pre-war era explains why so little economic history has been written for this city-state that was founded as an outpost of the East India Company in 1819 by Sir Stamford Raffles. Wong himself was an eminent scholar of Singapore’s economic past and was responsible for assembling the first coherent set of statistics on its early trade in his classic monograph (Wong, 1960). Subsequently, he extended the data up to the initial decades of the 20th century in two articles that provided panoramic surveys of Singapore’s growth as the commercial hub of Southeast Asia, viewed through the prism of trade (Wong, 1978; 1991). In the first of these, Wong referred to only two studies: Chiang (1978) and a doctoral thesis that was published much later as Huff (1994). The former focused on the rapid expansion of foreign trade in the Straits Settlements, which was dominated by Singapore, during the last quarter of the 19th century and therefore straddled the earlier and later historiography of Wong.

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The latter study continued from where Chiang (1978) had left off and sought to discern the longer-term patterns of economic development in Singapore over the course of the 20th century. Relying primarily on qualitative analysis but supported by statistical evidence, Huff (1994) advanced the argument that Singapore grew as a trading centre during the first half of the century essentially through its role as a staple port-of-call that is intimately dependent on the re-exports of rubber, tin and petroleum produced by its British Malayan and Netherlands Indian hinterlands. This is in contradistinction to its meteoric rise in the 19th century as a regional entrepôt due to free port status and extensive trade with the Malay Archipelago, as Wong (1960) had shown earlier.¹

Given the importance of foreign trade to Singapore’s later development as a staple port, an overriding issue that arises is the relationship between trade performance on the one hand, and economic growth and fluctuations on the other. In Huff (1994), the focus was on long-term growth, wherein it was implicitly assumed that an unambiguous nexus ran from export expansion to growth. However, no attempt was made to establish this relationship statistically due to the absence of hard data on the real output of the colony.

We overcome this limitation in the present paper by utilizing the GDP series recently constructed for the pre-war period by Sugimoto (2009). This comprehensive dataset enables us to explore the relevance and applicability of the staple theory of export-led growth to Singapore during the early part of the 20th century, in the first instance by reviewing the historical growth and fluctuations in national income and its components. From subsequent regression and counterfactual analyses, we find that the spectacular expansion of trade witnessed in that period seems to be well explained by the basic postulates of the staple thesis. In particular, specialization in the re-export of a few key commodities had served as a powerful engine of growth for Singapore.

Although not explicitly articulated in this theory, trade could also be a source of great instability as a heavy dependence on staple items left the economy vulnerable to pulsations in global demand and prices. We therefore go on to investigate whether these forces had indeed contributed to volatility in Singapore’s exports. In stark contrast to the benevolent role of world commercial growth, the results confirm that violent fluctuations in staple prices and revenues, especially in the tin mining industry, were the *primum causum* of the oscillations in the colony’s foreign trade and income. Moreover, these sharp swings were aggravated by the

shocks that buffeted the turbulent international economy in the inter-war period, the most devastating of which was the Great Depression of the 1930s.

Following this introduction, the main aspects of the staple theory and their relevance to colonial Singapore are presented in the next section. After that, we provide a quantitative account of commercial growth and fluctuations from the turn of the century to the eve of the Second World War with the aid of statistical detrending and filtering methods. Trend and cycle components in national income are extracted and used to demonstrate the linkages between trade conditions and domestic economic activity. The penultimate section of the paper examines the role of exports as an engine of growth and a source of instability in the light of the staple theory. Finally, the study’s findings are summed up in the concluding section.

2 The staple theory of growth

As originally propounded by the Canadian economic historians Harold Innis and W. A. Mackintosh, the staple theory of export-led growth postulates that with the discovery of a primary product in which the country has a comparative advantage, previously idle or undiscovered resources are brought into use, thus creating a return to them through the channel of international trade. In Richard Caves’ (1971) later exposition, the staple theory describes ‘a sequence of events whereby the rapid expansion of some commodity, requiring a substantial input of natural resources but relatively little local processing, induces higher rates of growth of aggregate and per capita income through a higher rate of capital formation, inflows of capital and labour to the region.’

By contrast, G. Bertram’s (1963) elaboration of the original staple theory emphasized the progress of the Canadian economy as the successful exploitation of a series of staples—resource-intensive commodities occupying a dominant position in exports—beginning with cod, and moving through fur, timber, wheat, ores, petroleum, and metals. The discovery of new natural resources, availability of immigrant labor, development of new technology, and shifts in world demand are some of the key factors that unleashed new waves of staple growth. With reference to economic development, Bertram wrote that “the growth-inducing income distribution resulting from certain staple industries operated through the consequent increase in consumption and through further effects on investment”.

According to his contemporary M. H. Watkins (1963), the spread effects on consumption and investment can take place through the creation of backward linkages, forward linkages,
and a rise in incomes, referring respectively to input production, staple processing, and induced final demand. When these linkages are important, the domestic sector will expand *pari passu* with the export sector, thereby bringing about broad-based economic growth. Unemployed or underemployed workers will be quickly absorbed into the labour force and once domestic resources are fully utilized, the continuation of growth will depend on the ability to import productive factors. If the supply of foreign factors is elastic, a potential rise in their prices is averted and costs of production will be prevented from being driven up, thus preserving the export boom.

More generally, production costs play a crucial role in the supply-side responses of the economy to a sustained increase in external demand (Altman, 2003). By lowering costs, producers could shift the supply curve of staple products to a more competitive position and increase exports. Even though demand is exogenously determined, staple-based economic development can be driven domestically by favourable shifts in the supply curve, so that a rise in demand is a sufficient but not necessary condition for export-led growth. Indeed, Kravis (1970) maintained that the presence of favourable domestic supply conditions such as an abundance of land, a large population and a conducive system of social and economic organization are more critical to the growth process. As such, he argued that international trade served more nearly as a handmaiden of growth rather than as an autonomous engine of growth.

Although formulated to fit the circumstances of regions of recent settlement such as Canada and Australia, the staple theory of export-led growth bears a structural similarity to Hla Myint’s (1958) ‘vent-for-surplus’ model which attempts to explain the process by which underdeveloped economies were opened up to trade with Europe during the 19th century. In both theories, surplus resources initially exist and are left unexploited. The function of trade is to create new effective demand for the output that could be produced by these resources whilst the contribution of Western enterprise to economic development was mainly improvements in transportation and communications, and discoveries of new products. Supporting this view, prominent writers like Nurkse (1961) and Lewis (1980) have singled out the expansion of world commerce as the propulsive force behind economic growth in primary exporting countries.

Despite the colonial setting, the staple theory seems to describe accurately the historical dynamic of Singapore’s development as a staple port during the early 20th century, which was as much the outcome of growing market integration within the British Empire as well as
Global trade expansion was stimulated by the new transport and communications forms: steamships, railways and telegraphs. By the late 19th century, road and rail links between Singapore and its newly acquired economic hinterland in the Malay Peninsula had already been established for the transportation of tin for processing and export through the port. Capital and entrepreneurship for the tin mines were provided by local Chinese merchants while labour was supplied by coolies imported from China, most of whom transited through Singapore.

Rubber made its appearance as the new staple at the turn of the century with pioneering ventures by Chinese businessmen in Singapore. The initial reluctance of European interests to invest in rubber planting was overcome as prices and dividends rose after 1910, the year marking the beginning of the international rubber boom. An increasing number of agency houses in Singapore began to act on behalf of foreign companies as managers of estate plantations in British Malaya, in addition to their role as importers of machinery and equipment for the tin mining industry, which had taken on a capital-intensive nature with the introduction of the tin dredge in 1912. Starting from just 28,000 acres under cultivation in 1904, the rubber industry was firmly established across the length of the Malayan peninsula by the beginning of the First World War with a total of 1.1 million acres devoted to the *Hevea* crop, the dramatic increase in acreage coming from both large estates and small-holders.

By the time the war ended, Malayan rubber cultivation had reached 1.9 million acres and the contribution of rubber earnings to Singapore’s merchandize exports had risen correspondingly to 36% at the expense of traditional commodities such as gambier, pepper, rattan, sago, tapioca and even tin, the share of which declined to 10% from 23% in 1906. Simultaneously, there was a structural shift of Singapore’s markets from the UK to the USA because the latter’s booming automotive industry was the world’s biggest buyer of natural rubber. In consequence, the colony had to look to the Outer Provinces in Dutch East India for additional supplies of small-holder rubber in the 1920s. In British Malaya itself, the shortage of labour inputs in the rubber industry was relieved by large-scale immigration of estate workers from India. As pointed out by Findlay and Lundahl (1994), these Tamil workers

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2 The account of staple development that follows draws on the works cited in the introduction and footnote 1, supplemented by the *Annual Report of the Straits Settlements* compiled by the colonial government.

3 According to one estimate, Netherlands Indian small-holding rubber acreage increased from 450,000 acres in 1922 to 1.65 million in 1929 (*Rubber Growers’ Association’s Bulletin*, February 1931).
were excellent labourers and the fact that the migration took place between two British colonies greatly facilitated the process.

Singapore’s third and last staple product, petroleum, was acquired in the 1920s by virtue of its geographical advantages. The offshore islands near the western entrance to the harbour afforded an ideal location for the blending of oil imported from Sumatra and Borneo into various petroleum products for distribution to consumers in the Far East, especially Japan and Australia. By the 1930s, petroleum revenues contributed 15% on average to annual export earnings, although this figure is understated because the sale of oil bunkers at the port was not deemed to be exports in the colonial trade statistics. Coming at the end of an era and given the industry’s minimal economic linkages, however, petroleum built on the existing commercial and physical infrastructure but did little to develop it further until the post-World War II period.

Summing up the case for the staple trade as the mainspring of economic growth, L. D. McCann (1978, 1979) has provided an insightful analysis of how the development of Canadian cities in the 19th century, influenced as it was by staple production, can be understood through a heartland-hinterland conceptualization of regions. Singapore’s transformation into a premier staple port during the early decades of the last century can similarly be rationalized within this framework. As the heartland city, it supplied those factors of production—capital, labour, technology and entrepreneurship—that were used to develop the resource base of the surrounding region, functioning effectively as the intermediary between the staple hinterland and world capital markets. Being a port-of-call, Singapore’s economic base was characterized by functions such as trading, transportation, warehousing, and financial and business services.

3 Growth and fluctuations in colonial Singapore

3.1 Data

National income accounting for Singapore can be said to have its beginnings in Benham’s (1959) attempt to estimate the expenditures of the Crown Colony in 1956. He simply added an estimate of net capital formation to the consumption of private households, inclusive of free public services, to obtain a rough figure of 1,723 million Straits Settlements dollars (SS)—the currency in use since the early 20th century—for national income in that year. After the colony became a self-governing state three years later, the official task of collecting economic statistics fell on the Department of Statistics, which subsequently published annual
data starting from 1960 in accordance with the standard conventions of the United Nations’ System of National Accounts.

For the next half century after Benham’s maiden effort, no further attempt has been made to prepare a set of retrospective national accounts for Singapore. Sugimoto (2009) undertook to fill this void via the expenditure approach to the measurement of GDP. By digging deep into the copious economic records kept by the British colonial authorities, ranging from statistical abstracts to the annual reports of government departments, he arrived at detailed tables setting out the quantities and prices associated with nominal GDP and its components from 1900 to 1960, save for the war decade of the forties. Details of the methodologies employed in their reconstruction and reliability of estimates be found in the Appendix.

The periodization chosen for this study is the pre-World War II years of 1900–39, this being partly forced upon us by the nature of the statistical techniques we employ, which cannot accommodate missing data. This epoch is worthy of attention because it was marked by spells of economic progress alternating with bouts of hardship. Apart from overall GDP, we make use of Sugimoto’s (2009) data on private final consumption expenditures, government final consumption expenditures, gross capital formation, exports/imports of goods and services, and the balance between them i.e. net exports. Unless stated otherwise, these aggregates are expressed in millions of real Straits dollars valued at the relatively stable prices prevailing in 1914.

3.2 Statistical methodology

Our narrative of growth and fluctuations below presupposes that the trend and cycle components in GDP and its constituents can be clearly separated, even though some economists believe that they are inextricably intertwined. Insofar as trend extraction is concerned, the older economic history literature has tended to rely on rigid exponential growth trends or the use of moving averages. Rather than follow that tack, the procedure adopted here is based on the Hodrick and Prescott (1997) filter, which is widely employed these days to purge economic time series of rapid fluctuations. This the filter does by trading off goodness-of-fit against curvature to identify the underlying trend of a data series with a smooth but flexible curve that goes through its realizations.\(^4\) Needless to say, there are potential problems with the use of such a filter; in particular, Cogley and Nason (1995) have

\(^4\) The smoothing parameter controlling the trade-off is fixed at the value of 10 following recent research (Mills, 2003).
shown that, when applied to difference-stationary series, the Hodrick-Prescott filter can lead to artificial cycles. However, we use the filter here merely to detrend time series, thus avoiding this pitfall.\(^5\)

For the purpose of isolating cyclical fluctuations, a band-pass filter is used instead. This filter retains medium-term fluctuations in economic series with durations of between 2 and 8 years, corresponding to the life spans of most historical business cycles. We have chosen to apply the frequency domain version proposed by Corbae and Ouliaris (2006) because it has more attractive statistical properties compared to its time domain cousin developed by Baxter and King (1999).\(^6\) As this filtering method is less well known, a brief explanation of it is in order.

Assume \(x_t\) to be an integrated time series of order one with discrete Fourier transform \(w_i(\lambda)\), where \(\lambda = 2\pi s / n\), \(s = 0,1,\ldots,n-1\) are the harmonic frequencies for a sample size of \(n\). Corbae, Ouliaris and Phillips (2002) demonstrated that

\[
w_i(\lambda) = \frac{1}{\sqrt{n}} \sum_{s=0}^{n-1} x_s e^{i\lambda s} = \frac{1}{1-e^{i\lambda}} w_i(\lambda) - \frac{e^{i\lambda}}{1-e^{i\lambda}} \frac{(x_n-x_0)}{\sqrt{n}}
\]

for \(\lambda \neq 0\) in the second line. The first term there represents the stationary component of the series while the second expression can be traced to its stochastic trend. It is the latter, whose presence is due to leakage from the zero frequency, that potentially frustrates our attempt to separate trend and cycle. The fix suggested by Corbae and Ouliaris (2006) is to detrend \(w_i(\lambda)\) by regressing it on \(-e^{i\lambda} / (1-e^{i\lambda})\sqrt{n}\), which supplies an unbiased estimate of \((x_n-x_0)\).

Filtering is then carried out on the regression residuals to annihilate the unwanted frequencies in \(w_i(\lambda) / (1-e^{i\lambda})\), followed by taking its inverse Fourier transform to retrieve the cycles in the time domain.

3.3 Trend growth

Fig. 1 presents the trend estimates of Singapore’s historical GDP and its components \(\text{à la}\) Hodrick and Prescott. By construction, the extracted trends are smooth but they are by no means monotonic in nature. Instead, phases of acceleration, deceleration, and even absolute

\(^5\) Furthermore, a simple 5-year moving average yields very similar, albeit more erratic, trend curves.

\(^6\) The frequency domain filter is a consistent approximation to the ideal band-pass filter for economic variables with stochastic trends. It also does not lead to truncation at the end-points of series.
declines, can be discerned in the plots. These time-varying growth rates are summarized by the yearly averages in Table 1.

In view of Singapore’s status as a staple entrepôt, the export and import curves are virtually indistinguishable in Fig. 1, although import volumes did rise somewhat more rapidly in the early 1910s and late 1920s than export quantities, so that a wavelike movement was produced in the balance of trade in goods and services. Generally speaking, the long-term movements in GDP and private consumption reflect the trends in trade flows, as hypothesized by the staple theory of export-led growth. On the other hand, the trends in government consumption and gross capital formation seem at first sight to chart their own courses. Upon closer examination, however, their undulations were in fact not completely divorced from the trajectories followed by the other national income components.

The 20th century began promisingly enough for the colony with real GDP increasing on average by 3.6% per annum during the first decade due to steady growth in government consumption expenditures and a 13.7% surge in investment spending, a portion of which went into the upgrading of port facilities. By contrast, the entrepôt trade stagnated until just before World War I broke out, when the trend rates of growth of exports and imports jumped to a pace in excess of 5% as world demand for, and the prices of, primary commodities rocketed up. The war itself did not affect Singapore’s trade negatively as the opening of trans-Pacific ocean routes allowed the island to circumvent the shipping restrictions in force. In fact, exports continued to boom until the stock market bust of 1929, punctuated only by a mild inflexion caused by the global recession of 1921, when a general restriction of credit by banks in all parts of the world served to depress the prices of rubber and tin. Nevertheless, the positive multiplier effects of this secular trade boom on national income were not evident until after hostilities ended in 1918, in part because gross capital formation was held in check during the war years. As a result, GDP rose by only 2.3% per annum in the 1910s, the slowest among all the decades, even though private consumption growth improved to 3.1%.

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7 The vexed historical question of the import surplus that has shown up in Singapore’s trade statistics since the 19th century was addressed by Chiang (1978) and Huff (1994).
Without a doubt, the 1920s was the golden decade of the era. The annual rate of increase in real GDP accelerated to 6.2% whilst private consumption rose by 5.3%. The colonial government, buoyed by higher tax revenues from opium sales to the local populace, lifted its general expenditures by 7.7% per annum. Capital accumulation, too, increased by 11.7% annually to keep pace with the great expansion in trade, and as large sums were poured into the construction of new municipal offices and public infrastructure. Fixed investment outlays on machinery and equipment, in particular, saw a seven-fold increase between 1923 and 1929, confirming the presence of the spread effects postulated by the staple thesis.
Table 1 Trend growth rates of national income components (yearly averages in percent).

<table>
<thead>
<tr>
<th>Period</th>
<th>GDP</th>
<th>Private consumption</th>
<th>Government consumption</th>
<th>Gross capital formation</th>
<th>Exports</th>
<th>Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900s</td>
<td>3.6</td>
<td>2.3</td>
<td>3.5</td>
<td>13.7</td>
<td>-0.3</td>
<td>-0.2</td>
</tr>
<tr>
<td>1910s</td>
<td>2.3</td>
<td>3.1</td>
<td>2.8</td>
<td>1.5</td>
<td>5.9</td>
<td>5.9</td>
</tr>
<tr>
<td>1920s</td>
<td>6.2</td>
<td>5.3</td>
<td>7.7</td>
<td>11.7</td>
<td>5.0</td>
<td>5.2</td>
</tr>
<tr>
<td>1930s</td>
<td>5.7</td>
<td>5.1</td>
<td>2.5</td>
<td>4.7</td>
<td>-1.1</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

Source: authors’ calculations based on data in Sugimoto, 2009.

But the unprecedented prosperity was soon followed by impoverishment as the Great Depression in the industrialized countries hit Singapore with a vengeance and the upward trends in most series reversed in the early 1930s. Foreign trade flows suffered the most severe and prolonged declines, investment succumbed to a steep fall, and household and government spending levelled off. By 1933, however, domestic demand had begun to turn around in a remarkable recovery that yielded a GDP trend growth rate of 5.7% for the decade in spite of the depression. Re-exports also rebounded by mid-decade and subsequently benefited from the international effort to stockpile tin and rubber with the advent of the Second World War. For the period 1900–39 as a whole, the long-run average growth rate of the Singapore economy as estimated by the changes in trend output was 4.5% per annum. Even though consumption increased at a similar rate of 4% per year, this did not translate into a big improvement in material living standards as the domestic population grew by about 3% each year during the first two decades and close to 4% in the 1920s (Sugimoto, 2009). It then contracted by 12% between 1929 and 1933 due to the widespread repatriation of unemployed labourers but this was offset by growth of nearly 6% for the remainder of the decade. In per caput terms, therefore, the real national income of the colonial period advanced by only 1.4% per annum on average, with most of the progress occurring in the 1920s and late 1930s. Still, staple-based growth had raised real GDP per capita by nearly two times from S$182 in 1900 to S$321 by 1939.

3.4 Cyclical fluctuations

The charts in Fig. 2 show the output from passing the national income data through the frequency domain filter.\(^8\) The fluctuations manifested by the filtered series may not be cycles in the strict sense of the word, but they seem to capture well the ebb and flow of economic life in colonial Singapore. Looking at the graphs, it is clear that commercial development,

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\(^8\) Cycles derived from the Baxter-King filter are not very different from those presented here.
impressive as it was, did not progress evenly over the four decades covered; quite the opposite, it was constantly disrupted by periodic crises and temporary setbacks.

More so than the other components, private consumption expenditures went through numerous cycles over the forty years covered by the charts. The first two troughs in 1903 and 1913, with an interim peak in 1909, coincided with economic slowdowns in Great Britain and unfavourable trade conditions. Thereafter, consumption seems to have depended less and less on the buoyancy of exports, at least with regard to the timing of expenditures, until the last decade of the period. For example, the sharp curtailment of expenses that took place in 1919–20 was caused by the severe downward pressure exerted on real wages by high worldwide inflation and aggravated by the rice crisis in Southeast Asia.\(^9\) There follows another trough in the mid-twenties before a buying frenzy erupted and abruptly ended as the economy went into recession in 1929. Surprisingly, the cycle estimates indicate that the retrenchment in consumption during the depression was not any worse than in the preceding recessions, a finding subtly confirmed by the smaller decline in imports relative to exports.

An inspection of the cyclical patterns in government consumption, which appear to be more regular than the rest, reveals that the peaks in administrative expenditures were located at 1904, 1914, 1921 and 1931—years when the spending of the private and foreign sectors were bottoming out. Whatever the explanation for this counter-cyclical behaviour of the colonial authorities, it had the salutary effect of partially compensating for otherwise low aggregate demand during the early 1920s and in the 1930s.

On the other hand, the investment cycles that come out from filtering gross capital formation corresponded to the cycles in exports and imports. The fact that these components of GDP rise and fall together is evidence that trade volatility had spilled over to the domestic economy. Their upper turning points differed however: while physical investment scaled the heights of the financial bubble in 1928–29, exports and imports reached their tallest summits earlier in 1919. Furthermore, the amplitude of this trade cycle, as surveyed from peak to trough, exceeded the downswing of the thirties.

From the standpoint of business cycle historicity, the last three graphs in Fig. 2 tell the following story: a mild cycle that ran from 1903 to 1915, measured trough-to-trough, was followed by a vigorous upturn as the US economy prospered even though Europe went to war; the world economic slump of the early 1920s is seen to have affected not just Singapore’s trade but also its business confidence with a slight delay; the next cycle began

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\(^9\) Sugimoto (2009) estimated that consumer prices rose on average by 23% per annum from 1918 to 1920.
with the peaking of rubber prices in 1925, progressed through the investor euphoria of the late twenties, and culminated with the collapse of international trade and commodity prices in 1931–32; finally, we witness the revival in the years leading up to World War II.

As a result of the desynchronized movements of private and public consumption expenditures *vis-à-vis* their sister components, the period up to 1925 was a relatively tranquil time for real GDP. Nonetheless, the business cycles of the first two decades are palpable in the filtered series. The aggregative impact on national income of changes in its constituents really became obvious only from the later 1920s, as the cyclical motions in exports, consumer spending and investment mutually reinforced each other and ushered in the deepest output contraction of the colonial epoch in conjunction with the Great Depression of the century.

For the individual expenditure components, cycles tended to become more accentuated in the period after 1914. Table 2 shows that the standard deviations of the latter day fluctuations doubled in magnitude from pre- to post-1914 in most cases and more than tripled for gross capital formation and GDP. Moreover, standard *F*-tests of equality of variances yielded the conclusion that the increases in the average variability between the two sub-periods were statistically significant. This finding of high macroeconomic volatility in the inter-war period has already been documented for the industrialized countries (see for example Backus and Kehoe, 1992; Bergman, Bordo and Jonung, 1998).

### Table 2  Volatility of cycles in national income components (million S$).

<table>
<thead>
<tr>
<th>Period</th>
<th>GDP</th>
<th>Private consumption</th>
<th>Government consumption</th>
<th>Gross capital formation</th>
<th>Exports</th>
<th>Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1900–39</td>
<td>17.24</td>
<td>4.31</td>
<td>0.72</td>
<td>7.16</td>
<td>39.95</td>
<td>34.46</td>
</tr>
<tr>
<td>1900–14</td>
<td>6.47</td>
<td>2.87</td>
<td>0.40</td>
<td>2.52</td>
<td>21.71</td>
<td>21.61</td>
</tr>
<tr>
<td>1915–39</td>
<td>21.39</td>
<td>5.03</td>
<td>0.87</td>
<td>8.92</td>
<td>48.09</td>
<td>40.69</td>
</tr>
<tr>
<td><em>F</em>-test</td>
<td>10.92*</td>
<td>3.06*</td>
<td>4.66*</td>
<td>12.50*</td>
<td>4.91*</td>
<td>3.55*</td>
</tr>
</tbody>
</table>

Notes: Statistics are the standard deviations of the cyclical components of variables. The *F*-test is a variance ratio test with a critical value of 2.35 at the 5% level. An asterisk denotes a statistically significant outcome.
4 Trade, economic growth and instability

The previous section reviewed the effects of Singapore’s external trade on internal growth and fluctuations. In this section, we first turn our attention to a cliometric examination of the factors underlying the long-run expansion of the colony’s exports over the period 1900–39. Then we investigate the impact of global income and price pulsations on trade cycles. In each case, a regression analysis is performed, followed by counterfactual experiments.

4.1 Staple-led growth

In the light of the staple theory discussed in Section 2, we will attempt to get an idea of the relative importance of demand and supply factors in influencing the growth trends of Singapore’s exports through a linear regression analysis. Due to data inadequacies, we will have to be content with an indirect ‘reduced-form’ approach rather than a complete system of demand and supply equations. The empirical specification used is derived from the cobweb model of agricultural markets in which demand for a staple product is a function of current price and income, but supply depends only on last year’s price:
Solving the two equations jointly results in the following expression for equilibrium quantity:

\[ Q_t = \pi_0 + \pi_1 Y_t + \pi_2 P_{t-1} + \eta_t \]

where the error term is a composite of random demand and supply disturbances, and the unknown parameters are functions of the structural coefficients.

Since the lagged price term is a predetermined variable, this last equation can be estimated using the technique of ordinary least squares without giving rise to simultaneity bias, with the year-to-year percent change in the trend of Singapore’s real exports as the dependent variable. On the right-hand-side of the regression, the corresponding trend growth in world trade volumes is the variable that shifts the demand curve for staple commodities.\(^{10}\) The price variable is represented by the export unit value index.\(^{11}\) In addition, we include a dummy variable to capture the possible effects on export growth of the Straits Homeward Conference, a cartel controlling international shipping charges on maritime routes to Britain and Europe. It has been alleged that the Conference adversely affected the trade and shipping of the colony by diverting cargo to neighbouring ports and hastening the rise in direct shipments in the East-to-West trade—a plausible outcome given our earlier trend analysis which showed exports and imports stagnating up to about 1911.\(^{12}\)

The regression results are presented in column (1) of Table 3. Although the explanatory variables are correctly signed and their coefficients are statistically significant at the 1% level, the low Durbin-Watson statistic indicates that there is first-order residual autocorrelation. As a remedy, we estimated a dynamic specification in which two lags of each of the dependent

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\(^{10}\) World trade volumes was constructed from the dataset used by Glick and Taylor (2010) containing average bilateral trade figures (exports plus imports divided in half) for the period 1870–1997. To cope with the problem of missing observations, country pairs were excluded whenever more than a quarter of the values for 1900–39 are not available. Remaining gaps were then filled in by interpolation using trade growth rates or average market shares. On aggregating the interpolated data, a continuous time series expressed in constant US dollars is obtained that covers trade involving forty nine countries, including the Western industrialized nations as well as large Latin American and Asian economies.

\(^{11}\) The index used is of the chained variety and was compiled by Sugimoto (2009). It enters into the regression specification in levels instead of growth rates since it’s time series is not characterized by a strong upward trend of the sort seen in exports and world trade. In technical jargon, it is a stationary variable whereas the other two are integrated and needed to be transformed.

\(^{12}\) The Conference came into force in 1897 by means of a secret rebate made by shipowners to an influential group of agency houses in Singapore to garner their custom and loyalty. Ocean freight rates rose by 35% after the formation of the Conference (Huff, 1994; 2000), but Chiang (1978) claimed that they did very little damage to the colony’s trade. The Conference was effectively terminated in 1911 after a public outcry.
and independent variables were included in the regression. For comparability with the static specification, the implied long-run coefficients from this equation are reported in column (2). The elasticity of world trade volumes is estimated to be much smaller in the dynamic specification, suggesting that Singapore’s exports grew at one-third the rate of world trade, ceteris paribus. The positive price semi-elasticity is about the same in both cases, with a one point rise in the index of export prices inducing a 0.13% increase in the quantity of staples shipped from Singapore. Interestingly, the coefficient on the Conference dummy is both statistically and economically significant—contrary to Chiang’s (1978) view, the shipping cartel was likely to have reduced export growth by more than three percentage points every year during the period of its operation.

Table 3  Regression results for Singapore’s exports, 1900–39.

<table>
<thead>
<tr>
<th></th>
<th>Export trend growth</th>
<th>Export cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Constant</td>
<td>–11.45</td>
<td>–9.544</td>
</tr>
<tr>
<td></td>
<td>(–7.14)</td>
<td>(–9.33)</td>
</tr>
<tr>
<td>World trade</td>
<td>0.599</td>
<td>0.327</td>
</tr>
<tr>
<td></td>
<td>(6.53)</td>
<td>(3.24)</td>
</tr>
<tr>
<td>Lagged export prices</td>
<td>0.146</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td>(9.79)</td>
<td>(13.21)</td>
</tr>
<tr>
<td>Conference dummy</td>
<td>–4.66</td>
<td>–3.32</td>
</tr>
<tr>
<td></td>
<td>(–5.42)</td>
<td>(–4.96)</td>
</tr>
<tr>
<td>Rubber price</td>
<td>0.655</td>
<td>0.712</td>
</tr>
<tr>
<td>Tin price</td>
<td>2.28</td>
<td>2.78</td>
</tr>
<tr>
<td>Petroleum price</td>
<td>0.943</td>
<td>0.970</td>
</tr>
<tr>
<td>War dummy</td>
<td>–191</td>
<td>–222</td>
</tr>
</tbody>
</table>

|  \( \bar{R}^2 \) | 0.78 | 0.99 | 0.78 | 0.77 | 0.78 |
| S.E.E.          | 1.95 | 0.34 | 44.9 | 47.4 | 46.3 |
| DW              | 0.30 | 2.41 | 1.83 | – | – |

Notes: t-statistics in parentheses. There are 39 observations for the first two regressions and 40 for the rest.

As the dynamic specification results in an improved Durbin-Watson statistic and the regression produces an \( \bar{R}^2 \) value of close to one, we will use it next in a counterfactual analysis aimed at quantifying the differential contributions of international demand and staple prices to export performance. In this regard, a quick review of the trends in world trading activity over our sample period shows intermittent periods of boom from 1900–13, 1923–27

\[ 13 \] Standard errors for the long-run coefficients were calculated from the delta method.
and 1934–39. These are the times when the growth in global trade volumes was positive and it should have boosted the demand for Singapore’s re-exports.

The first counterfactual history we contemplate is therefore one in which world trade had not increased during these periods. Given our estimated reduced form equation, we can compute the implied counterfactual path for the dependent variable by setting the growth rate of world trade to zero over the years concerned and leaving export prices at their historical values. What would have happened to Singapore’s exports under such a scenario? The answer is that the average trend increase in exports would have been only 1% instead of the actual rate of 2.4%. In other words, the expansion of external demand made a significant contribution to domestic export growth and in particular, it mitigated the negative effects of the Straits Homeward Conference during the early years of the 20th century.14

But important as demand forces were in staple-led development, they did not operate independently of supply conditions. As shown by the regression coefficients in Table 3, the output of staple commodities and tropical produce in Singapore’s hinterlands was further stimulated by the high prices they fetched from about 1908 to 1929.15 Let’s suppose then that export prices had stagnated at their 1908 levels instead of rising. We can expect exports to be slashed, assuming nothing happened to the global demand for staples. The anticipation is correct: the growth rate of exports would have decelerated to a mere 1.2% per annum over this period, a far cry from the actual 4.9%. Beginning from 1930, however, if commodity prices had not collapsed, exports would have expanded by 1.6% per annum rather than contracted by 1.1%. Taken cum grano salis, these counterfactual results provide estimates of the asymmetric supply responses to changes in the world demand for primary products in the long run.

4.2 Export instability
Staple theory, though quite capable as we have just seen of explaining the trend increase in Singapore’s commerce, has paid scarce attention to the cyclical instability that attends to the growth process. As exports constituted the biggest and most volatile component of colonial national income (Table 2), the Singapore economy was highly vulnerable to recurrent gyrations in staple prices and proceeds, especially with its concentration in the three key

14 The counterfactual exercise showed that without the rise in demand that took place when the cartel was in effect, exports would have fallen by 1.3% per annum.
15 It can easily be shown that the coefficient of the lagged price term in the reduced form equation for exports is equal to its parameter in the supply equation.
products of rubber, tin and petroleum. Moreover, efforts made during the inter-war years to stabilize primary commodity markets through international output agreements among producers met with only limited success (Lim, 1967).

Development economists who recently investigated the effects of terms of trade movements on economic growth have found that price volatility lowers the long-term growth prospects of nations depending heavily on primary exports (see for example Mendoza, 1997 and Blattman, Hwang and Williamson, 2007). Yet our interest lies not in the consequences of volatility for growth but rather its ramifications for business cycles. Our central concern is whether wide swings in world staple prices had been transferred to exports and if so, with what force. Certainly, visual examination suggests a strong correspondence between the cycles in the prices of the major commodities and Singapore’s nominal exports. By dint of this observation, focusing on the overall export price index will defeat our purpose since its aggregate behaviour has been swamped by the heterogeneous price movements of lesser items.

Commodity prices aside, changes in the economic conditions of the industrial centre could be another important source of instability affecting the cyclical demands for raw materials produced by the periphery countries of the world economy. After a lag, the pulsations were likely to have induced parallel changes in the demand for food and manufactured goods in Singapore’s hinterlands, which were supplied by the city in exchange for primary and tropical products. To account for these fluctuating demands from the port’s principal markets in both East and West, we regressed the band-pass filtered cycles in Singapore’s nominal exports against the analogous cycles in two composite GDP indexes constructed for the Western and regional countries respectively. The regression specification also includes cyclical price indices for rubber, tin and petroleum, as well as a dichotomous variable to control for the effect of the United States’ imposition of quotas on rubber imports in 1918 as a result of the country’s entry into the First World War, which restricted Singapore’s rubber re-exports for half of the year to 50,000 tons.

Column (3) of Table 3 shows the results. As expected, the estimated income coefficients are positive, thus confirming our conjecture that business cycle fluctuations in the outside

\[16\] Angus Maddison’s estimates of real GDP for individual countries in international Geary-Khamis dollars are the source of the income data. The countries selected for inclusion in the Western index are the USA, UK, France, Germany, Italy, the Netherlands, Belgium, Austria, Switzerland, Denmark, Sweden, Norway, Finland, Australia and Japan, while the regional index is made up of Malaya and Netherlands India. As the observations for Malaya are incomplete, we use Maddison’s figure for our base year of 1914 to obtain a levels series by applying the GDP growth rates provided by Nazrin (2002). The rubber and tin indices are based on London pound sterling prices while the petroleum index is derived from statistical estimates in Huff (1994).
world tended to raise export volatility in Singapore. However, the geographical sub-division into Western and regional markets seems to have created multicollinearity between the two income variables as both their $t$-statistics turned out to be insignificant. Furthermore, one could argue that a problem of endogeneity bias arises with the least squares estimates because an output increase by Singapore’s large hinterland suppliers of rubber and tin to the world market has the effect of depressing prices. Hence, there is reverse causality from exports to the price variables in the regression. In column (4), the outcomes of an instrumental variable estimation are reported as an alternative.\(^{17}\) Despite accounting for endogeneity bias, the coefficients on the income variables remain insignificant, supporting Huff’s (1994) assertion that commodity exports to the West were the main cause of Singapore’s trade cycles and goods re-exported to the region merely fluctuated in tandem. Consequently, we consolidated the incomes of Singapore’s main trade partners into an aggregate foreign GDP index and used it in the last regression shown in column (5) in place of the region-specific indexes.

This last regression, again using instrumental variables, performed much better: it manages to replicate nearly four-fifths of the cyclical variation in export revenues—no mean feat considering their volatility—and all the explanatory variables possess the right signs. Except for the rubber price, paradoxically, the regressors are also significant at conventional levels, including the dummy variable for American import controls which accounted for an improvement in the equation’s fit of 10%. The Durbin-Watson statistic is invalid in the presence of reverse causation from exports to prices and so it was not computed, although a graphic inspection indicates that the residuals are well-behaved. Finally, the chi-squared statistic for the Sargan test of overidentification, with a value of 8.21 and associated marginal significance level of 0.145, does not give us strong reason to doubt the validity of the instruments employed.

Going by this last set of regression results, it would appear that the proximate causes of Singapore’s export cycles were shifts in overseas incomes working hand in hand with fluctuations in commodity prices.\(^{18}\) We now perform a series of counterfactual exercises to sort out which amongst them are predominant. The experimental design is as follows: the cycles in variables are eliminated, one at a time and then together as a group, and the result

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\(^{17}\) Two lagged values of commodity prices and foreign GDP were employed as instruments.

\(^{18}\) In spite of an apparent tendency for foreign income and commodity prices to move in unison, multicollinearity is not a potential problem in the instrumental variables regression. The historical correlation between GDP and the rubber price is only 0.31, that for GDP and the tin price is 0.35, while the correlation between the two prices is 0.34. Correlations between the petroleum price and the other variables are even smaller.
on export volatility is enumerated by the standard deviation. We concentrate on the hypothetical outcomes for the tumultuous inter-war years and divide them into the two sub-periods of 1915–29 and 1930–39. Our findings are laid out in Table 4 where, for ease of interpretation, the counterfactual standard deviations are presented as ratios to the actual statistics.

Despite having the largest estimated coefficient of them all, foreign GDP disturbances actually made the smallest difference to export instability for the full period under review. Business cycles in the industrial core were a weak contributory factor to volatility during the pre-1929 years but a much stronger one in the 1930s, no thanks to the Great Depression in the US. Had the global slump not ensued and the derived demand for Southeast Asia’s primary products not being depressed by it, Singapore’s export proceeds would have been 40% less variable. Large as this number is, it is still surpassed by the dramatic 62% reduction in volatility that could be achieved if all commodity prices had been completely stabilized (see the last column in Table 4). Better yet, the improvement would be spread uniformly throughout the period.

**Table 4** Counterfactual volatilities of nominal exports.

<table>
<thead>
<tr>
<th>Period</th>
<th>Actual (S$ million)</th>
<th>Zero fluctuations in:</th>
<th>Foreign income</th>
<th>Rubber price</th>
<th>Tin price</th>
<th>Petroleum price</th>
<th>All prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1915–39</td>
<td>119.37</td>
<td>86%</td>
<td>83%</td>
<td>54%</td>
<td>77%</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>1915–29</td>
<td>140.16</td>
<td>92%</td>
<td>86%</td>
<td>55%</td>
<td>72%</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>1930–39</td>
<td>83.08</td>
<td>60%</td>
<td>76%</td>
<td>47%</td>
<td>95%</td>
<td>36%</td>
<td></td>
</tr>
</tbody>
</table>

Note: Percentages are ratios of counterfactual to actual standard deviations, shown in the second column.

The biggest surprise to come out of the counterfactual experiments, however, is the finding of the tin price as the main source of trade instability. Tin price movements were
consistently responsible for about one-half of realized volatility; in contrast, rubber fluctuations accounted for a quarter of export cycle variance during the 1930s and less before that. Even the pronounced swings in the international petroleum price in the 1920s, at a time when the local oil industry came into prominence, had a more powerful effect. So what explains the unimportance of rubber prices when rubber products constituted the bulk of Singapore’s re-exports in value terms from 1915 onwards?

The puzzle is resolved if one looks at Figure 3, which juxtaposes time series plots of the three key staple prices. After peaking in 1910, the cycles in rubber prices were comparatively muted in the subsequent decades because of increases in production capacity, aided by the Stevenson Scheme in the twenties and the International Rubber Regulation Scheme in the thirties. A similar international agreement for tin had to wait until 1934, and there was none at all for petroleum, with the consequence that the prices of these two commodities underwent greater fluctuations that eventually showed up in the colony’s nominal exports.

5 Conclusions
We commenced our writing of new economic history for colonial Singapore with a quantitative account of commercial development and business cycles from 1900 to 1939, underpinned by statistical decompositions of the major expenditure components in real GDP into trend and cyclical movements. This historical review substantiated the received consensus that the years between the First World War and the Great Depression were a very prosperous period for Singapore, but one that was also characterized by high economic volatility resulting from both recessionary and inflationary episodes. More generally, the survey demonstrated that the basis of the growth and fluctuations of the re-export economy lies in entrepôt trade.

Our next task is therefore to explain why exports expanded and fluctuated as they did, in the process casting new light on the close dependence of the primary exporting peripheral countries in the world economy on the industrial core. With regard to the first issue, counterfactual findings based on a regression analysis suggest that supply expansion in Singapore’s hinterlands made a more important contribution to her growth as a staple port than the increase in international demand for staples, even as the latter spurred the former greatly by raising global commodity prices and stimulating further investment in agricultural production. Our estimates suggest that the primary boom during the 1910s and 1920s could have boosted export growth by four percentage points annually through the impetus imparted,
in particular, to rubber output from the Malayan plantation and Netherlands Indian small-holder sectors. Staple induced growth was clearly at work.

The flip side of the growth purchased by staple exports was the macroeconomic instability which was transmitted from the trade sector to domestic spending. On this second issue, we mustered cliometric evidence to show that export volatility was attributable in part to the exogenous economic shocks associated with crises and worldwide depressions. However, the fluctuations in aggregate export proceeds seem to more directly reflect cycles in individual commodity prices—by our reckoning, volatility would have been more than halved in the absence of price fluctuations in the handful of commodities re-exported by Singapore. Being much more volatile than their rubber counterparts, tin prices would have accounted for most of the improved stability.

From the vantage point of the staple theory of export-led growth, colonial Singapore appeared to have acted as the vent for the surplus resources of its economic hinterlands in British Malaya and Dutch East India. In doing so, the port city benefitted from the spread effects of staple development through strong growth in its consumption, investment and GDP. By spawning numerous service industries catering to the growing local population, the export sector augmented national income and led to a further diversification of the economic base. The ready availability of raw materials encouraged the setting up of forward processing industries such as tin smelting, rubber milling, pineapple canning and sawmilling on the island, although the impact on industrialization was insignificant. Equally if not more important, British political control facilitated easy access to additional factors of production and created a virtuous circle whereby the government’s income from taxes financed the additional investments in public utilities, transport, health and education so essential for sustained economic expansion.\footnote{A. O. Hirschman (1977) referred to such spending as ‘fiscal’ linkages.}

To conclude then, the rising world demand for primary commodities during the great era of globalization in the early 20th century had been a prime mover of Singapore’s economic development during colonial times. But the city’s provision of critical services to its hinterlands surely facilitated and made possible the dynamic supply responses to high commodity prices. Blattman, Hwang and Williamson’s (2007) metaphor is apposite here: Singapore flourished by picking a few winners in the commodity lottery as engines of growth, although the price paid by the colony’s residents for those tickets was instability in their incomes and earnings.
Appendix A. Methodologies and Sources for the Construction of Historical GDP

Compared with contemporary estimates of GDP, the construction of historical GDP faces more serious constraints in that every step in the estimation procedure depends critically on the availability of statistical information. The gathering and preparation of statistical material into a time series database represents the first step in the process. Ideally, estimates using the three different approaches, namely production, income and expenditure approaches, would be most desirable since the reasonableness of the results can then be evaluated by comparing them with one another. However, this is again constrained by the availability of the relevant data. Based on what is available for the period under study, it was decided to apply the expenditure approach rather than the production or income approaches. Several novel methodologies were applied but always consciously conforming, as closely as possible, to the definitions as outlined in “The System of National Accounts 1968” (SNA68). The following sub-sections briefly describe the estimating procedures for each component of GDP, namely private final consumption expenditures by resident households (PFCE), government final consumption expenditures (GFCE), gross capital formation (GCF) and net exports of goods and services.

Private Final Consumption Expenditures

Presently, household budget surveys and commodity flow tables are widely utilized for the computation of PFCE. However, these modern approaches could not be employed due to the dearth of such data for the early period. Consequently, alternative techniques had to be devised to arrive at these estimates. As presented in Figure 1, two distinctive approaches were employed viz., the direct and indirect approaches. In the direct approach, data on consumption expenditures pertaining to opium, education, medical fees and utilities (gas, water supply and electricity) was gathered independently from various official sources. The indirect approach involved the estimation of PFCE on food, beverages and tobacco, clothing, rent, domestic servants and transport. Summing up the expenditures derived from these two approaches provides us with the PFCE in current and constant prices.

The indirect approach involved a number of steps. Firstly, six consumption standards were recognized based on significant differences in consumption levels and expenditure patterns amongst the ethnic groups in Singapore. Subsequently, the current per capita consumption expenditure of each major object of consumption was identified for each standard. These figures were then deflated by the consumer price index for each major object of
consumption to obtain expenditures in constant prices. Real per capita consumption expenditures of each major object of consumption for each standard was then derived based on the changes in real income over time, taking into account the income elasticities of demand for each major object of consumption. For example, annual figures on PFCE of food for the European standard in both constant and current prices were computed as follows: If in the base year \( t \), the real per capita expenditure on food for the European standard is \( RPCF_t \) and if the real wage index increases from 1 in year \( t \) to 1.2 in year \( t+1 \), real per capita expenditure on food in year \( t+1 \) (\( RPCF_{t+1} \)) was calculated as:

\[
RPCF_{t+1} = RPCF_t + ((RPCF_t (1.2-1.0)/1.0) * 0.7)
\]

Real per capita expenditures of the European standard on food was then multiplied by the population of each year of the European Standard to obtain the real European PFCE on food for each reference year. The derived figures were then inflated by the food price indices to arrive at PFCE in current prices. Similar procedures were applied for each major object of consumption for the six consumption standards. PFCE in the domestic market was then derived by aggregating the figures of the direct and indirect components. In order to obtain PFCE by resident households, non-resident consumption was deducted.

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20 The Consumer price index (CPI) forms a basis for measuring the rate of inflation and a useful tool for deflating PFCE, wage rates, etc. It provides a measure of the average rate of change in prices of a fixed basket of consumer goods and services which represents the household expenditure pattern. For this purpose, CPI by major object of consumption was required to obtain the respective real per capita consumption expenditures. Additionally, the overall CPI was utilized to compute real wage indices. The following actions were taken to compute the CPI. Firstly, estimate the private final consumption expenditure of each major object of consumption for each consumption standard for the base year (1914 = 100). Secondly, compute the base weights of private final consumption using the total private final consumption expenditures of each major object of consumption by each consumption standard. The weights of private final consumption of each consumption standard within a particular major object of consumption should add up to unity. Subsequently, multiply the base weights of private final consumption of each consumption standard within a particular major object of consumption by the relevant price indices of each year. Based on the above procedures, derive the overall price index of each major object of consumption by adding up the weighted index of each standard. This would give the overall price index for each major object of consumption for each year.

21 Data on household income was not available. The movements of the nominal weighted wage indices of the agricultural and non-agricultural sectors were then used as surrogates for household income changes.

22 The assumed income elasticities of demand are 0.7 for food, 0.8 for rent and 1 for beverages, tobacco, clothing, domestic servants, and transport (other than railway).

23 Ideally a real wage index should be constructed using the weighted average of wages in all sectors of the economy. Unfortunately, no such detailed time series data was available. As an alternative approach, the wage index was constructed based on the daily wage rates of carpenters, joiners, blacksmiths and bricklayers and the Indian factory workers in Singapore to capture wage movements in the non-agricultural sectors, while rubber estate tappers’ wage rate was used to reflect movements in the agricultural sector. A weighted wage index was constructed based on the employment shares of the two sectors according to the 1921 Census of Population. The real earnings index was then derived by deflating the nominal earnings index with the overall CPI.
Appendix Fig. 1: Steps in Estimating Private Final Consumption Expenditures

**Government Final Consumption Expenditures**

The GFCE component was derived by deducting from government output of goods and services the sales of producers of government services. The output of producers of government services was computed by summing up the compensation of employees (personal emoluments), the intermediate consumption of goods and services and the depreciation allowances of all producers of government services. These estimates include the expenditures incurred by the Colony of Singapore, the Municipality/City Council of Singapore and the Rural Board. Military expenditures on capital formation items have been treated as intermediate consumption of goods and services and form part and parcel of output.

To meet the definitions of SNA68, the following steps were taken to identify government spending. In general, the government accounts presented expenditures incurred by each department. Within the department, two major classifications were made viz., personal emoluments (compensation of employees) and other charges (annual recurrent and special

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24 Military expenditures on capital formation items have been treated as intermediate consumption of goods and services and form part and parcel of output.
expenditures). Under this broad classification, details were supplied. Unfortunately, no systematic presentation of the expenditures incurred was available. In view of this, it was necessary to set up a coding system that would identify for our purpose, compensation of employees, intermediate consumption, capital formation, transfers and others. This procedure, moreover, was not fully applicable to all government accounts due to data deficiencies. Therefore, the following approach was adopted instead.

Firstly, information on revenue received by class of account was utilized to identify the sales of other goods and services by producers of government services. For the compilation of GFCE, the expenditures incurred by the following departments were excluded: (i) Drainage and Irrigation Department; (ii) Electric Supply Department; (iii) Gas Supply Department; (iv) Government Monopolies Department; (v) Post and Telegraph Department; (vi) Printing Department; (vii) Public Works Department; (viii) Railway Department; and (ix) Water Supply Department. Secondly, independent transfer items from the producers of government services such as pensions, purchase of land, and payment of loans are also excluded. Having done these deductions, the output of producers of government services which constitute compensation of employees and intermediate consumption expenditure was obtained. Consumption of fixed capital, however, is very difficult to trace due to the dearth of data. Therefore, based on information from the post-independence period, it was assumed that 1% of the gross output of producers of government services would be classified as a depreciation allowance. Thirdly, government revenues from sales of other goods and services (school fees, hospital fees, etc) were deducted from the gross output to arrive at nominal GFCE. Real GFCE is then obtained by deflating this with the consumer price index, in the absence of an index for the price of government output.

**Gross Capital Formation**

The estimates of Gross Capital Formation (GCF) include investments made on construction, machinery and equipment, and cultivated assets. Inventories include stocks of goods held by producers to meet temporary or unexpected fluctuations in production or sales, and work in progress other than construction.

In the case of construction output capitalized, total construction output was first derived by using input-output coefficients of cement with respect to total construction output based on the first construction survey in 1972. Total construction expenditure that went into fixed capital formation was then derived by deducting from total output of construction, the expenditures incurred on repairs and maintenance.
In the case of investment on machinery and equipment (M&E), it was assumed that the M&E produced locally was negligible for the period under study. This means that total net imports valued at market prices was equivalent to total investments in M&E. Net imports of M&E at c.i.f. values were obtained from official trade statistics. No commodity taxes were levied against M&E, which meant that the c.i.f. (basic) and producers’ values were identical. Trade and transport margins were added to producers’ value to arrive at market prices. The final step was to determine what proportion of net imports was to be capitalized. Some of these imports would have been used as inputs into construction activity and some as part of private final consumption expenditures.

In preparing the estimates for investment in cultivated assets, only rubber and coconut were selected since other perennial crops were found to be negligible. All expenses sunk into perennial crops prior to their reaching the bearing age were treated as part and parcel of capital expenditures. Three types of information were utilized for the above computation, namely, newly planted acreage for each year, the number of years it takes for the crop to reach bearing age and annual cost per acre of bringing the crop into production. The yearly estimates of expenditures on cultivated assets at different years of maturity were derived by multiplying the total immature acreage with the corresponding base year estimates of cost of investment per acre at different stages of maturity. These yearly estimates were then aggregated to arrive at the yearly estimates of real capital expenditures. Total real investment in cultivated assets was then inflated by the nominal rubber tappers’ earnings index (See Figure 2). For both rubber and coconut, a distinction was made between smallholding and estate cultivation.

Inventory as defined in SNA 68 consists largely of raw materials, finished or partly finished products awaiting sale, and unpaid work in progress on assets which take a long time to produce. The colonial government records, however, did not provide sufficient information to construct reliable estimates. Under these circumstances, official figures available after 1960 were used as a guide. Since it was observed that there was a positive correlation between GDP growth and the value of changes in stock, the percentage contribution of inventories to GDP changes were assigned values based on the calculated GDP growth rate (excluding stock changes).
<table>
<thead>
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<th>Year</th>
<th>1910</th>
<th>1911</th>
<th>1912</th>
<th>1913</th>
<th>1914</th>
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<td>10</td>
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<tr>
<td>Cost per acre</td>
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<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
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<tr>
<td>Value</td>
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<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
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<td>Newly planted acreage</td>
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<td>30</td>
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<tr>
<td>Cost per acre</td>
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<td>20</td>
<td>20</td>
<td>20</td>
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<td>Value</td>
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<td>600</td>
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<tr>
<td>Investment (1914 prices)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>600</td>
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<tr>
<td>Rubber tappers index</td>
<td>60</td>
<td>70</td>
<td>80</td>
<td>90</td>
<td>100</td>
<td>110</td>
<td>120</td>
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<tr>
<td>Investment (current prices)</td>
<td>300</td>
<td>1190</td>
<td>640</td>
<td>720</td>
<td>800</td>
<td>880</td>
<td>720</td>
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</table>

Appendix Fig. 2: Format for Calculating Investment on Coconut Planting at Current Prices

Exports and Imports of Goods and Services

Export and import statistics cover transactions of goods and services between the residents of one country and non-residents of another. Foreign trade data on merchandise imports and exports of Singapore were available for the period 1900–27. For the period 1928–39, Huff’s (1994) estimates were used. Estimates of exports and imports of services were obtained from port and other related statistics.

Deflators

Real GDP figures were arrived at by deflating each component of aggregate demand in current prices by various deflators to convert them into constant 1914 prices. Figure 3 summarises the various deflators used in the process. For example, the CPI and Import and Export Unit Value Indices were computed using the Laspeyres formula.

Unit values of commodities were derived from the quotients of values and quantities. As it was not feasible to derive a continuous series due to the changing composition of exports, the sample period was broken down into several overlapping intervals with different base years. The criteria for the selection of intervals and their base years include the stability of the shares of commodities and their relative tranquility. In this exercise, the base year of each interval is identified based on the proximity of the price of the commodity that commands the largest weight to its average price level during the corresponding interval. This method preserves the same growth rates of the estimates associated with 1914 prices.
### GDP Components

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<tr>
<th>GDP Components</th>
<th>Method Applied/Deflator</th>
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<tr>
<td>Private Final Consumption Expenditure</td>
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<td>Indirect Approach</td>
<td>Consumer Price Indices for each major object of consumption</td>
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<td>Direct Approach</td>
<td>Consumer Price Indices</td>
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<td>Machinery and Equipment</td>
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<td>Merchandise</td>
<td>Export Unit Value Indices</td>
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<tr>
<td>Port (goods and services)</td>
<td>UK Weighted Indices for Fuel and Light, Transport, Communication and Other Services</td>
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<td>Non-resident consumption in domestic market</td>
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**Appendix Fig. 3:** Deflators Employed for GDP Components

### Appendix B. Reliability of GDP Estimates

Each component of GDP was constructed by employing various estimating techniques based on the availability of historical statistical information to meet the modern definition as outlined in “A System of National Accounts (SNA) 1968”. By summing up each component, historical GDP estimates of Singapore were then constructed. This estimated GDP series, however, requires to be checked from various aspects to assess the reliability or validity of the estimate.

In the field of historical GDP estimates, there are broadly three ways in which the reliability of the main aggregates can be assessed: (1) by comparison with other estimates, (2) by comparison from two or more different approaches (eg. production and income approach in the case of GDP) and (3) by reference to the subjective evaluations of statistical personnel responsible for the compilation of the each component (Feinstein, 1972:10). In the case of GDP estimates of Singapore, however, there are constraints in conducting these reliability checks. To begin with there were no previous exercises attempted in the construction of historical GDP estimates for Singapore. For second method, up till today, no attempt has been made in constructing GDP estimates from the income and production approach. The third method involves assessing the reliability of the GDP series, undertaken by the investigator responsible for the estimates and expressed in terms of reliability grades.
However, this assessment would be arbitrary because it is rare that we can set a correct margin of error.

In view of these constraints, this study conducts unit root tests for checking the consistency of time-series data on GDP and its components. The presence or absence of unit roots, to put it simply, helps to identify some features of the underlying the data-generating process of a series. If a series has no unit roots, it is characterized as stationary, and therefore exhibits mean reversion in that it fluctuates around a constant long run mean. Also the absence of unit roots implies that the series has a finite variance which does not depend on time and that the effects of shocks dissolve over time. Alternatively, if the series feature a unit root they are better characterized as non-stationary processes that have no tendency to return to a long-run deterministic path.

The study by Nelson and Plosser (1982) conclude that the evidence presented supports of non-stationary in economic time series. In other words, their study found that many fluctuations in GDP and its components are permanent, in the sense that there is no tendency for GDP to revert to trend line following a shock. Similar results were obtained amongst others by Sosa-Escudero (1997), Carrera, Feliz, and Panigo (1999), Noriega and Ramirez-Zamora (1999), Thornton (2001) and Rapach (2002).

Appendix Figure 4(A) shows the result of unit root tests for GDP and its components of Singapore for the period 1960-2000 (1990 prices) for Singapore, based on official data compiled from Department of Statistics, Singapore and the ADB Key Indicators. For unit root tests, Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) approaches were conducted. As is observed from the results of unit root tests, time series of real GDP and its components are all integrated of order one, I(1), since only its first difference and second difference are stationary. This result portrays that the null hypothesis of a unit root test cannot be rejected, indicating that Singapore’s time series of GDP and its components are difference stationary for the period 1960-2000. These results are similar to those observed for other countries. A similar exercise on unit root tests was made this time for the period, 1900-39 using 1914 as the base year. As is observed in Appendix Figure 4(B), the results of two different unit root tests for 1900-39 are of order Integrated (1). The results were similar to that of the data for the period 1960-2000. The result of these econometric tests bears out the fact that there are consistencies in the nature of long-term time series data on Singapore for the entire twentieth century.
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Augmented Dickey-Fuller Test  

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(B) 1900-39 (1914 Prices)  
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Appendix Fig. 4 Singapore: The Results of Unit Root Tests of GDP and Its Components

Notes:
1. All variables are natural logarithm figure.
2. Automatic selection of lag were determined by Schwartz Info Criterion
3. Bandwidth was determined based on the Newey-West using Bartlett kernel
4. (***, **, *) denotes significance at the 1%, 5% and 10% level respectively.
5. I(0) = stationary, I(1) = unit root

Abbreviations:
Pfce=Private Final Consumption Expenditure by resident households, Gfce=Government Final Consumption Expenditure, GCF=Gross Capital Formation, Exgs= Exports of Goods and Services, Migs= Imports of Goods and Services

Similar unit root test was conducted for other Asian countries, namely Japan, Taiwan, Korea and Malaya and all countries showed a similar result of unit root test.
References


