Growth and Fluctuations in Colonial Singapore, 1900–1939†

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Abstract

Our paper represents a quantitative inquiry into the economic growth and fluctuations of the British colony in Singapore during the early 20th century. Hitherto, little 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). Trend and cycle components in national income and its constituents are estimated through statistical techniques. The results are used to study commercial development and business cycles in the colonial era as well as to explore the role of foreign trade both as an engine of growth and a source of economic instability.

Keywords: Economic growth, business fluctuations, entrepôt trade, colonial Singapore

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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 a commercial hub, viewed through the prism of trade (Wong, 1978; 1991). His conclusion: Sino-Western enterprise, in a colonial enclave dedicated to uninhibited *laissez-faire*, made Singapore the premier entrepôt port of Southeast Asia for exchanging the indigenous produce of the region for the foodstuffs and manufactures of the West.

In his first article, Wong referred only to two other studies: Chiang (1978) and a doctoral thesis in progress at the time, which was published later as Huff (1994). The former focused on the rapid growth of foreign trade in the Straits Settlements, which was dominated by Singapore, during the last quarter of the 19th century following the opening of the Suez Canal. It therefore straddles the earlier and later research of Wong and makes a notable contribution to the economic historiography of the colony.

By contrast, the latter study is indisputably a path-breaking work, taking off where Chiang had left and seeking 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 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 re-exports of the 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 emporium due to free port status and extensive trade with the Malay Archipelago, as Wong (1960) had shown earlier. In consequence, it prospered through a spectacular expansion of commercial activities and without much concomitant industrialization.

It is important to recognize that a significant gap exists between quantitative historical research on Malaya, including Singapore, and the OECD countries mainly because of the lack of a macroeconomic statistical database which conforms to internationally accepted definitions.[1] In this respect, the construction of historical Gross Domestic Product (GDP) time series will open up new ground. Such a task was undertaken by Sugimoto (2009), who managed to derive a set of national income accounts at current and constant prices for Singapore reaching back into the early years of the 20th century, with a hiatus during and immediately after the Japanese Occupation caused by the absence of data. Like Huff (1994), Sugimoto's primary objective was to obtain a long-term perspective on Singapore's economic growth in the last century and secondarily, to unravel its connections with economic instability and the government's fiscal behavior. Unlike Huff however, he had the benefit of the hindsight afforded by the newly derived GDP data series.

What other uses could an economic historian—or an econometrician for that matter—conceivably put these estimates to? After all, the development of national

[1] There was the occasional study on the pre-war economy such as Brown (1994), Shimizu and Hirakawa (1999) and Huff (2001). These dealt with specific aspects or episodes and adopted a descriptive approach.

income accounting had provided the initial catalyst for the transformation of economic history into a systematic field of study based on measurable phenomena and the construction of synthetic aggregates that paint a picture of how an economy in its totality evolves over successive time periods. Wong (1960) lamented of his statistics that 'it is quite futile to claim that they can be used for purposes of accurate statistical analysis, but this fact does not diminish the value of these figures as rough signposts showing the trend and fluctuations of the trade of Singapore.' We contend to the contrary that the comprehensive national income data compiled by Sugimoto (2009) is good enough for a rigorous analysis of the trends and cycles that Wong alluded to, and not merely with respect to the proxy of international trade but for the economy as a whole.

Our purpose in the present paper is to conduct such an analysis with the aid of statistical detrending and filtering methods that are designed for extracting the trend and cycle components in national income. In particular, we seek to understand how war and crisis, booms and slumps, interrupted and disrupted the secular growth of Singapore during the colonial era from 1900 to 1939—a research agenda that Huff (1994) did not pursue, albeit one which is surely a legitimate part of economic history, although it is true that historians have on the whole been more interested in changes of a long-term rather than short-run nature.

With detailed information on the various expenditure components that make up GDP, moreover, the interdependences between the production, consumption, accumulation and exchange spheres of economic activity in colonial Singapore can be explored through hypothesis tests and correlation analyses. In macroeconomic parlance, an examination of the so-called 'stylized facts' of long-run balanced growth and short-

run business cycles is facilitated, pertaining to the empirical regularities that characterize the relations and co-movements amongst income, spending, investment and trade in market economies. Further, these facts can be compared to those that have hitherto been documented for the industrialized countries.

In view of the importance of foreign trade to Singapore's early development as a 're-export economy', a pertinent issue that arises is the relationship between trade performance on the one hand, and economic growth and fluctuations on the other. It has long been accepted by the historians cited above that an unambiguous nexus runs from trade expansion to growth. In this paper, we investigate more formally through regression and counterfactual analyses the extent to which the long-run trend in exports was first retarded by monopolistic practices in the shipping industry during the initial years of the 20th century, mitigated by a surge in world trade, and then subsequently boosted by a primary commodity boom. We find that, contradicting the experience of most primary producers, specialization in the re-export of a few staples had served as a powerful engine of growth for Singapore.

At the same time, however, others have noted that the factors responsible for growth were also a source of great instability. We therefore perform another counterfactual experiment, this time of trade cycles, to infer how much less volatile Singapore's exports would be if key commodity prices had been stable, or if incomes in her principal markets had not pulsated. In stark contrast to the benevolent role played by world commercial growth in Singapore's economic development, the empirical results suggest that violent fluctuations in staple prices and revenues, especially in the tin mining industry, were the *primum causum* of the observed oscillations in the colony's foreign trade and income. Moreover, these sharp swings were aggravated by

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

Despite the intent here to write 'new economic history', traditional economic history is not forsaken by the paper. Following this introduction, we provide the backdrop to the above quantitative investigations through a narrative account of commercial growth and fluctuations in colonial times. Primary and secondary sources are culled to paint a picture of the major economic milestones and changing business conditions from the turn of the century to the eve of the Second World War. The chronological sweep that results is not only suggestive of the historical causal forces at work but can also be employed with profit to validate the trends and cycles estimated later.

2. Commercial growth and fluctuations in colonial Singapore

Perhaps the most basic indicator of commercial growth during the colonial period is the number of ships calling at Singapore's port. In 1900/01, the tally of vessels over fifty tons displacement that came was 4,787; by 1919/20, this had risen to 5,694, and it further increased to 9,737 in 1928/29 before falling back to 6,465 in 1938/39.[2] As early as 1903, Singapore had become the seventh busiest port in the world in terms of shipping tonnage handled. The *Singapore and Malayan Directory* shows that the growth in maritime traffic was matched by expansion of the local mercantile community: the number of firms residing in the city and performing increasingly sophisticated commercial functions doubled from 1900 to 1929.

But commercial development did not progress evenly over the four decades covered—quite the opposite, it was constantly impeded by external shocks and

[2] The account of commercial growth that follows draws heavily on Huff (1994) and Wong (1978).

temporary setbacks. Contemporary attempts to take the pulse of the colonial economy, moreover, were stymied by the absence of national accounting concepts and GDP data. Nevertheless, the Governor did provide a running commentary on economic conditions in his dominions in the *Annual Report of the Straits Settlements*. The content and slant of the official reports divulged an implicit belief that the principal causes of economic fluctuations in Singapore lay outside the region—in the sharp expansions and contractions in global demand for its commodity re-exports.

Thus, it was observed in 1904 that 'general depression marked both imports and exports, and the state of trade was far from satisfactory.' Since the European merchants—including the agency houses that came into existence in the 19th century to grasp the opportunities of trade—were responsible for exporting tropical produce to the West and importing a return flow of simple manufactured items (notably cotton piece goods before World War I), fluctuations first showed up in their business. The effects then spread further afield through their symbiotic relationship with Chinese dealers, who collected agricultural and mineral products from all over the Archipelago and bartered foodstuffs and consumer goods in exchange.

In 1910, the Governor reported that the most salient feature of the year was the great rise in the price of rubber, signalling the beginning of the rubber boom. One consequence was that an increasing number of agency houses began to act on behalf of foreign companies as managers of estate plantations, in addition to their role as importers of machinery and equipment for the tin mining industry in British Malaya. Unlike tin extraction, the rubber plantation industry was an almost wholly Western enterprise right from the outset. European companies did not produce more tin than their Chinese counterparts until 1929, seventeen years after the introduction of the tin

dredge, while their investment in rubber had already amounted to £100 million by 1921. 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 came from both small-holders and large estates.

With Great Britain experiencing an economic slowdown in 1913, passing reference was made by colonial officials to a fall in the rubber price as having an unfavourable effect upon local trade conditions. In the following year, they remarked that the prices of the chief Malayan agricultural exports had suffered a similar fate. However, the economy was overshadowed by the attention given to the completion of construction work on two large docks—the Empire and King's Docks at Tanjong Pagar and Keppel Harbour respectively—that added substantially to the port's wharfage. In this connection, it was noted that total expenditures on public works in 1913 was the highest on record. The omens of war that followed instilled some fear in the local business community but in the event, proved to be unwarranted as wartime demand sent rubber and tin prices rocketing up again.

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. Between 1915 and 1939, two-thirds to four-fifths of processed rubber was exported to the United States while the tin-plate industry there increased

the colony's dependence by funnelling another one-half to two-thirds of tin shipments to the continent. In the inter-war years, America seldom absorbed less than a third of Singapore's total exports, with the exception of the Great Depression period. The rest were mainly split between Britain, Continental Europe, Malaya and Netherlands India.

This realignment of final markets was doubtless helped by the opening of trans-Pacific ocean routes during World War I, allowing Singapore to circumvent the shipping restrictions in force. Requisitioning of ships by the Allies also did not interfere unduly with ensuring adequate supplies of food and vegetables to the island although the shortage of tonnage resulted in the accumulation of large stocks of produce at the port in 1918. The situation quickly changed when drought and poor harvests in Burma and Siam created a crisis of sorts for the rice trade, which was almost completely in the hands of Chinese dealers and formed an integral part of a vigorous intra-Asian exchange of food that centred on Singapore. In 1919, the shortage resulted in the volume of rice re-exports being cut by half and in the following year, by another 60%.

Exports recovered in 1921 but by then, recession had taken hold of most of the Western world. Calling itself a 'deeply interested spectator', the Straits government described the onset of the slump in late 1920 as follows:

> The general restriction of credit by banks in all parts of the world acted and reacted on the falling price of rubber and tin. General depression followed upon financial stringency and deepened to stagnation at the close of the year. Money and credit became scarce and scarcer from June to December and anxiety increased. There was also a conspicuous decline in American and Japanese competition and a number of these firms closed down.

Two years on, however, the Governor was able to declare that the trade of the colony showed signs of recovery and by 1925, there was a complete revival as rubber prices touched a high that would not be surpassed in the next two decades, due in no small

measure to restrictions on the export of rubber that came into effect in the November of 1922 as part of the Stevenson Scheme.

The fluctuating fortunes of rubber also had a revolutionary effect on Singapore Chinese enterprise and finance in the late 1910s and 1920s. After the local rubber market was inaugurated in 1911, the numerous rubber traders and millers who appeared in the community enabled the amassing of financial capital that made possible the founding of the local Chinese deposit banks and insurance companies. Prior to this, the foreign banks in town were the sole providers of trade credit to the European merchants. Long-term capital for rubber estate development came from British shareholders through the agency houses. Domestically, only the Chettiar moneylenders complemented the banks by financing small firms. The establishment of the Chinese institutions therefore opened a new chapter in Singapore's commercial history by mobilizing the savings of the public and making banking facilities widely available to Asian businessmen. Some Chinese merchants began to sort, grade and pack Straits produce for sale to the agency houses, on whom they had previously depended for credit, and rubber millers exported their output directly to Western markets.

Ironically, the Chinese banks got into trouble during the Great Depression in the early 1930s precisely because of huge loans extended to rubber interests. As industrial demand for rubber and tin plummeted, prices dropped below the production costs of the bigger estates and mines in Malaya, causing severe distress to their owners and financiers in Singapore. Still, the European agency houses and banks weathered the slump without too much difficulty—it was some of the prominent Chinese firms and banks that were forced to merge or went bankrupt. The locally orientated economy was not spared either as over five hundred shops closed their doors in the second half of

1930 alone while the poorer classes were hard hit with many turning to hawking to survive. In the face of mass unemployment, the colonial authorities had no choice but to limit immigration of male Chinese labourers and to repatriate destitute coolies at public expense.

As the global depression lifted, rubber and tin prices staged a modest rebound that gathered momentum after the International Rubber Regulation Scheme to control supply was implemented in June 1934. The higher prices brought relief to all branches of commerce and industry in Singapore but rubber export taxes imposed by the Dutch East Indian government and its policy of smelting tin ore in the Netherlands denied the port of a substantial amount of rubber and tin imports from the Outer Provinces.[3] This significantly reduced the profits from processing and marketing them in Singapore, which had compensated for her falling share of Malayan exports of these staples in the late 1920s due to the rise of Penang and Port Swettenham as alternative ports. Making matters worse were the efforts by rival colonial powers to promote direct trade in tropical produce and manufactured products between countries in the region and the outside world.

Luckily, Singapore managed to soften the impact of the trade diversions through the acquisition of a new staple product by virtue of its geographical advantages—petroleum. 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. In 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

[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).

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.

3. Trends in national income

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 (S$)—the currency in use since the early 20th century—for national income in that year.[4] 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 changes in GDP and its components from 1900 to 1960, save

[4] For an idea of the margin of error in this estimate, compare it with Sugimoto's (2009) GDP figure of S$1,954 million for the same year.

for the war decade of the forties. Details of the methodologies employed in their reconstruction can be found in the Appendix.

The periodization chosen for our study is the pre-war years of 1900–39, this being partly forced upon us by the nature of the statistical techniques we employ, which cannot accommodate missing data. As just narrated, this epoch is worthy of attention because it was marked by spells of economic progress alternating with bouts of hardship. Apart from GDP, the components examined are 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. Hodrick-Prescott filter

Our analysis in this paper presupposes that trend and cycle components in GDP and its constituents can be clearly separated, even though more than a few observers believe growth and fluctuations to be 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 employed here is based on the Hodrick-Prescott (1997) filter, which is widely used 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.[5]

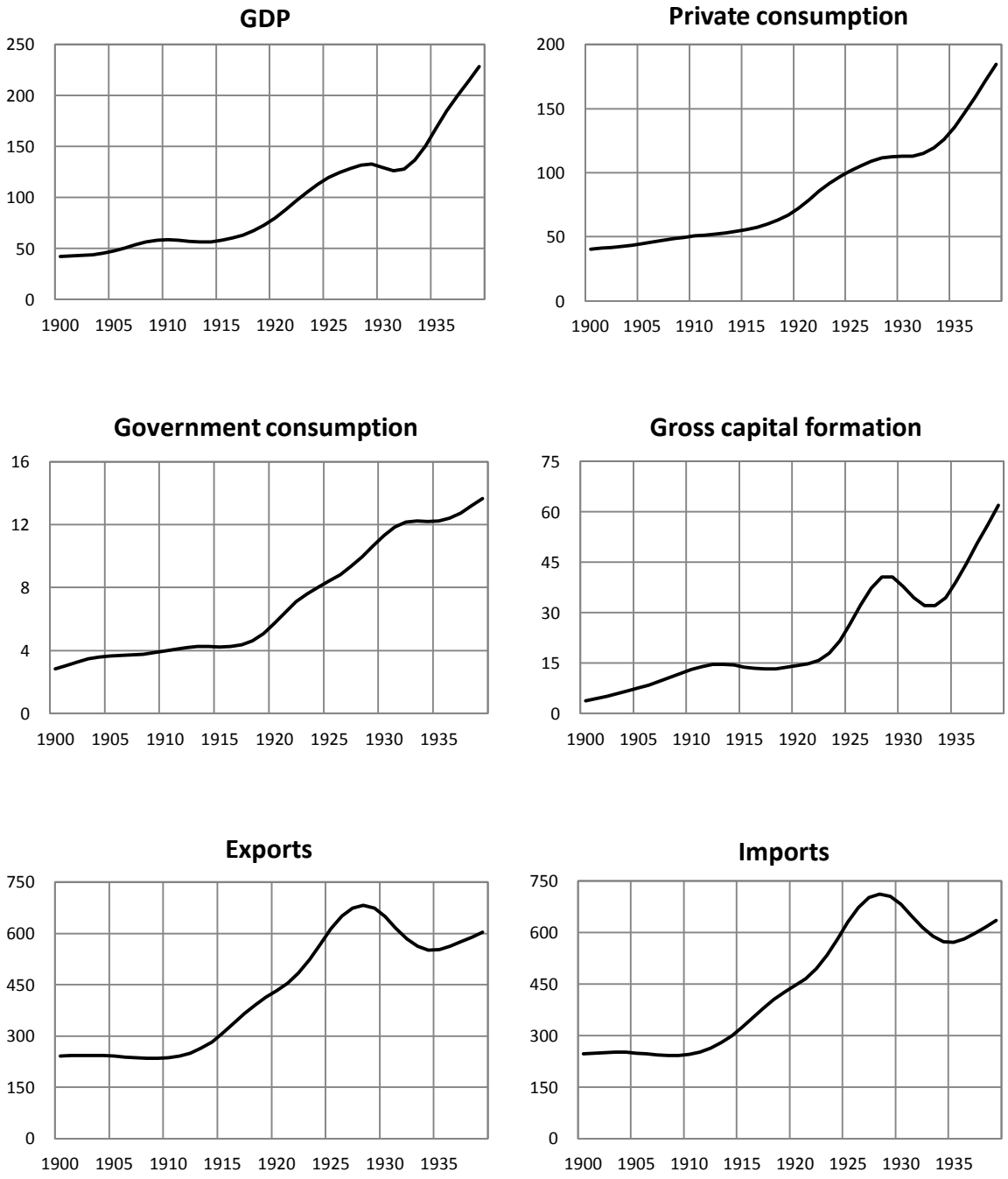


Fig. 1. Trends in national income components (million S$ at 1914 prices).

[5] The smoothing parameter controlling the trade-off is fixed at the value of 10 following recent research (Mills, 2003).

3.3. Trend estimates

Fig. 1 presents the trend estimates for historical GDP and the components therein *à la* Hodrick and Prescott. By construction, the extracted trends are smooth but they are by no means monotonic in nature.[6] Instead, phases of acceleration, deceleration, and even absolute declines, can be discerned in the plots. These time-varying growth rates are summarized by the decennial averages in Table 1.

Table 1

Trend growth rates of national income components (yearly averages in percent).

Period	GDP	Private consumption	Government consumption	Gross capital formation	Exports	Imports
1900s	3.6	2.3	3.5	13.7	−0.3	−0.2
1910s	2.3	3.1	2.8	1.5	5.9	5.9
1920s	6.2	5.3	7.7	11.7	5.0	5.2
1930s	5.7	5.1	2.5	4.7	−1.1	−1.0

Generally speaking, the long-term movements in GDP and private consumption expenditures show the most agreement over the period studied, not surprisingly since consumption constitutes the main use of income. And given Singapore's re-export economy, the export and import curves are virtually indistinguishable, although import volumes did rise somewhat more rapidly in the early 1910s and late 1920s than export quantities, so that a wavelike movement is produced in the balance of trade in goods and services.[7] 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.

[6] Interestingly, a simple 5-year moving average yields very similar, albeit more erratic, trend curves.
[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).

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 personal and governmental 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 prices of, primary commodities shot up. That secular boom was to last till the stock market crash of 1929, punctuated only by the mild inflexion caused by the recession of 1921. Its multiplier effects on GDP and consumption were not apparent until the late 1910s, in part because gross capital formation was held in check during the war years.

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 the colonial government, buoyed by tax revenues from increased consumption of opium amongst the local populace, lifted its general expenditures by 7.7% per annum. Capital accumulation, too, increased by 11.7% per year to make up for lost business opportunities during wartime 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.

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 were 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 swung the GDP trend

growth rate for the decade into positive territory 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 growth rate of the Singapore economy as revealed by changes in trend output is estimated to be 4.5% per annum. This did not translate into a big improvement in material living standards as the domestic population increased by about 3% each year during the first two decades and close to 4% in the 1920s. It then contracted by 12% between 1929 and 1933 due to repatriation of labourers but this was offset by average yearly population growth of nearly 6% for the rest of the decade. In per caput terms, therefore, the real national income of the colonial period advanced by only 1.4% per annum, with most of the progress occurring in the 1920s and late 1930s.

3.4. Balanced growth paths

Few empirical relations in economics have the exalted status of being 'stylized facts'. The 'great ratios' characterizing the long-run balanced growth paths of key macroeconomic aggregates count amongst them (as do the shorter-term co-movements between such aggregates, which are treated in the next section). It was Kaldor (1957) who first drew attention to these 'broad tendencies' of economic growth, stressing specifically the historical constancy of output per worker, the capital-output ratio, the labour share in income and the return to capital. Since data on these variables is non-existent for the colonial period, we shall have to be content with ascertaining the stability of the relative shares of consumption and investment in GDP as an indirect

means of throwing light on the empirical veracity of Kaldor's facts. The trend estimates discussed above, being free from cyclical fluctuations, are ideal for this purpose.

We shall proceed in two ways. First, we calculate the average rates of growth of the trend components in national income from 1900 to 1939 and the degree of dispersion of yearly observations around these arithmetic means, as measured by the standard deviation. Pairwise inferential tests of the hypothesis that an expenditure category shares the same growth rate as GDP are then carried out.[8] An inability to refute the hypothesis would suggest long-run increases in spending that are equiproportionate to output and hence, balanced growth behavior. This simple test is complemented by a second, more direct assessment of the stationarity or otherwise of the expenditure-to-income ratios. Of the many possible approaches available for tackling the issue, we opted for the celebrated Dickey-Fuller (1979) unit root test. If the individual GDP components exhibit trend growth but their respective ratios do not, we can expect to get rejections of the null hypothesis.

The left panel in Table 2 displays the first set of descriptive statistics and tests. On the face of it, the average rates of increase in GDP, private consumption and government consumption appear to be in the same ballpark. Their standard deviations varied rather more, with household consumption being the least volatile. Standing out from the crowd, fixed capital formation boasted the highest mean growth rate and this was accompanied by an equally large dispersion—both close to 8%. In line with this, the *t*-tests of equality of means show that any differences in the trend rates of income and consumption growth—irrespective of whether the latter originate from private or public sources—are not statistically significant, but that in gross capital formation is. We are left for the

[8] A matched pairs *t*-test of equal means was used since observations from the same year were compared.

time being with the tentative conclusion that only the long-run paths of real output and consumption are consistent with balanced growth.

Table 2

Balanced growth: descriptive statistics and tests.

	Growth Rates (%)			Ratios to GDP		
	Mean	S.D.	t	Mean	S.D.	$\hat{\tau}_\mu$
GDP	4.5	3.9	–	–	–	–
Private consumption	4.0	2.6	−1.58	0.89	0.05	−3.72*
Government consumption	4.1	3.4	−0.45	0.07	0.01	−6.25*
Gross capital formation	7.8	8.3	2.60*	0.21	0.05	−3.89*

Notes: The statistics are calculated for the trend estimates of the various components over the period 1900–39. S.D. stands for standard deviation. t is the test of identical means with critical values of $\pm$ 2.33 at the 5% level. $\hat{\tau}_\mu$ is the augmented Dickey-Fuller test statistic with a constant, one lag and critical value of −2.93. An asterisk denotes a statistically significant outcome.

Table 2 also presents analogous statistics on the consumption-income and investment-income ratios in the right panel. Private consumption's average share in GDP was 0.89, although the ratio has fluctuated widely from 0.8 to 0.97 over the years. In contrast, the share of government purchases in output hovered about 0.07 except during the Great Depression when it rose to about 0.09. Consistent with the marked volatility of the trend in gross capital formation, the investment-output ratio has a much higher coefficient of variation than the consumption ratios.

The hypothesis of a unit autoregressive root is rejected at the 5% significance level for all three types of expenditures by the augmented Dickey-Fuller test's equivalent of the Student t-statistic, denoted $\hat{\tau}_\mu$ in Table 2.[9] Thus, the data has decided in favour of constancy of the great ratios over this stretch of history. Note that this is not to say the trend ratios did not exhibit time-dependent variation: on the contrary, they sometimes meandered off for long periods but there was always a tendency for them to revert to their means, as happened in the case of the investment-income ratio. We view these

[9] The augmentation takes the form of adding the first lag of the dependent variable to the regression of annual changes in the ratios on their levels, in order to eliminate serial correlation in the residuals.

findings as strong evidence—contradictory to the earlier test result for capital formation—that economic growth in early 20th century Singapore had occurred in a manner that was balanced between spending, saving and accumulation.

This stylized fact should be put into historical perspective. Official time series on private consumption expenditures and real GDP after 1960 indicate that the proportion of income consumed has fallen continuously to less than 40% by 2008. Abeysinghe and Choy (2004) tested the average propensity to consume in modern Singapore for non-stationarity and discovered that the null hypothesis cannot be rejected even after wealth effects were taken into account. They concluded that domestic consumption had failed to act as a built-in stabilizer for the economy and that more volatile components such as investment spending and exports have come to dominate the movements in GDP. Contrast this state of affairs with the situation in colonial times, when consumption smoothing clearly cushioned real output from the deflationary effects of the 1930s depression (see Fig. 1).

The stability of the investment-income ratio probably has the greatest bearing on Kaldor's facts. It is a simple matter to show that, starting with a fixed stock of capital, stationarity of this statistic implies a constant capital-output ratio under stochastic uncertainty. The fact that the former ratio has shown some upward drift during the colonial period suggests that the latter ratio has risen correspondingly. By 1939, the contribution of investment to GDP had reached 27%—a shade below the minimum one-third share that is a hallmark of the post-independence economy.

As our last word on the subject of balanced growth, we may note that the government consumption-to-GDP ratio has a special significance in the context of testing Wagner's Law on fiscal creep in modern polities. Sugimoto and Tan (2009)

pointed out that the British administration applied the financial principle of 'living within its means' to Singapore, effectively forcing the colony to balance its budget. Nonetheless, this principle is not at odds with Wagner's Law provided that tax revenues rise in tandem with income. The constancy of the government spending ratio during the pre-war period can accordingly be construed as being weakly compatible with the law, notwithstanding the fact that Sugimoto and Tan (2009) could not find any statistical long-run relationship between public expenditures and income.

4. Business cycles

4.1. Band-pass filter

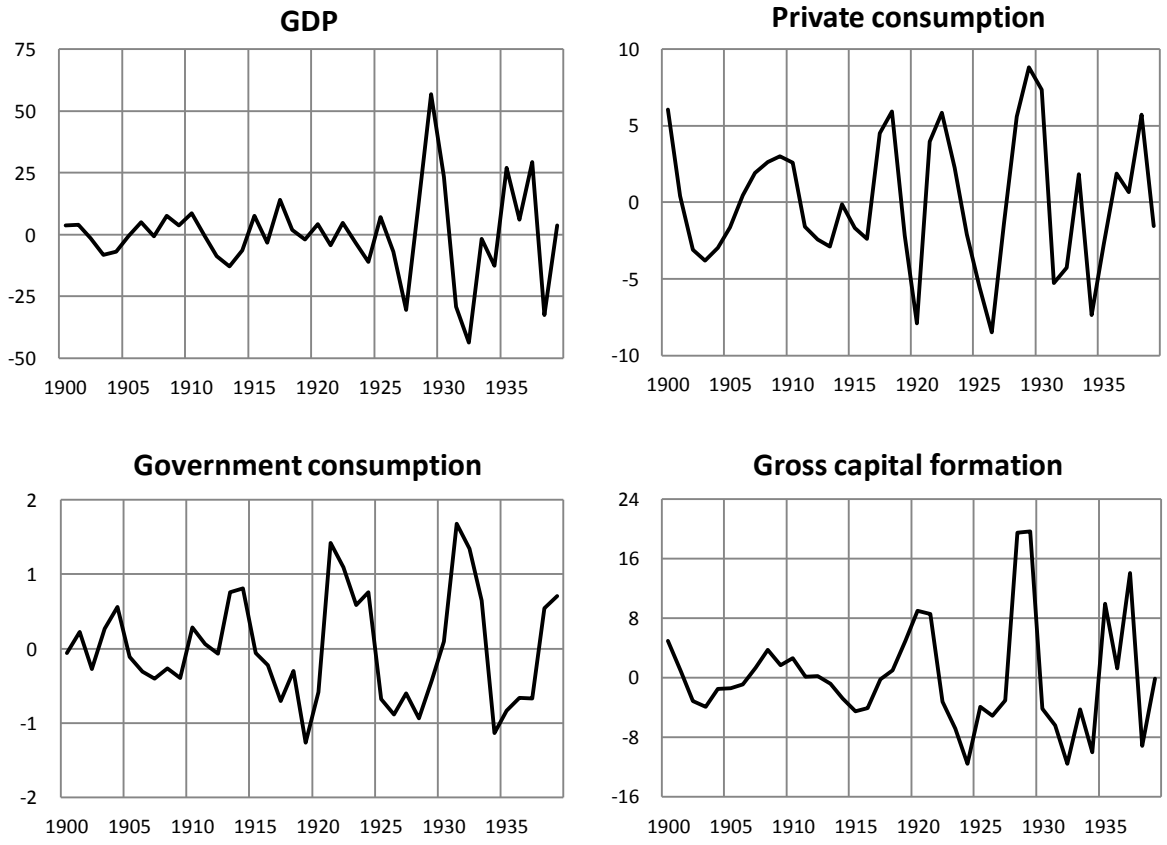
In contrast to the Hodrick-Prescott filter which can be viewed as a low-pass filter that isolates the long-run movements in a data series, the cycle estimation procedure used is a band-pass filter that retains medium-term fluctuations with durations of between 2 and 8 years, corresponding to the life spans of most historical business cycles. We have chosen to apply the frequency domain algorithm 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).[10] As this filtering method is less well-known, we offer a brief explanation of it here.

Assume x_t to be an integrated time series of order one with discrete Fourier transform $w_x(\lambda)$, 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

[10] The frequency domain filter is a consistent approximation to the ideal band-pass filter for economic variables in possession of stochastic trends. It also does not lead to truncation at the end-points of series.

$$w_x(\lambda) = \frac{1}{\sqrt{n}} \sum_{t=1}^{n} x_t e^{i\lambda t}$$
$$= \frac{1}{1-e^{i\lambda}} w_v(\lambda) - \frac{e^{i\lambda}}{1-e^{i\lambda}} \frac{\left(x_n - x_0\right)}{\sqrt{n}}$$

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 $w_x(\lambda)$ 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 $w_v(\lambda)/(1-e^{i\lambda})$, followed by taking its inverse Fourier transform to retrieve cycles in the time domain.



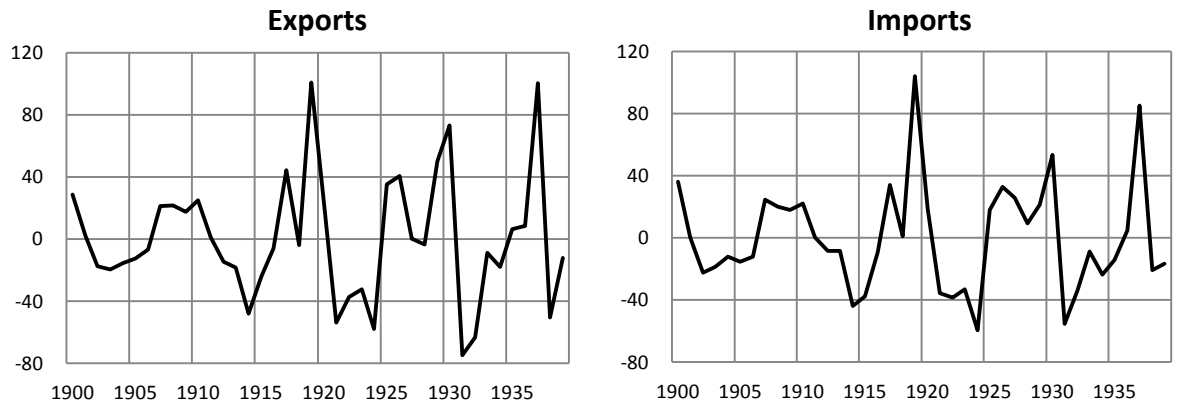


Fig. 2. Cycles in national income components (million S$ at 1914 prices).

4.2. Cycle estimates

The charts in Fig. 2 show what happens to the raw national income data when it is passed through the frequency domain filter.[11] The fluctuations manifested by the filtered series may not seem to be cycles in the periodic sense of the word, but this should not detract from their ability to capture the ebb and flow of economic life in colonial Singapore. In the next few paragraphs, we describe these pseudo-cycles with a view to corroborating the events chronicled in Section 2.

Since national accounting rules make GDP the sum of consumption, investment, exports and imports, we start our discussion with them. More so than the other components, private consumption expenditures went through numerous cycles over the forty years covered by the plots. The first two troughs occurred in 1903 and 1913 with an interim peak in 1909 and they mirrored the doldrums in trade noted in Section 2. 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

[11] Cycles derived from the Baxter-King filter are not very different from those presented here.

caused by the severe downward pressure exerted on real wages by high worldwide inflation and aggravated by the rice crisis in Southeast Asia. Sugimoto (2009) estimated that consumer prices rose on average by 23% per annum during the three years from 1918 to 1920. There follows another trough in the mid-twenties before a buying frenzy erupted and then abruptly ended as the economy went into depression. Surprisingly, the cycle estimates indicate that the retrenchment in consumption during this episode was not any worse than in the preceding recessions, a finding subtly confirmed by the smaller decline in imports, inclusive of manufactured goods, compared 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. This contrarian and intriguing behaviour of the colonial authorities is confirmed below, and it had the salutary effect of partially compensating for otherwise low aggregate demand during the early 1920s and 1930s.

On the other hand, the home investment cycles that come out from filtering gross capital formation are congruent with the cycles in exports and imports. That these components of GDP rise and fall together is not at all unexpected, as Huff (1994) has observed that the expansion of trade provides strong incentives for the colony to build good roads, telecommunications and harbour facilities. 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, actually exceeded the downswing of the thirties.

From the standpoint of business cycle historicity, the last three graphs in Fig. 2 tell the same story as that of Section 2, albeit in quantitative terms: 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 global 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 boom associated with the euphoria of the late twenties is clearly evident and so is the ensuing bust that came with the collapse of international trade in 1931–32; and 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 its constituents really became obvious only from the later 1920s, as the cyclical motions in consumer spending, investment and exports mutually reinforced each other and ushered in the deepest output contraction of the colonial epoch in conjunction with the Great Depression of the century.

4.3. Volatility and co-movement

The reader may have noticed, when looking at Fig. 2, that the cycles not just in GDP but also in its components were more accentuated for the period after 1914. Such a perception is not misplaced, for Table 3 shows that the standard deviations of the latter day fluctuations are indeed larger. These surrogate statistics for volatility doubled in magnitude from pre- to post-1914 in most cases and more than tripled for gross capital

formation and GDP. Moreover, the execution of standard *F*-tests of equality of variances delivers the conclusion that the increases in the average variability between the two sub-samples are statistically significant.

Essentially, we have discovered for pre-war Singapore what researchers found to have been true of the industrialized countries—economic volatility was considerably higher in the inter-war period than during the late 19th and early 20th centuries (Backus and Kehoe, 1992; Bergman, Bordo and Jonung, 1998). Of course, this owes in no small part to the dislocations associated with the First World War and the 1930s depression, although we have seen previously that Singapore was relatively unaffected by the former catastrophe. Comparing across variables instead of over time, the following ranking of volatility in increasing order can be deduced: government consumption, private consumption, gross capital formation, imports, exports. Except for the exaggerated variances of the trade series, this line-up conforms to one of the most famous stylized facts of business cycles.

The other facts concern the temporal co-movements amongst the macroeconomic components of aggregate income and were robustly established through bivariate correlation analysis by the aforementioned authors. We have performed a similar analysis on Singapore's band-pass filtered data in Table 4, wherein tests of significance of the estimated correlation coefficients are also reported.[12] The main stylized facts surface once again in the second column of the table, and not merely as the trivial consequences of the national accounting identity being respected in the reconstruction of the historical statistics. Consumption, investment, exports and imports were all pro-cyclical in the sense that their business cycles moved during the colonial period closely

[12] The test statistics are based on Fisher's *z* transformation, which tends to the normal distribution at a quicker rate than the usual *t*-test.

with, and in the same direction as, the overall cycle in real GDP. In a noteworthy deviation from the international historical experience of a generally counter-cyclical trade balance (Backus and Kehoe, 1992), net exports are also found to be strongly pro-cyclical. On the other hand, government purchases were counter-cyclical because they tended to offset the movements in income and its constituents, as noted earlier.

Table 3

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

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

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.

Table 4

Business cycle co-movements.

	GDP	Private consumption	Government consumption	Gross capital formation	Exports	Imports
GDP						
Private consumption	0.43*					
Government consumption	−0.44*	0.08				
Gross capital formation	0.71*	0.38*	−0.39*			
Exports	0.64*	0.17	−0.71*	0.51*		
Imports	0.43*	0.18	−0.66*	0.48*	0.95*	
Net exports	0.84*	0.03	−0.46*	0.29	0.56*	0.29

Notes: The numbers represent correlation coefficients between the cycles of the components. An asterisk means that a correlation is statistically different from zero at the 5% level according to Fisher's *z*-test.

Turning to the annual fluctuations in the expenditure components themselves, we are able to confirm the positive correlation of gross investment in fixed capital with the trade flowing into and out of the island. What is more interesting is that its cross

correlation with private consumption expenditures is also statistically different from zero, thus indicating that individuals, businesses, and the government—an active participant in capital formation—shared some common responses to the economic and political events of the time. Exports were much more strongly correlated with GDP and the foreign trade balance than imports, thereby explaining the pro-cyclicality of net exports. The largest correlation of 0.95 recorded in Table 4, however, is that between exports and imports, which provides incontrovertible evidence of the entrepôt basis of Singapore's economy during colonial times.

5. Trade, economic growth and instability

The development of Singapore as a staple port in the late 19th century was the consequence of growing market integration within the British Empire as well as outside it. Global trade expansion was itself stimulated by the new transport and communications forms: steamships, railways and telegraphs. Closer to home, road and rail links between the city and its newly acquired economic hinterland in the Malay Peninsula began to be established for the transportation of tin, and subsequently rubber, for processing and export through the port. The economy grew in size and scope as a result, and the first business cycles soon appeared. Indeed, the extant trade statistics suggest that there was already a rough coincidence of the economic fluctuations of Singapore with those of Great Britain prior to 1900. In this section, we explore the causal effects of the colony's external commerce on internal growth and instability starting from this date.

5.1. Staple-led growth

Richard Caves (1971) has defined the staple theory of export-led growth as describing '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.' As elaborated by Huff (1994), this dynamic is an accurate characterization of the historical role played by the staple re-export trade in fostering Singapore's economic development. Capital and entrepreneurship were initially provided by Chinese merchants for tin mining in Malaya and this was followed later by large infusions of European investment and management expertise into the rubber plantation industry there. Cheap labour was secured by persistent inflows of immigrant coolies from China and estate workers from India.

Serving as a proxy for rising staple demand from the industrialized economies, the expansion of world trade during the 19th century has often been considered by prominent writers like Nurkse (1961) and Lewis (1980) to be a prime mover of economic growth in primary producing countries and the port cities that serviced them. This view has not gone unchallenged, however. In a classic paper, Kravis (1970) raised the question of whether international trade served more nearly as a handmaiden of growth, rather than an autonomous engine of growth. He maintained that the presence of favourable domestic supply conditions such as an abundance of land, a large population and socio-economic infrastructure could be even more critical to the growth process. External demand, where it was present, merely provided 'an added stimulus which varied in importance from country to country and period to period.'

It is not an easy matter to disentangle the complexity of forces affecting the varying growth trends of Singapore's exports—and by implication, her imports—during the first half of the 20th century. Nevertheless, we can get some idea of the relative importance of demand versus supply factors by performing a linear regression analysis, taking as the determinants of exports the quantum of world trade and the lagged average prices of export commodities.[13] In addition to these variables, historians of Singapore have drawn attention to the controversy over the effects of the Straits Homeward Conference (Chiang, 1978; Huff, 1994).[14] Its detractors alleged that the activities of 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 in light of our previous trend analysis of exports and imports which showed stagnation up to at least 1911, the year the conference was effectively terminated. The claim is readily scrutinized here by including in the regression equation a dummy variable to capture any impact of the cartel on export growth, with the following results:

[13] Due to data inadequacies, we will have to be content with a 'reduced-form' equation for exports which is not amenable to structural interpretation. However, the empirical specification used can be rationalized by a simple cobweb model of agricultural markets in which demand is a function of price and income, and supply depends only on last year's price, making the latter a predetermined variable:

$$Q_t^d = \alpha_0 + \alpha_1 P_t + \alpha_2 Y_t + \varepsilon_t^d$$
$$Q_t^s = \beta_0 + \beta_1 P_{t-1} + \varepsilon_t^s$$

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 unknown parameters are functions of the structural coefficients and can be estimated using ordinary least squares techniques without giving rise to simultaneity bias.

[14] The Straits Homeward Conference was a cartel controlling international shipping charges on maritime routes to Britain and Europe. It 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).

$$\Delta EXPORT_t = \underset{(-8.20)}{-11.4} + \underset{(6.55)}{0.599} \cdot \Delta TRADE_t + \underset{(9.47)}{0.146} \cdot PRICE_{t-1} - \underset{(-5.72)}{4.66} \cdot DUMMY_t$$

$$R^2 = 0.80 \qquad SEE = 1.95\% \qquad DW = 0.288$$

The dependent variable is $\Delta EXPORT_t$ or the year-to-year percent change in the trend of Singapore's total exports, $\Delta TRADE_t$ is the corresponding growth in world trade volumes, while $PRICE_{t-1}$ is the last period's trend in the export unit value index.[15,16] The Durbin-Watson test indicates that the residuals are autocorrelated but the excellent explanatory power of the regression suggests that this is likely due to the static specification employed rather than the more serious problem of omitted variables. Taking this into account, we have reported within the parentheses *t*-statistics which are computed using autocorrelation-consistent standard errors.[17] A plot of actual versus fitted values reveals a close match except for the 1910s when export growth was somewhat under-predicted.

All the right-hand-side variables are statistically significant at the 1% level when fitted to the historical data. The first estimated partial regression coefficient implies that Singapore's exports grew at three-fifths the rate of world trade, *ceteris paribus*, and this agrees well with studies on the British economy for the inter-war period (Hatton, 1990).

[15] 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. The export unit value index used is of the chained variety and was compiled by Sugimoto (2009).

[16] The price variable enters into the regression specification in levels instead of growth rates since it 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.

[17] These are Newey-West standard errors for residuals that are heteroskedastic and serially correlated for one period.

Having the same sign as the trade coefficient is the positive price 'elasticity', the size of which indicates that a one point rise in the index of export prices induces a 0.15% increase in the volume of staple products shipped from Singapore in the next period. Even more interesting is the coefficient for the Conference dummy. Contrary to Chiang's (1978) speculation that higher freight rates inflicted very little damage on the colony's trade, we find that the estimated impact in the regression equation is large and economically significant: over the period of the Conference's operation, average export growth was reduced by over four percentage points every year.

In order to quantify the differential contributions of international trade and staple prices to export performance, we shall proceed by the method of counterfactual analysis. A quick review of the trends in world trading activity over the period 1900–13 shows a continuation of the boom that started *circa* 1870 and that is usually attributed to reductions in transport costs. Thereafter, trade volumes commenced a long-run decline to 1939 which was temporarily halted by an upsurge in the mid-1920s.[18] Export prices, in contrast, took off only in 1908 and kept ascending right until 1919, followed by a reversal that merged into the Great Depression. Both series experienced a brief resurgence after the worst of the depression years had come to pass.

The first counterfactual history we contemplate is therefore one in which global trade stagnated at the volumes attained by the turn of the century. What would have happened to Singapore's exports under such a scenario? Given our estimated reduced form equation, we can compute the counterfactual path for the dependent variable by setting the implied growth of world trade to zero. The answer is that the trend increase in exports would have been -1.6% instead of the realized rate of 0.7% during the pre-

[18] Estevadeordal, Frantz and Taylor (2003) traced the fall to protectionism, higher shipping costs and the final collapse of the gold standard.

World War I era. In other words, the increase in external demand which in fact occurred went some way towards mitigating the negative effects of the Straits Homeward Conference. For the rest of the inter-war years, international trade made only a small positive contribution to domestic export growth because it was in secular retreat.

Although demand forces clearly initiated the process of staple-led development, they did not operate independently of supply conditions—as shown by the regression coefficients presented above, the output of staple commodities and tropical produce was further stimulated by high export prices. Let's suppose that Singapore's export prices had neither shot up nor gone down, but remained dormant at the levels that prevailed prior to 1908. Then we can expect exports to be slashed thenceforth up to 1929, by which time average prices had more or less fallen back to their initial benchmarks. The anticipation is correct: the growth rate of exports would have decelerated to a mere 0.9% per annum over this period, a far cry from the actual 4.9%. Beginning from 1930, however, if commodity prices had not collapsed, the pace of export expansion would have speeded up to 1.4% per annum rather than contracting at roughly the same rate. Taken *cum grano salis*, these counterfactual figures provide evidence of asymmetric supply responses to changes in the world demand for primary products in the long run, as well as estimates of their magnitudes.[19]

Summing up the role of the staple trade as the mainspring of economic growth, it can be concluded that the fortuitous mobility of factor inputs in the Straits Settlements and British Malaya created a virtuous circle whereby a larger export base led to the additional investments in public utilities, transport, health and education so essential for sustained economic expansion, which in turn cemented Singapore's position as the

[19] It can be shown that the coefficient of the lagged price term in the reduced form equation for exports in Footnote 13 is equal to the corresponding parameter in the supply equation.

staple port of the region. And superficial though the impact might be on industrialization, the ready access to primary commodities did encourage the setting up of processing industries such as tin smelting, rubber milling, pineapple canning and sawmilling. Of more relevance to welfare, by spawning numerous service industries catering to local consumption, the growing export sector augmented the national income and diffused the benefits of growth more widely to the city's inhabitants.

5.2. Export instability

A central concern of this study is with elucidating the short-run fluctuations of foreign trade and income in colonial Singapore. Staple theory, though quite capable of explaining the trend increase in commerce over this period, has paid scarce attention to the cyclical instability that attended to the growth process (cf. Fig. 2). With its export concentration in the three key staple products of rubber, tin and petroleum all having inelastic demands and supplies, however, the Singapore economy was highly vulnerable to recurrent gyrations in export prices and proceeds. In this regard, efforts made during the inter-war years to stabilize primary commodity markets through international agreements among producers aimed at restricting output met with only limited success (refer to Lim, 1967 for a detailed discussion).

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 is not in volatility *per se*—whose impact is probably too subtle to detect in our relatively short sample span—but rather its ramifications for business cycles. We wish to know whether

the wide swings in world staple prices had been communicated to export values and if so, with what force. Certainly, visual examination suggests a strong correspondence between the cycles in the prices of the major commodities and nominal exports. By dint of this observation, focusing on the overall export price index will defeat the purpose since its behaviour has been swamped by the heterogeneous price movements of lesser items.

Commodity prices aside, changes in the economic conditions of the industrial centre were 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 induced parallel changes in the demand for food and manufactured goods imported through Singapore and re-exported to the surrounding countryside in exchange for primary and tropical products. As the century progressed and real incomes rose all round, the imports diversified into more volatile consumer durables such as electrical appliances and motor cars (Huff, 1994). These fluctuating foreign demands from the port's principal markets in both East and West are suitably represented by shifts in either their respective or composite GDPs.

Supply influences should also not be neglected when analyzing cycles. As the last sub-section shows, commercial agricultural production responded elastically to buoyant export prices in the long term. However, higher output by Singapore's large hinterland suppliers of rubber and tin to the world market has the immediate effect of depressing prices, with the implication that instrumental variables should be utilized in the regression analysis we plan to carry out. Applying the method of two-stage least squares, we ran multiple regressions that reflected the commodity structure and

geographical distribution of the colony's re-exports in alternative ways.[20] The one that performed best is:

$$EXPORT_t = \underset{(0.92)}{6.46} + \underset{(2.74)}{6.27} \cdot GDP_t + \underset{(1.38)}{0.646} \cdot RUBBER_t + \underset{(6.44)}{2.56} \cdot TIN_t + \underset{(4.49)}{1.09} \cdot PETROL_t - \underset{(-4.37)}{217} \cdot DUMMY_t$$

$$R^2 = 0.81 \qquad SEE = 42 \qquad \chi^2_4 = 8.21$$

where $EXPORT_t$ is the cycle extracted from the current dollar values (in millions) of goods and services exports, GDP_t is the analogous cycle in the aggregate index representing the incomes of Singapore's main trading partners, and the three arguments that follow next are the cyclical price indices for rubber, tin and petroleum respectively.[21] The dichotomous variable $DUMMY_t$ is 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.

The instrumental variables regression fulfills our expectations: it manages to replicate four-fifths of the cyclical variation in export revenues—no mean feat considering their volatility—and the explanatory variables possess the correct signs. Except for the rubber price, paradoxically, the regressors are also significant at

[20] Lagged values of commodity prices and combined GDP were employed as instruments for this purpose. We first tried functional specifications in which foreign demand was geographically sub-divided into country or regional markets. Even with time lags incorporated, they proved to be inferior, thus supporting Huff's (1994) assertion that commodity exports to the West were the main cause of Singapore's trade cycles and imported goods merely fluctuated in tandem.

[21] 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 aggregate index are the USA, UK, France, Germany, Italy, the Netherlands, Belgium, Austria, Switzerland, Denmark, Sweden, Norway, Finland, Australia, Japan, 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 information in Huff (1994).

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. We report instead the chi-squared statistic for the Sargan test of overidentification, with its *p*-value of 0.145 giving not much reason to doubt the validity of the excess instruments employed.

Going by the regression results, it would appear that the proximate causes of Singapore's export cycles were fluctuations in overseas incomes working hand in hand with fluctuations in commodity prices.[22] 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 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 5 where, for ease of interpretation, the counterfactual standard deviations are presented as ratios to the actual statistics.

Table 5

Counterfactual volatilities of nominal exports.

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

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

[22] 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.

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 5). Better yet, the improvement would be spread uniformly throughout the period.

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 pauses to look 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.

6. Summary of findings

We commenced our study of growth and fluctuations in colonial Singapore with a narrative account of commercial development and business cycles from 1900 to 1939 to set the context. Underpinned by econometric decompositions of the major national income components into trend and cyclical movements, the historical-statistical analyses which followed confirmed the qualitative impression 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 episodic economic slowdowns and a global recession in the early 1920s.

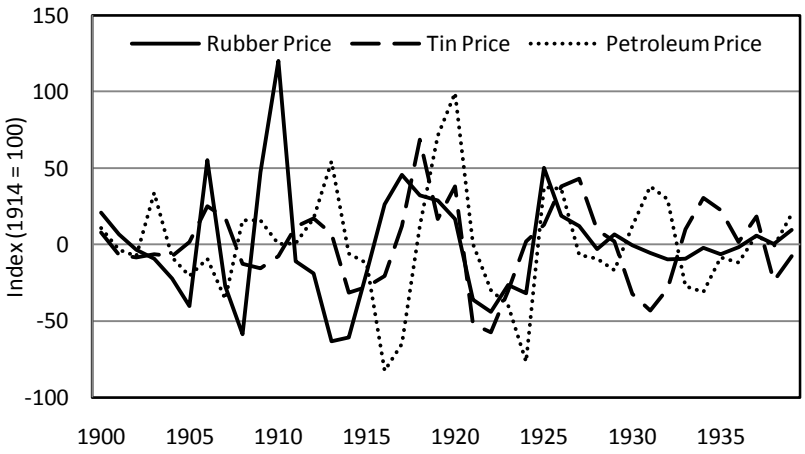


Fig. 3. Cycles in key staple prices.

Moving from event history to the interdependences between macroeconomic aggregates, some orthodox stylized facts emerged: in the short run, consumption and investment were pro-cyclical with respect to output whilst in the long run, increases in such expenditures kept up with the secular rise in GDP to bring about balanced growth

for the economy, according to time series tests. The basis of income and wealth fluctuations in colonial Singapore, however, lies in entrepôt trade, as evidenced by the strong pro-cyclicality of exports, net exports, and imports to a smaller degree.

Our next task is therefore to explain why exports expanded and fluctuated as they did, in the process casting new quantitative light on the close dependence between Singapore and the world economy emphasized by previous observers. With regard to the first issue, counterfactual findings based on a regression analysis suggest that supply expansion in the city's hinterlands made a more important contribution to her growth as a staple port than the increase in international demand, even as the latter spurred the former greatly by raising global commodity prices and stimulating further investment in agricultural production. Our estimation demonstrates that the primary boom during the 1910s and 1920s could have boosted export growth by four percentage points through the impetus imparted, in particular, to rubber output from the Malayan plantation and Netherlands Indian small-holder sectors.

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 further statistical evidence to show that export volatility was attributable in part to the exogenous economic shocks associated with crises and worldwide depressions. But 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.

To use Blattman, Hwang and Williamson's (2007) metaphor, Singapore flourished in the early years of the 20th century by picking a few winners in the commodity lottery as engines of growth, but 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[23] 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[24] over time, taking into

[23] 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.

[24] 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.

account the income elasticities of demand for each major object of consumption.[25] 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[26] 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:

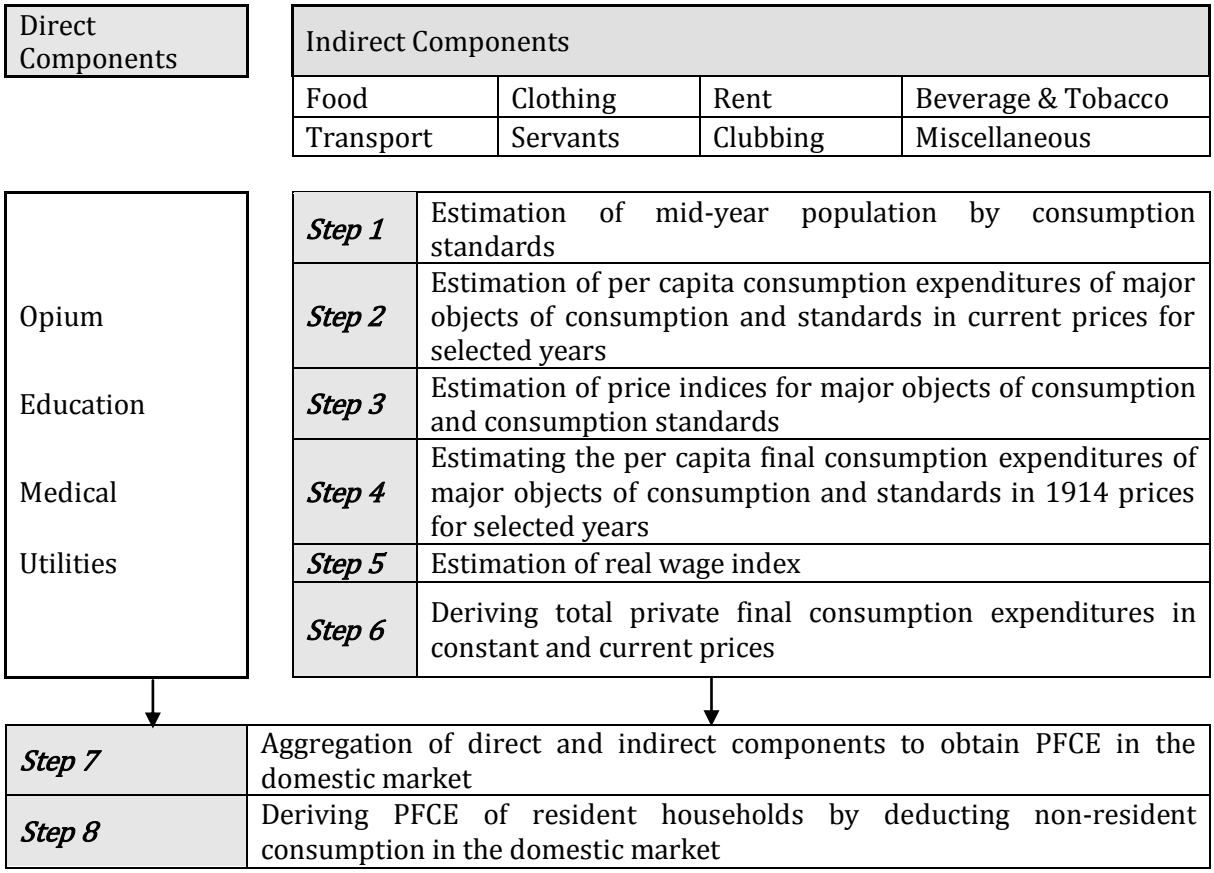
$$RPCF_{t+1} = RPCF_t + ((RPCF_t \times (1.2\text{-}1.0)/1.0) \times 0.7)$$

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.

[25] 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).

[26] 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 Figure 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.[27] Detailed expenditures recorded in conventional government accounts varied among administrative bodies and also within each administrative body over time.

[27] 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 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).

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

	1910	1911	1912	1913	1914	1915	1916
Newly planted acreage	10	10	10	10	10	10	
Cost per acre	50	20	20	20	20	20	
Value	500	200	200	200	200	200	
Newly planted acreage		30	30	30	30	30	30
Cost per acre		50	20	20	20	20	20
Value		1500	600	600	600	600	600
Investment (1914 prices)	500	1700	800	800	800	800	600
Rubber tappers index	60	70	80	90	100	110	120
Investment (current prices)	300	1190	640	720	800	880	720

	1	2	3	4	5	6
Cost per acre in 1914 prices	50	20	20	20	20	20

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 merchandize 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.

Appendix Figure 3: Deflators Employed for GDP Components

GDP Components	Method Applied/Deflator
Private Final Consumption Expenditure	
Indirect Approach	Consumer Price Indices for each major object of consumption
Direct Approach	Consumer Price Indices
Government Final Consumption Expenditure	
Government Output	
Compensation of Employees	Consumer Price Indices
Intermediate Consumption	Consumer Price Indices
Sales of Government Services	Consumer Price Indices
Gross Capital Formation	
Cultivated Assets	Rubber Tappers' Wage Index
Construction	Import Unit Value Indices of Cement
Machinery and Equipment	UK Price Indices of Machinery and Plant
Change in Stock	Import Unit Value Indices
Exports of Goods and Services	
Merchandize	Export Unit Value Indices
Port (goods and services)	UK Weighted Indices for Fuel and Light, Transport, Communication and Other Services
Non-resident consumption in domestic market	Consumer Price Indices
Imports of Goods and Services	
Merchandize	Import Unit Value Indices

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