An Analysis of Provincial District Prices in New Zealand: 1885-1913.

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Abstract

The paper presents some new estimates of the Consumer Price Index (CPI) for New Zealand (1885-1913), including the four Provincial Districts of Otago, Canterbury, Wellington and Auckland. The start date coincides with the availability of district level nominal price series reported annually in *Statistics New Zealand*. The construction of provincial CPIs was achieved by using nominal prices for a chosen basket of goods (based on the *Labour Department Household Survey* in 1893) from various sources. Analysis of the data involves a range of time-series approaches including unit root and cointegration-based estimation methods to identify whether the spatially separated price series exhibit common stochastic trends or alternatively, common cycles. From an economic perspective these methods will used to consider the integration of markets over time and space and which of the four provinces were the driving forces in the economy during that period.

Keywords Consumer Price Index (CPI); New Zealand; Convergence; Law of One Price

JEL Classifications C43: R11: N37

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0. Overview

Measuring prices, both in terms of levels and rates of change, plays a fundamentally important role in a wide range of economic applications. Whether we consider individual goods and services or aggregate into baskets of commodities, price data allow us to consider changes in ‘real’ values and measure, estimate and test a wide range of economic hypotheses and relationships including, for example, changes in the cost and standard of living, purchasing power parity, real income and real wage convergence, both regionally and internationally. In most developed economies, the recent, post-war, history has been one of universal price inflation, where the differences that we see are only in terms of the rates of inflation and global, spatial, variation. However, long term price series, where they exist (e.g. Australia[1], Britain[2]), remind us that these post-World War II experiences are far from typical. Long periods of price stagnation and significant periods of decline were punctuated with relatively short periods of inflation, often caused by the need for the state to finance wars. Furthermore, the recent economic downturns associated with the global financial crisis led some to consider the possibility that the world might return to the spiraling deflations of the 1930s and renewed interest in historical analysis of prices including specific items e.g., housing and land. When we seek to undertake historical based analysis using New Zealand data, however, we immediately face a lack of data, at least in a readily usable form.

Price data are important as we assume that they embody a range of information on the products with which they are associated allowing consideration of such fundamental ideas as the “Law of One Price” (LOOP). Measures like the consumer price index (CPI) are based upon the ability to appropriately aggregate weighted combinations of goods and services to provide a summary cost of living measure of changes over time and space. Deviations in the LOOP are often used to consider the efficient functioning of markets, impediments to free trade, etc. An analysis of regional prices is important, especially when we consider the earlier periods of development, which were generally identified with exceptional fluctuations in prices in different localities due to the lack of facilities of communication, gold discoveries that altered the demand and supply of products etc. These factors could cause scarcity of certain products which would be reflected in prices, undoubtedly affecting the standards of living of that region or regions. A wide range of price indices exist, including wholesale prices etc., but the headline measure remains the CPI.

The New Zealand consumer price index was first developed by Fraser (1915) for the period 1891-1914. This was followed by Arnold (1982) who constructed a national CPI for 1870-1913. For many, this Arnold series is regarded as the most reliable series for that period. Nesbitt-Savage (1993) extended the Arnold series from 1847 to 1992 by using statistical methods to back cast the series. To extend the series forward, his new data were linked to the *Department of Statistics* CPI, producing a single, linked, series from 1847 to 1992. It is simple to extend this series forward to create a continuous, national, series from 1847.

This paper has two main purposes. Firstly, we will construct a New Zealand CPI series for the period 1885-1913 from a spatial perspective i.e., disaggregated at the level of the four major provincial districts: Auckland, Canterbury, Otago, and Wellington,[3]. The start point coincides with the availability of district level nominal price series reported annually in *Statistics New Zealand*. The construction of provincial CPIs was achieved by using nominal prices for a chosen basket of goods (based on the *Labour*

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[1] Mclean Ian (1999) – Consumer prices and expenditure patterns in Australia, 1850-1914. Bambrick, S. (1973), Australian price levels, 1890-1970.

[2] Mitchell B. (1988) – British historical Statistics, 1845-1966.

[3] *Statistics of New Zealand* in its yearly publications reported average prices of produce, provisions etc. for each provincial district of New Zealand from approximately 1847-1849.

Department Household Survey in 1893) from various sources[4]. Furthermore, to assess the representativeness of the newly derived provincial CPI series, they are aggregated and compared to the national level indices created by Arnold (1982) and Nesbitt-Savage (1993), and Sauerbeck's ('Prices of Commodities', various years) British series for the same period, to consider consistency, differences, etc.

Using these new data, the second focus of the paper will be on identifying and analyzing regional price movements and trends for the 1885-1913 period. This provincial level analysis will use a range of time-series methods including unit root and cointegration-based estimation methods to identify if the price series exhibit common stochastic trends or where appropriate, Engle and Kozicki (1993) and Vahid and Engle (1993) methods will be used to test for common cycles. From an economic perspective these methods will be used to consider the integration of markets over time and space, and to determine which of the four provinces were the driving forces in the economy during that period. The remainder of the paper is organized as follows. Section 1 provides a brief overview of previous work on New Zealand prices and is an adjunct to that provided by Briggs (2003). Section 2 presents the methods used, the choice of consumption basket and a discussion of the various indices presented. Section 3 considers the existence of common trends and cycles in the provincial level price data at the product level, commencing with a brief overview of the econometric testing methods employed. Section 4 presents and analyzes an aggregate price index at the provincial level and Section 5 at a national level. Section 6 considers avenues for future work and Section 7 - some conclusions.

1 New Zealand's historical prices series

1.1 McIlraith's series (1861-1910)

The earliest price index (wholesale prices) for New Zealand was developed by McIlraith[6] in 1911, most likely in response to heightened inflation prior to World War I.[7] The objective of the series was to measure changes in the general level of prices from 1860. In particular, McIlraith was interested in examining changes in the purchasing-power of money and to ascertain the causes of the changes in the local price level. McIlraith did not attempt to weight the commodities used in the series, but rather derived the unweighted wholesale prices from the import and export schedules, including prices of non-consumer items (e.g. zinc, lead, bar iron). Although McIlraith assumed that prices would deviate little among the main centers (provinces) based, in the main, on the upon the assumption that transport and communication between the different commercial centers of New Zealand was frequent and cheap[8], he adopted Wellington prices for the most frequently imported goods, and Christchurch retail prices for agricultural produce items such as cereals and meats. McIlraith used the Sauerbeck (1886, 1893, 1893-1912 publications) and the "Economist"[9] series to compare New Zealand and English price levels, and

[4] *Appendices of the Journal of the House of Representatives* (AJHR), Statistics New Zealand Yearly publications, Official Yearbooks: please refer to bibliography.

[6] James W. McIlraith, *The course of Prices in New Zealand: An Inquiry Into the Nature and Causes of the Variations in the Standard of Value In New Zealand.*

[7] Nesbitt-Savage, p.2

[8] McIlraith's (1911), p.32

[9] McIlraith's refers to "Economist" (Economist Magazine) price index (English price index) to compare New Zealand prices with prices in Britain.

found a marked coincidence among the series, specifically for the 1880-1889 decade, with average prices falling between 1880 and 1887 in both countries. He also compared his series to the Falkner[10] series (for the U.S.) and found that "…America, like New Zealand, did not experience the wave of inflated prices till 1872."[11] However, McIlraith was not clear on the sources and references of the series he had compared his series to.

As noted by Nesbit-Savage (1993), the McIlraith indices are not, however, an adequate consumer price series, since the prices he used to construct the indices are wholesale prices, which provide only approximate measures of the annual rate of change of prices.

1.2 Fraser series (1891-1914)

Sudden increases in prices in 1895-1896 subsequently appeared to change the *Department of Statistics'* view on the importance of surveying relative price movements. As a consequence, from 1914 the Government Statistician, Malcolm Fraser began regular surveys to monitor consumer prices, and produced a report on the long-term cost of living index.[12] Fraser was the first to attempt to weight the series based on records of people who were engaged in retail trade over the period 1891-1913.

The expenditure for each individual item (the "mass-unit") was ascertained by taking the average production of each commodity in New Zealand plus or minus the excess of imports over exports, or *vice versa*, all averaged over the past ten years. Fraser states that he used monthly sales for the various grocery items. The relative expenditure shares of the household budgets, collected by the *Department of Labour* in 1911-1912, were used to verify the results. The index numbers of retail prices for each sub-group (Grocery, Dairy, Meats and Rent) were compiled from prices collected in the four chief centers (Auckland, Wellington, Christchurch, Dunedin) over the 1891-1914 period.

Fraser's cost of living index has several limitations. Firstly, the retail prices for the grocery group in Christchurch were not collected prior to 1899. Secondly, the weights used by Fraser only approximate to the results obtained by the *Department of Labour* as he did not include certain items of fruit and vegetables[13] and also omitted the "other items" section, which by the 1910 expenditure survey constituted 40.34 percent of household expenditure[14]. However, most importantly, Fraser "neglected"[15] the *Statistics of New Zealand* annual return of retail prices published for each year since 1847, with the number of

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[10] McIlraith's (1911) reported the series from Falkner (America) for 1861-1899 period (p.64), he was not clear, however, on the source of the publication of the Falkner series.

[11] McIlraith (1911), p.75

[12] Nesbitt-Savage, p.3

[13] Fraser, M., *Report on the cost of living in New Zealand, 1891-1914,* p. 10

[14] Collins J.W., Cost of Living in New Zealand (report and evidence of the Royal Commission on). Department of Labour, 1912, H.18, p. xxi

[15] Refer to Arnold M.N, *Consumer prices 1870 to 1919,* p.1

items expanding from 1885[16]. Fraser's series is also restrictive in scope as it covered only food and rent. Finally, the series is "further limited because the compliers relied on less than optimum sources."[17]

1.3 Arnold's series (1870-1919)

In order to address problems with the Fraser series (e.g., a limited expenditure basket) and to extend the series (the Fraser series commences in 1891), Margaret Arnold developed a CPI series by revising the weighting scheme used by Fraser using annual average returns of prices reported in *Statistics New Zealand* from 1870 to 1919.

Arnold's long term series consisted of the five major subgroups of expenditure: food, housing, clothing, fuel and light, and miscellaneous items where she collected the prices for individual items for the years 1870-1901 and then linked them to the Fraser series. She constructed the individual series by first taking the midpoint of each range of values given for each province, and then weighting these midpoints by the proportion of population in the province. To develop her final CPI, she linked the five sub-series together. Although, for her final series she used various weights (Karamea, *Department of Labour*, and Fraser), Arnold reports that using different weights "made relatively little impact on the series." Arnold concluded that the five subseries all move together, showing the same U-shape as the general trend.

The completeness (Arnold used a wide range of commodities including miscellaneous items), and the similarity of the general trend with other existing series, appear to be the main reasons why it is the most commonly used index of changing consumer prices in New Zealand for the 1870-1919 period.

1.4 Nesbitt-Savage series (1847-1990)

Nesbitt-Savage (1993) used Arnold's series from 1870 to 1919 as the basic starting point when constructing his long run CPI (1847-1990).To obtain data prior to 1861 he used the Sauerbeck series (from Mitchell's "British Historical Statistics") from 1847-1860 arguing that there was a high coefficient of correlation between Arnold and Sauerbeck. However, the Sauerbeck index seems to suffer from the same basic problems as the McIlraith index (i.e., both series appeared to be static over time).

As a consequence, Nesbitt-Savage (1993) developed two models to construct (rather than directly measure) a long run CPI from 1847-1992. The first model used an overlap between McIlraith and Arnold to construct the series for 1861-1869. The second model used the correlation between Sauerbeck's and Arnold's series to derive an approximation for the 1847-1860 period. Nesbitt-Savage assumed the same consumption patterns (unchanged basket of goods) throughout that whole period (1847-1919). The models used simple linear regression techniques to predict the series, and the final series linked the four series: Model 2 (1847-1860), Model 1 (1861-1869), Arnold (1870-1919), *Department of Statistics* (1920-1992). Since his work, there has been considerable work on time series data related issues including unit root testing, cointegration and spurious regression. We will return to some of these issues later in the paper.

[16] Statistics New Zealand expanded the range of prices published since 1885 e.g. farm yard produce (eggs, ham, bacon etc.), garden produce (potatoes, onions, carrots, cabbages etc.), miscellaneous (coal, firewood etc.).

[17] Refer to Nesbitt-Savage, p 4. and Arnold M., p. 1 (for the period of 1891 to 1914 indirect methods were used: "...reminiscences and records of people who had been engaged in retail trade over the period")

2. Methods and data

This section describes the data sources used, the extent of the data coverage and the weights selection in the consumer price index basket. The period chosen covers the years 1885-1913. The period of data coverage could, in future, be expanded both backwards and forwards in time, and extended by including additional provinces as data exists for various provincial districts from 1847.

2.1 Basket choice

The basket of goods chosen in this study for constructing regional CPIs is similar to that reported in Arnold, but with minor changes (i.e., includes eggs in the grocery group; uses Fraser's expenditure breakdown for oats and rice, dried fruits, and vegetables – potatoes are also included; omits fish from the grocery basket). Arnold reported three different weighting schemes for different periods: *1875 Karamea weights* (1870-1893); *1893 basic expenditure weights* (1885-1919); *1910 Fraser Budget study weights* (1895-1919). Since the Karamea weights are less representative (the weights came from one store book), and Fraser's weights covered only a portion of the total expenditure pattern, here we use 1893 weights derived from the *Department of Labour's* 1893 *Household Survey* throughout the1885 to 1913 period. Table 1., below, lists the different basket weights for countries with similar labour markets. In these countries food and rent typically constitute the largest proportion of the overall expenditure with Australia and Britain having higher expenditure on rent than New Zealand.

Table 1. Country-specific alternative basket weights for Consumer Price Indexes

	New Zealand			Australia		Britain	
	1893 Household survey	1910-11 Labour Depart.	1875 Karamea weights.	1913 McLean (1999)	1911 Knibbs* 1994	Shergold (1982) 1914 Allen (1994)	The World Aggregate Williamson (1995)
Food	52.7	34.13	63.05	38.52	32.23	55	52
Rent (housing)	10.38	20.31	6.14	19.43	13.7	18	18
Clothing	17.52	13.89	14.6	21.39	12.72	16	
Fuel and Light	8.08	5.22	2.08		3.46	7	
Tobacco					0.63	2	
Alcohol	1.16		3.22	12.12	0.74	2	
Miscellaneous	10.16	26.45	10.91	8.54	36.52		

Notes and Sources:

* Extracted from R. Allen (1994): Australia, Knibbs (1911: 14, 19), food includes non-food groceries and non-alcoholic beverages.

Knibbs (1911) was the first, in 1910-1911, to survey, Australian spending patterns. Knibbs's Australian results – with their very small share of income spent on food and correspondingly large share spent on "other things",[18] produced results, for the same period, that were similar to those derived by the *Labour Department* of New Zealand.

McLean (1999) estimated a consumer price index for Australia for the 1850 and 1914 period using different expenditure composition patterns, and compiled several variants of the price index (the weights presented in the table above are for the 1913 expenditure weights).

Allen (1994) constructed a long run CPI for 1879-1913 to examine real income changes in Australia, UK, Canada and the US. He used Shergold's 1914 Burningham survey weights. The high expenditure weights on food and clothing are similar to the weights used in New Zealand for the 1893 Household Survey. Not all available weighting schemes are presented above, simply those that are commonly used in the literature.

In constructing the long run regional CPIs (for the four major provinces), it is assumed here that the same expenditure patterns/weights (the weights for the consumer basket are reported in Table 1 of Appendix B.) are used for the entire 1885-1913 period and for all of the provinces. However, for future work there is a possibility of applying different expenditure weights for different provinces although this would require a number of assumptions being made. *The Cost of Living in New Zealand Report* (1912) by the *Royal Commission* estimated differences in the cost of living between Christchurch and Auckland using a simple basket (food and rent): "the figures show an increase of 20 percent in the cost of living (food and rent) in Christchurch as against an increase of about 34 percent for Auckland. The Auckland budget shows an increase in food of only about 25 per cent., that for Christchurch about 21 percent."[19] These are examples of the figures prepared by the *Department of Labour (1912),* however, the sources of the information on the cost of living in major centers were not completely reliable. The report itself is a rudimentary summary of the statistics on prices in the Dominion at that time[20].

2.2 Calculation of the price series

The starting point for the construction of the various CPI data is chosen to be 1885 as this is when *Statistics New Zealand* started to collect a wider range of prices (extended vegetable and home produce section, as well as prices for fuel and light). In addition, most of the Census data (industrial census) are also only available from 1885 (the clothing series were calculated from that data). Finally, this start point includes the beginning of the refrigeration era and its subsequent boom years. Most of the grocery prices, meat, dairy, fuel and light prices were extracted from *Statistics New Zealand* annual publications for the four main regions: Auckland, Canterbury, Otago and Wellington. Grocery prices for such items as jam and dried fruits were taken from the import schedule until 1890 (except for Canterbury – until 1899) and were then linked with corresponding items reported in Fraser. The breakdown of dried fruits into prunes and apricots was converted into a single price series for dried fruits (75% of expenditure was assigned to prunes, and 25% - to apricots).[21] The fancy biscuit series was omitted since neither the household expenditure survey of 1893, nor the Fraser budget survey utilized this item.

[18] Allen (1994), 108

[19] Collins J.W., Cost of Living in New Zealand (report and evidence of the Royal Commission on). Department of Labour, 1912, H.18, p. xix

[20] Same, p. xii "...the work of the Commission has been made exceedingly difficult and less exact than should be desired, by the very serious defects in the statistics of the Dominion..."

[21] Fraser, Cost of Living Index. P. 11

In New Zealand, it has been common for some time for people to own their homes, and the *State Advances Department* assisted New Zealanders with this aim. The cost of housing includes the cost of upkeep, rates, and interest on mortgages owing. The practice of tenants leasing their homes at a fixed rent was more widespread than bargaining for weekly rents.[22] In this paper, consistent housing price data were derived from two sources: *Statistics New Zealand* pre-1902 (calculated from the number of boroughs and the rental value of rateable property), and the prices reported in Fraser (from 1902 -1913 differential housing prices (various number of rooms in the house) were assigned different weights and averaged). From the expenditure survey it is clear that four bed-roomed homes were most widespread, and as such, the highest weight was assigned to that category.

The *Miscellaneous* series consists of the prices on soap (washing); books (the income of public libraries for the respective education district); furniture and medical expenses. Proxying education is a difficult task since it was free, except for the cost of books, in New Zealand from 1877. Arnold used the value of imported printing paper as a proxy for education, however, this is potentially a misleading measure to account for the expenditure on books, as the paper was mostly used for printing newspapers.

As an alternative, in this study, public libraries subsidy data derived from the AJHR for each education district are used as a proxy for education expenditure. The way total income was calculated ("the only income recognized as entitling to subsidy was that derived from subscriptions and voluntary contributions…")[23] allows the data to be used as a possible proxy for overall literacy (total income for each education district was divided by the total population at each successive census). Furthermore, this alternative proxy can be compared with using the value of imported books to consider the effects on the resulting series.

Furniture prices were estimated by taking equal weights for carpenter's' wages (for each province) and the average price for exported timber (dressed timber) assuming the same regional prices.

Arnold derived medical expenses from the average contribution to Friendly Societies' funds. In an attempt to find a more appropriate proxy for medical expenditure, data on hospitals' receipts, 1885-1913 from *Statistics New Zealand* were utilized here. The actual data used were the total amount received from patients for each subsequent year, divided by the total number of patients in hospitals in the respective provinces. The four price series considered above have been combined to produce a 'Miscellaneous' series where the weights assigned were taken from Arnold, (1982).

2.3 Index choice and construction

Choice of an appropriate index for the analysis of our regional CPI is constrained by the availability of data. Prior to 1913 only annual data are available and we use the 1893 expenditure weights for the entire 1885-1913 period and apply them to all four major provincial districts.

If we consider the literature on index numbers, there are several axiomatic approaches to the choice of a price index. Under the first axiomatic approach, the quantities and prices are independent variables (the cross-elasticities of demand are zero). There are approximately twenty tests under which the indices are evaluated[24]. The Fisher index satisfies all twenty axioms, while the Young, Laspeyres and Paasche indices fail three time reversal tests. The Walsh index fails four tests, and the Tornqvist index fails nine tests. Nevertheless, the Tornqvist and the Fisher may be expected to approximate each other

[22] New Zealand Official Yearbook (1915)

[23] AJHR, annual publications, (1884).

[24] Consumer Price Index Manual: Theory and Practice. ILO Bureau of Statistics (2004)

quite closely numerically when the data follow relatively smooth trends[25]. In the second axiomatic approach, in which a price index is defined as a function of the two sets of prices, or their ratios, and two sets of values, the Tornqvist is the only price index that satisfies all seventeen axioms. This is one reason why this index is currently favored by many researchers.

In this paper, several indices are utilized to consider the robustness of the results. Most statistical offices use the Lowe index when calculating the aggregate CPI measure. The Lowe index measures the percentage change between the periods compared to the total cost of purchasing a given set of quantities (a "basket"): $P_{Lo} \equiv \sum_{i=1}^{n} (p_i^t / p_i^0) s_i^{0b}$, where s_i^{0b} are the weights (hybrid expenditure shares because the prices and quantities belong to two different time periods, 0- price reference and b –weight reference period, respectively), p_i^t / p_i^0 are the price relatives of the price of good i in period t and period 0 (period 0 is the price reference period). Special cases of a Lowe index are the Laspeyres index (when b=0 or the quantities are those of the price reference period), and the Paasche index, when b=t or the quantities are those of the other period. The Laspeyres index is also (similar to the Lowe index) calculated as a weighted arithmetic average, while Paasche is a weighted harmonic average of the price relatives that uses the actual expenditure shares in the later period t as weights ($P_p = \left\{ \sum_{i=1}^{n} (p_i^t / p_i^0)^{-1} s_i^t \right\}^{-1}$ - Paasche index).

The Young index is similar to the Lowe and Laspeyres indices as it is calculated as a weighted arithmetic average of the individual price relatives, holding constant the revenue shares of period b:

$P_{Yo} \equiv \sum_{i=1}^{n} s_i^b \left(\frac{p_i^t}{p_i^0} \right)$. The way this index is calculated, means that it is either assumed that the quantities of period b remain constant or the expenditure shares in period b remain constant. Here, the prices and quantities in the expenditure share belong to the same period. There is a geometric version of the Young index that is calculated as a weighted geometric average of the price relatives using the expenditure shares of period b as weights:

$$P_{GYo} \equiv \prod_{i=1}^{n} \left(\frac{p_i^t}{p_i^0} \right)^{s_i^b}$$

The geometric Laspeyres is a special case in which b=0 and the geometric Paache uses the expenditure shares of period t. In this paper the constant expenditure weights were assumed for the entire 1885-1913 period, which means that we are not able to differentiate between the weight reference period and the price reference period (the quantities are not available for every year). The indexes that are derived in this paper will be a fixed basket indexes due to data limitations. Other indexes that are not as widely used by statistical offices, but are theoretically valuable based on axiomatic and economic approaches, are the Fisher, the Walsh, and the Tornqvist. The Fisher price index is defined as a geometric average of the Laspeyres and the Paache indexes:

[25] CPI manual (2004), chapter 1.

$P_F = \sqrt{P_L P_P}$. Since the information on quantities is not available, it is not possible to use the Walsh index. The Tornqvist index is derived as a geometric average of the price relatives weighted by the average expenditure shares in the two periods ($\sigma_i = \frac{S_i^t + S_i^0}{2}$):

$$P_T = \prod_{i=1}^{n} \left(p_i^t / p_i^0 \right)^{\sigma_i}$$

The expenditure shares in both periods are equal in our case (1893 expenditure weights are assumed for the entire period), therefore the Tornqvist index is similar to the Geometric Laspeyres. Due to the limited information available for the construction of regional CPIs, we are not able to construct exact Tornqvist, Fisher, Laspeyres or Paache indexes by definition, but rather assume the regional consumer indexes, calculated in this paper, will be a close approximation of the latter indexes.

The indexes were calculated for each sup-group (three food groups: Meat, Dairy, and Grocery; Housing; Clothing; Fuel and Light; Miscellaneous), which were then aggregated into the final series using a higher-level index formula that depends upon the index used for the lower-level aggregation. The assigned individual weights for some items (the ones that imply variety e.g., dried fruits) were derived from consumption expenditure figures reported for individual items in Fraser. The base used for the indexes was the average of the 1909-1913=100.

The *food group* consists of three sub-groups: Grocery, Dairy, and Meat. The most "important" item in the grocery group was bread (flour expenditure weight was about 10 % of the bread weight), potatoes and rice prices series were both included, dried fruits (prunes and apricots) were presented as one series and tobacco was omitted since it was not included in the 1893 consumer basket.

The *frozen meat* price series comprises the prices on beef, mutton, pork, lamb and veal. Beef had the highest expenditure share, while mutton and lamb were assigned the same weights. The price of eggs was included in the *dairy price* index since it was reported in the home produce section (*Statistics New Zealand*), fresh butter and salted butter had the same weights.

Housing comprised only about 11% of total expenditure and it is much lower than the 20% in Fraser's Budget study, possibly because Fraser's survey was conducted for urban centers and at a later period, while rents in the 1893 expenditure survey were a provincial average. Fraser's breakdown of the expenditure basket may be considered at a later stage, however, as per Arnold, the final results are robust to the use of different weighting schemes.[26]

The *clothing* series were constructed from clothes, boots and shoes prices (derived from the Industrial Census' since 1885). Gaps in the clothing price series were estimated by linear interpolation. The percentage breakdown of expenditure for *miscellaneous items* was taken from Arnold (1982). To avoid taking any single year, which could be considered as abnormal, the mean of the 1909-1913 prices were used as the base period prices for all goods.

The resulting subgroups (*food: grocery, meat, dairy groups; fuel and light; housing; clothing; miscellaneous*) were then weighted according to the 1893 expenditure weights based on the household survey of the *Department of Labour* to produce a final CPI series for the four provincial districts. For the purpose of convenience, the sub-indices and final index presented in later sections, were derived as a Tornqvist price index, alternative (Paasche, Laspeyres and Fisher) indexes are presented in Appendix II.

[26] Arnold (1982), when calculating the final CPI series, tried different weights (Karamea's, Fraser's, and the 1893 expenditure weights), however, as she noted "this had made relatively little impact on the series," p.18.

3. Common trends and cycles: provincial price index series analysis

This section presents an analysis of some of the properties of each sub-series for the four main Provincial Districts using a range of time-series methods (e.g. Johansen (1988); Perron(1989); and Vahid and Engle (1993)). The first objective of this section is to identify whether any of the price series exhibit common deterministic or stochastic trends or cycles across the provinces. The second objective is to test for market integration by considering whether price convergence exists among the provinces (for traded goods) or if the product markets faced idiosyncratic shocks and/or exhibited different responses to them.

3.1 Composition of the sub-groups

The relative prices used to derive the spatial CPI series can be divided into items that were mainly exported, and ones that were being imported. (e.g. Exports: agricultural produce (oats, flour, potatoes); pastoral (beef, mutton, lamb, wool, butter, cheese, bacon). Imports: timber, kauri gum; foodstuffs (tea, coffee, salt, sugar, rice, pepper etc.); general items: clothes items, boots and shoes, coal, books. Home produce (eggs, vegetables: turnips, carrots, cabbages) were mainly produced and consumed domestically). It has been previously noted that we would expect the prices for imported items to be relatively constant over time compared with exported or home produced goods.[27] The reason for this distinction lies in the fact that in New Zealand export and home produce were mostly primary products, while imports were mainly secondary products. The relative prices were then grouped into the seven regional indexes.

The regional indexes consist of 7 sub-groups: grocery, dairy, meat, fuel and light, clothing, housing and miscellaneous. The individual items in each sub-group are supposed to comprise items that have similar price trends and are related to the assigned group. Most of the grocery group items are goods that were mainly imported or produced for domestic consumption (e.g. sugar) with the exception of wheat (the exportation of this commodity declined throughout the period and was extremely volatile due to its dependency on the weather). New Zealand's export sector could be identified with dairy (cheese, butter) and meat (lamb, mutton, beef) groups. Although the miscellaneous series index includes prices for a range of goods, this index series could also be associated with an export sector as it includes the price of timber. As for the clothing series, factory manufacturing began to increase from the middle of 1890's, whereas before that, most clothing items were imported. The fuel and light index included coal and firewood prices. The Otago region included a number of coalfields and the quantity of coal produced increased over the period, however, a large quantity was still imported.

3.2 Preliminary time series analysis of the series

Examination of the time-series properties of series typically begins with unit root testing to determine whether the series in question are non-stationary. Augmented Dickey Fuller (ADF) tests are probably the most commonly used unit root tests and are utilised here, however, the possibility that discontinuities exist in the series would lead to an incorrect size for the test leading to type I errors. To eliminate this problem, Perron-type unit root tests that account for structural breaks are also utilized (see Perron, 1989; Zivot and Andrews, 1992) where appropriate.

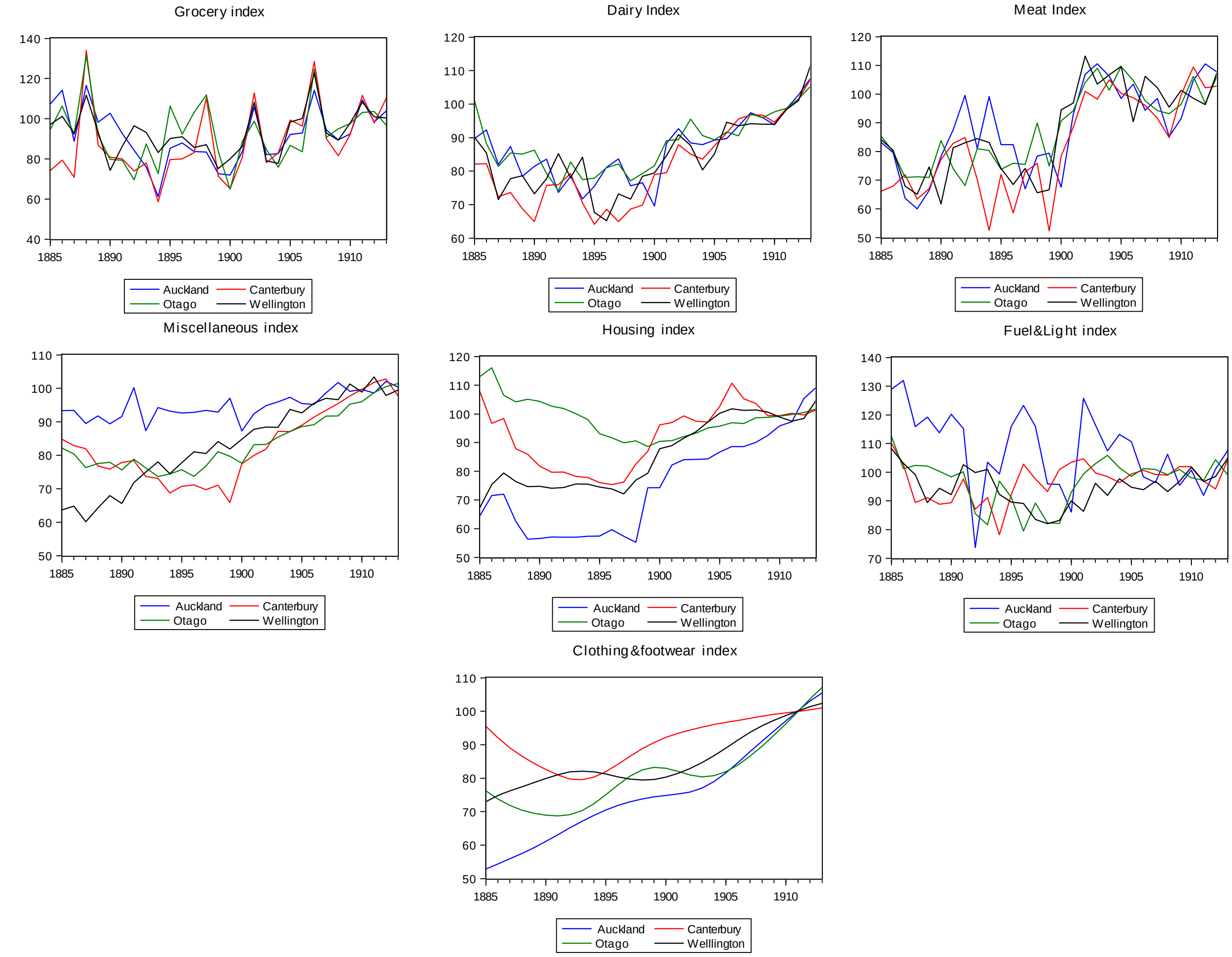
An alternative to using simple ADF tests is to use panel unit root testing approaches where the panel would comprise the four provincial districts. Much is claimed about the improved power properties of such tests and again, where appropriate, such tests will be performed. In particular, such tests will be

[27] Fraser, 18.

performed to check the robustness of the results of the individual ADF-type tests Here we use a range of panel unit root tests including Levin Lin and Chu (2002), (LLC) and Breitung (2000). These two tests are the only ones that assume identical autoregressive (AR) parameters across the panel (an identical first order autoregressive coefficient) and the Breitung test has been shown to perform better when deterministic components are included in the model. However, both of these tests would not be expected to perform well with our data as the LLC would have a loss of power in the presence of cross-sectional correlation as even in the absence of serial correlation it tends to overreject the null and Breitung is adversely affected by individual-specific effects which can have large effects on the appropriate critical values. The Fisher-type (Maddala, G. and S. Wu, 1999) panel tests will also be utilized as the effect of serial correlation is less severe for this test. In addition, the Fisher test has the highest power when performed in the presence of both stationary and nonstationary series in the group. Another important property of this test is that its asymptotic validity depends on $T \to \infty$ (in contrast the test of Im, Pesaran and Shin (IPS) depends on $N \to \infty$) which is more appropriate for our data ($N=4$, while $T=28$, therefore $T>N$). In spite of the advantages of the panel tests, the problem of the structural breaks in the data is the same as in individual ADF tests. The results with and without breaks (both individual and panel tests) will be presented for comparisons.

Before proceeding to the formal unit root testing, it would useful to examine time series the plots of the index series for each province. Figure 1 presents plots of the seven sub-series grouped by provincial district (PD)*:*

Figure 1. Sub-index series for the four main provincial districts (1909-1913=100)



In summarizing the data, each sub-series will be analyzed according to its PD. From the plot above, *the Grocery series* appears to fluctuate, or cycle, around a stationary trajectory for all the four PDs. Wheat and flour prices are responsible for the fluctuations in this index. The *Clothing series* also appears to exhibit a smooth trend with no yearly fluctuations or apparent outliers, however, this, in part, is due to the interpolation of the data between the industrial censuses. Whether these data are trend stationary or otherwise will be formally tested below.

From figure 1 and previous work by Greasley D., and Oxley L., (2010), we might expect that the *Dairy and Meat* series would be non-stationary. Dairy prices fell considerably in 1895 in Auckland and Wellington and this change in prices probably occurred as a consequence of the reduction of duties on imported goods in 1895 (there was a steady movement towards a reduction of the duties levied upon imported foodstuffs from 1895, followed by another tariff reduction in 1897)[28], and an extension of the tariff levied upon imported manufactured goods, which were put in place to protect infant industries, but often led to an increased cost of production. Price fluctuations due to tariff changes were not so apparent for the other two provinces (the index series were constructed using retail prices that were subject to customs regulations).

[28] Appendix III.

The *Meat and Dairy* index series fluctuations seem to differ, with Dairy having more of a u-shaped curve, and Meat appearing to be more stationary, but with more violent fluctuations across the provinces. The advances in the frozen meat trade likely played a role for this series' increasing trend, more clearly recognized after 1900. A possible structural break could be dated around 1898 for the meat series and associated with the falling prices of wool and mutton. The subsequent rise in meat prices was mostly driven by a rapid increase in the retail mutton prices in the early 1900's which appears to be universal across the four provinces where the frozen meat trade flourished, and technological innovations in that industry finally began to bring profits to New Zealand. The leading province of this sector was probably Canterbury, where meat production from this province dominated the frozen meat trade until the First World War. As the frozen meat trade to the UK began to flourish it was easier to switch large areas in the Canterbury region from growing crops to pasture than it would had been in the North Island as most of its territory was covered in bush. In 1900, 50% of frozen sheep carcasses exported were shipped from Canterbury where, by this time lamb had become increasingly important in the frozen meat trade.

The *Miscellaneous series* (washing, books/education, medical expenses, and timber exports) is a more heterogeneous series than the others since it includes data on various goods and services. In the case of Auckland, it appears to be trend stationary (the data has minor fluctuations with a constant trend). This index includes national timber prices which varied little across the provinces, suggesting that the disparities across provinces would not be due to fluctuations in timber prices. It seems, however, that the provinces had different time paths for this index, for example, Wellington has an apparent upward trend while the index series for Canterbury and Otago only begin to exhibit an increasing trend after 1899. The apparent increasing trend after 1899 for both Otago and Canterbury might, however, be driven by the education cost figures which was calculated as the total contribution to the public libraries divided by the population for each year.

The *Housing index* exhibits significant variation across provinces until 1900 (before 1900, the coefficient of variation had the highest value of all the indexes across provinces). Auckland's housing prices were consistently lower than those in other provinces before 1898, after which there was a rapid rise in prices that could be attributed to an increase in the population of that province due to migration. Provincial migration figures indicate a significant surplus in the net interprovincial migration during 1891-1896 compared to the previous decade[29]. This is perhaps not surprising considering that by the end of 1890's Auckland's economy was booming due to an increased demand for refrigerated products and /increased volume of exports to the UK, US and Australia triggered by the increase in dairy and meat production following the pastoral land expansion in the North. Wellington exhibited a similar trend of increasing housing prices after 1898. Otago, on the other hand, showed the opposite tendency: housing and rental prices fell throughout the period likely due to the net interprovincial outflow. Any trend in housing prices for Canterbury is not obvious from the plot where: prices were falling at the beginning of the period, but then started increasing after 1897, eventually converging to the provincial level. In 1897 Canterbury experienced a general increase in the cost of living, where the prices for most exported goods increased (flour and bread prices were at their peak probably due to an increase in export prices for flour).

Fluctuations of the *Fuel & Light index* are most apparent for Auckland with dramatic falls in 1893 and 1900, which look more like outliers rather than a part of the general trend. Apart from this, the tendencies of these index series are similar to the overall tendency of falling prices from 1892 until 1899 and a universal increase thereafter.

[29] Appendix I, Table 4.

The index series plots were carefully examined, some expected priors have been intimated with regards to their stationarity properties. In the next section we undertake individual ADF tests to ascertain the statistical properties of the series

3.3 Individual Unit Root tests

Table 2, below, presents a summary of the outcomes of ADF unit root tests on the seven sub-series reported by Provincial District:

Table 2. ADF unit root tests in levels for the sub-series in each Province

Index series by province	Auckland	Canterbury	Otago	Wellington
Grocery	∨	∨	∨	∨
Dairy	××	××	∨∨	××
Meat	××	××	∨∨	××
Housing	××	××	×	××
Fuel and Light	∨	∨	×	×
Clothing	∨∨	∨∨	×	∨∨
Miscellaneous	∨∨	××	∨∨	∨∨

Note: **"**∨**"**- the series are stationary or I(0), **"**∨∨**"** – the series are trend-stationary
"×" – the series are non-stationary without a linear trend, **"××"** – the series are non-stationary with a linear trend

Individual unit root tests indicate that Dairy, Meat and Housing are non-stationary in their levels for Auckland, Canterbury and Wellington. The Grocery index is stationary across the four provinces, whereas the Miscellaneous group is difference stationary (except for Canterbury). The Clothing series is difference stationary (except for Otago) and the Fuel and Light indices are non-stationary for Otago and Wellington. The results are interesting as Auckland, Canterbury and Wellington are similar in terms of the series that are non-stationary, while Otago appears to be an outlier. The important result here is that the export sectors (meat and dairy) seem to exhibit non-stationarity in the price series for more than one province. However, these individual ADFs do not account for possible structural breaks in the series, and as it was observed from the data plots earlier, that there are possible discontinuities around 1900 and the mid - 1890's.

3.4 Panel Unit Root tests

To consider the robustness of these results the next section presents panel-based unit root tests. As discussed earlier, the Fisher-ADF (Maddla and Wu, 1999) will be utilized for panel unit root testing for the sub-index series (individual effects and trends were included based on individual ADFs, lag selection was based on SIC criterion) and the results are presented as Table 3 below.

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Table 3. Panel unit root test (Fisher-ADF)

Panel variable	Z-statistics
Grocery	-5.14*
Dairy	-1.53
Meat	-2.45*
Housing	0.645
Fuel and Light	3.672*
Clothing	-3.427*
Miscellaneous	-2.432*

Note: Ho: existence of a unit root in the panel, H1: some cross-sections do not have a unit root. ***** indicated rejection of the null at the 5 % level of significance.

The results are similar to those discussed in section 3.3, however, they also do not account for possible structural breaks in the series.

3.4 Zivot and Andrews based Unit Root tests

Table 4 below presents the results of using Zivot and Andrews (1990) unit root tests to consider possible discontinuities in the series (please refer to Appendix for details):

Table 4. ADF unit root tests in levels (breaks considered) and first differences

Index series by province	Auckland	Canterbury	Otago	Wellington
Dairy	××	××		∨′
Meat	××	××		∨′
Housing	××	××	∨′	××
Fuel and Light			×	×
Clothing			∨′	
Miscellaneous		××		

Note: **"××" –** I(1) series (first-difference stationary) with a linear trend in levels
"×" – I(1) series without a linear trend in levels (constant trend)
"∨′"- I(0) series, stationary with a crash and trend in the data (when the crash and trend in the series are taken into account, see Appendix for details).

From these results it appears that 1895 and 1900 were the most commonly identified break points with four that were significant; two for Otago (Housing and Clothing series), and two for Wellington (Dairy and Meat). For Otago, there was a significant change in both the intercept and the trend in the Housing index in 1895, and a trend change (growth rate) in 1901 for the clothing series. These results are not unexpected as the two index series are stationary elsewhere, and the structural break was obvious from the plots. As for Wellington, the results are more interesting – for the dairy index the structural change (crash and trend) took place in 1895, however, the null (of a unit root in the presence of a break) was rejected marginally at 5%. The structural change in the dairy series was also the same for Canterbury as for Wellington - in Canterbury's case the changes had permanent effects, probably as a consequence of the reduction of duties on imported goods in 1895. The meat index had a different tendency, and the break occurred at a different time (crash and trend around 1900). The change in the level after 1900 is apparent from the meat series plot for the Wellington PD, and it seems that there was a general increase in prices after 1900 across all provinces. The conclusion here is that the break tests suggest that the series are stationary around the break in a trend and/or intercept, which would otherwise be considered as non-stationary based upon simple ADF or panel-based unit root tests.

3.5. Testing for Convergence in Prices

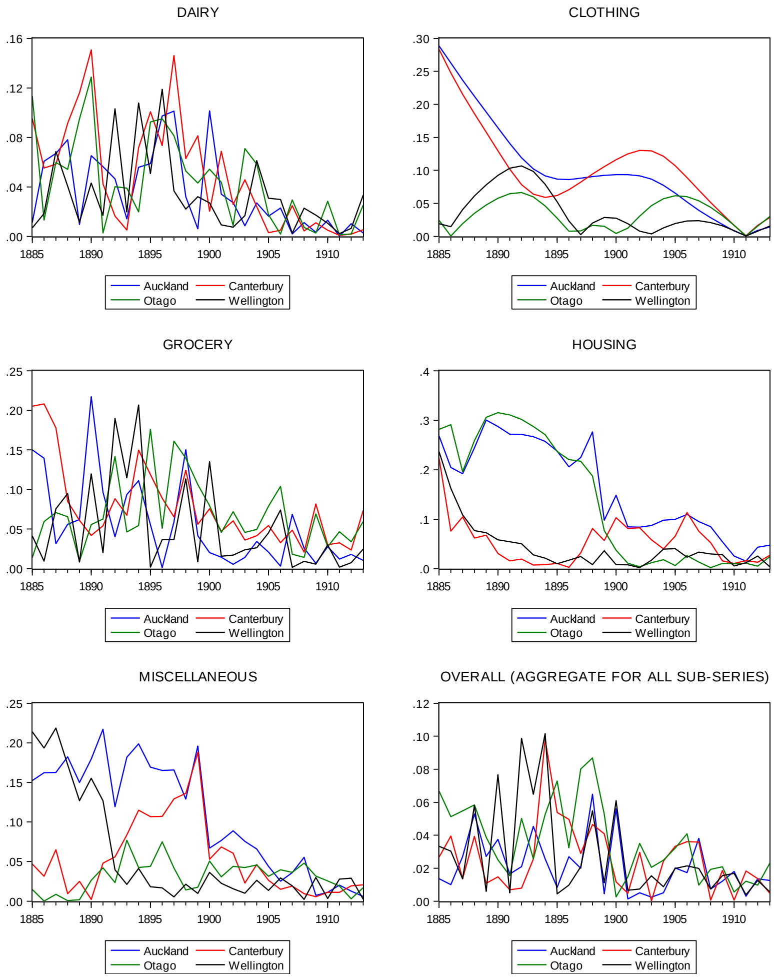
The previous sections explored the time series properties of the various sub-series that comprise the aggregate CPI series. In this next step, we will consider the possibility of convergence in prices or common trends in prices across the regions for certain traded commodities. Economically, such investigations are important for consideration of such issues as the Law of One Price (LOOP) and the integration of domestic markets. LOOP is more likely to occur for homogeneous, traded goods prices, and it is on these goods that we will concentrate. Tests for convergence will typically differ depending on the time series properties of the data and we will draw upon the results above to guide the choice of tests employed.

3.5.1 Testing for Convergence in Prices: Coefficient of variation

Figure 2 below presents measures of the coefficient of variation (absolute deviation divided by the weighted average) to consider the relationship between the dispersion of certain price index series (mainly food) across regions and the stage of the business cycle. Relative dispersion (coefficient of variation) measures were calculated for all the price index series.[32]

[32] Appendix IV, Figure 1.

Figure 2. Coefficients of Variation



The degree of dispersion across the four provinces appears to be lower for dairy, meat, fuel and light, and grocery which could reflect of the relative homogeneity of the items in each group. All the price series exhibit a universal decrease in the level of dispersion post-1900. From the plots, the meat index starts the period with relatively low levels of dispersion across provinces, which is followed by an apparent increase until it convergences post-1901. The Dairy index experiences the most dispersion during the 1885-1890 and 1894-1900 periods, and it appears that convergence occurs more slowly than for the meat index.

Overall, these simple measures of convergence appear to show convergence across the provinces especially post-1900.

3.5.2 Testing for Convergence in Prices: Bernard and Durlauf (1995)-type tests

According to Bernard and Durlauf (1995), the definitions of convergence rely on the notions of unit roots and cointegration in time series. The definition of convergence considers whether the long-run forecasts of (output) differences tend to zero as the forecasting horizon tends to infinity, which for non-stationary series requires that the two (or multiple) series are cointegrated with a cointegrating vector [1,-1]. If the series are not cointegrated with a vector [1,-1], they can still share a common trend (long-term forecasts are proportional at a fixed point in time), which would imply that that the two (multiple) series are cointegrated with a cointegrating vector [1,-a]. To operationalise this approach requires that the series are all integrated of the same order and are non-stationary. Our previous results established which of the seven sub-series are I (1) and which are I (0).

Bernard and Durlauf's (1995) approach can be used to consider bi-variate convergence and in this case the test is a simple unit root-based test of the differences in prices across provincial districts as defined by (1) below:

$$p_{it} - p_{jt} = \mu + \alpha(p_{i,t-1} - p_{j,t-1}) + \beta t + \sum_{\kappa=1}^{\nu} \delta\Delta(p_{i,t-k} - p_{j,t-k}) + \varepsilon_t \qquad (1)$$

where p_{it} represents the logarithm of price in district i in period t. If the difference between the price series contain a unit root, α=1, prices in the two provinces will diverge. The absence of a unit root, α <1, indicates either catching-up, if β≠0, or long-run convergence if β=0. Or can be multivariate across three or more districts utilizing either panel-based unit root testing techniques or cointegration methods for example y Phillips and Ouliaris (1988) and Johansen (1988).. For further details on the testing approaches, see Greasley D., and Oxley L., (2010).

Table 5 below presents the results based on unit root tests on the bi-variate differences between various pairs of provincial sub-series prices. On the bases of the results, the convergence hypothesis is not rejected in the Dairy series with long-run convergence present in the Meat series for the Canterbury-Auckland pair. Long-run convergence was also present in the Housing prices for the pair Canterbury-Wellington. To consider the robustness of these results (Table 5), we also consider Johansen-based estimation results to test for convergence and common trends, with the results presented in Table 6.

Table 5. Unit root test on the difference between each pair of provinces (without discontinuities) for the period 1885-1913

$y_{i,t+k} - y_{j,t+k}$	Dairy		Meat		Housing		Fuel & Light	
Provinces	ADF (2)	LM (SC)	ADF(0)	LM(SC)	ADF(0)	LM (SC)	ADF(0)	LM (SC)
Canterbury-Auckland	-4.66* (T)	1.92476	-4.779*	0.2646	-3.6287	1.194		
Canterbury-Wellington					-6.79*	0.0417		
Auckland-Wellington					2.4891	5.4307*		
Otago-Wellington							-3.486	0.225

*t-statistics denotes significance at the 5% level based on MacKinnon (1991), ADF (2) and ADF (0) indicate the number of lagged differences of the variables (based on SIC criterion). (T) relates to trend significance at the 5 %.

Table 6: Dairy and Meat price index series - Auckland and Canterbury
Cointegration results: Johansen estimates, VAR=1, 1885-1913
Unrestricted intercepts and trends in levels (all trends are stochastic)

	Canterbury			
	Dairy		**Meat**	
Auckland	21.251*$^{\alpha}$ 0.2416 $^{\alpha}$	21.009*$^{\beta}$ 0.2416$^{\beta}$	23.07*$^{\alpha}$ 1.962$^{\alpha}$	21.107*$^{\beta}$ 1.962$^{\beta}$

Note: α- indicates trace statistics and β- maximum eigenvalue statistics. *indicates the rejection of the null of no cointegrating relationship at the 5% level. Lag selection in VECM was determined by prior estimation of an unrestricted VAR model in levels for each system of equations.

The test results confirm that both dairy and meat series for the Canterbury-Auckland pair each exhibit one significant cointegrating relationship. The cointegrating vectors are presented as follows: [1, -0.73] and [1, -0.894] for the Dairy and the Meat, respectively. Following the Bernard and Durlauf (1995) approach, we can impose restrictions on the coefficients to identify if the series are converging with a cointegrated vector [1, -1], or share a common trend with a cointegrated vector [1, -α]. The likelihood ratio (LR) test for binding restrictions in the case of the dairy series rejected the restrictions [1,-1] on the coefficients at the 5 % level of significance (χ^2(1)=8.24), which suggests that Auckland and Canterbury share a common trend but do not converge to a common steady state equilibrium. The opposite was true for the meat prices series: LR test did not reject the null for binding restrictions [1,-1] with χ^2(1) =0.478 which is an indication that series have converged in a Bernard and Durlauf sense. Johansen's bi-variate test results for the housing price index, presented as Table 7 below, identify one significant cointegrating relationship: between Canterbury and Wellington. Housing prices in these two provinces are cointegrated with a cointegrating vector [1, -0.86].

Table 7: Housing index series.
Bi-variate Cointegration results: Johansen estimates, VAR=1, 1885-1913
Unrestricted intercepts and linear trends in levels

	Auckland	**Canterbury**		**Wellington**	
Auckland		13.453 $^{\alpha}$ 0.3238 $^{\alpha}$	13.129$^{\beta}$ 0.3238$^{\beta}$	13.643$^{\alpha}$ 0.354$^{\alpha}$	13.289$^{\beta}$ 0.354$^{\beta}$
Canterbury				31.861*$^{\alpha}$ 0.0105$^{\alpha}$	31.850*$^{\beta}$ 0.0105$^{\beta}$

Note: α- indicates trace statistics and β- maximum eigenvalue statistics. *denotes the rejection of the null of no cointegration at the 5 %.

As previously, we test the implied restrictions for convergence. The LR test for binding restrictions leads to non rejection of the null at the 5 % level (χ^2(1) =1.988). The results therefore suggest that, Canterbury and Wellington experience long-run convergence to the steady state, given that they are cointegrated with a cointegrating vector [1, -0.861]. A plot of the coefficients of variation supports this finding (the deviations from the weighted provincial mean of these two provinces seem to fluctuate closely together, with its subsequent decay at the end of the period).

3.6 Testing for Common Cycles: Engle and Kozicki (1993) and Vahid and Engle (1993).

Pairs of I(1) variables that do not exhibit a common stochastic trend (long-run movements do not follow a common path), may exhibit common cycles in the (stationary) first differences of the series. The first step to test this hypothesis is to examine whether cyclical dynamics are present in the data in the form of serial correlation. Following the procedure suggested by Engle and Kozicki (1993) and Vahid and Engle (1993), we tested for the presence of serial correlation in a VAR model in first differences (first for the Canterbury-Auckland pair, then for Auckland Wellington pair). The results are presented as Tables 8 and 9 below.

Table 8. LM tests (trend included) – Housing series

Dependent Variable	$\chi^2(3)$
Auckland	6.69
Canterbury	5.346

Table 9. LM tests (trend included) – Housing series

Dependent Variable	$\chi^2(3)$
Auckland	8.721*
Wellington	10.26*

*denotes rejection of the null of no serial correlation

LM statistics (calculated as N*R ^{2} with 3 df) indicate the presence of serial correlation in bivariate linear combinations for the housing series between Auckland and Wellington. The next step is to test whether these price series are driven by a common serial correlation feature, which can be estimated by utilizing a two-stage least squares approach using lagged values of the variables as instruments. Based on the 5% critical value of the LM test ($\chi^2(1) = 1.218$), there is no significant serial correlation present in the residual series, which suggests an existence of common cycles between Auckland and Wellington.

This suggests that the movements in the combined series are not predictable from the past information set and that the series' components were therefore generated by a common cyclical process.

The final I(1) series that were tested for cointegration are fuel and light prices for Otago and Wellington. Johansen test could not identify a significant cointegrating relationship between these two variables, which is consistent with our previous findings. Although, the fuel and light variables are not cointegrated, it is still possible to test for common cycles in the first differences of the series. LM statistics (calculated as N*R ^{2} with 2 df) did not indicate the presence of serial correlation in the bivariate linear combinations for fuel and light series:

Table 10. LM tests – Fuel & Light index (variables are in the first differences)

Dependent Variable	$\chi^2(2)$
Otago	0.81
Wellington	2.646

*denotes rejection of the null of no serial correlation

This suggests that it would not make sense to test for common cycle process as the series fluctuations are independent of each other, such that the series respond differently to the same and/or different shocks.

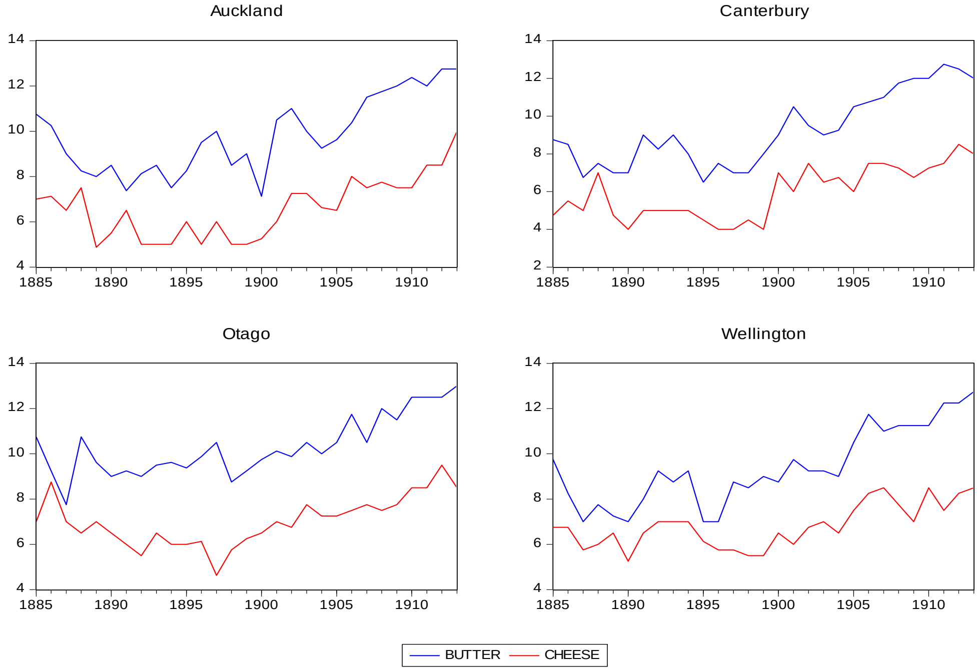
3.7 Testing for Causality: Leading Provinces

Johansen tests established three cointegrating variable pairs: the dairy, the meat (Auckland and Canterbury), and the housing price series (Canterbury and Wellington). If the variables are cointegrated then there must exist a causal relationship in at least one direction (Johansen, 1988). We might expect Canterbury to be the province leading price changes in both the dairy and meat sectors. When profits from refrigerated shipping were realized it was much easier to convert already available farm land from agricultural to pastoral in the case for Canterbury (the lands in the North were covered in bush, which delayed the use of that land for pastoral purposes). Nominal prices for all dairy (butter and cheese) and meat products (lamb, beef etc.) were the lowest in Canterbury. However, we should be cautious when making conclusions with regards to the dairy sector as it consisted of both butter and cheese, and, as previously noted in Greasley D., Oxley L. (2010)[33], those two commodities require different production technologies, and their growth paths could be dissimilar. During this period, the largest quantity of butter came from Canterbury due to its large farming population and the large area in Banks Peninsula devoted to dairy farming[34]. Most dairy factories were producing only butter for commercial purposes (export) in 1880's-1890's, and it was only in the late 1890's that many converted to produce both butter and cheese. To differentiate between the butter and cheese prices fluctuations, consider initially their individual time series plots:

[33] "…Meat and cheese show accelerating growth from the 1880's, whereas butter's faster growth came later with a spurt from the mid-1890's…Cheese also witnessed a more dramatic acceleration early in the twentieth century…pre-1914 trend growth accelerations may explain why the causality results show that cheese led butter, even though butter eventually became the dominant industry between the world wars" – Oxley L., Greasley D. (2010), p. 448.

[34] Te Ara - NZHistory.net.nz, Butter manufacturing

Figure 3. Butter and cheese prices (per lb.) for the four provinces (1885-1913)



Notably, prices of butter and cheese were the lowest in Canterbury until around 1900. The common price increase for prices of butter in 1890 could be due to extra costs from the change in technology of butter production: creameries were set up in the 1890's along with the skimming stations. In 1885 the manufacture of cheese was typically undertaken in factories, much more so than for butter. However, according to the Census, the returns from cheese factories were only around forty percent of the total factory produce.[35] Both butter and cheese series seem to have similar trends, however the yearly fluctuations are not common across provinces (only Auckland's price fluctuations seem to identify that butter lagged behind cheese prices). For further examination of the series, time series methods will be employed as previously, commencing with unit root tests:

Table 11. ADF unit root tests in levels (breaks considered) and first differences

Index series by province	Auckland	Canterbury	Otago	Wellington
Butter	××	××	√√	√√
Cheese	√′ (Trend – 1895)	√′ (C&T – 1900)	√′ **(**C&T – 1899)	√′ **(**Crash – 1895)

Note: **"××" –** I(1) series (first-difference stationary) with a linear trend in levels
"√√" – the series are trend-stationary
"√′"- I(0) series (level stationary) with a structural change or break.

[35] AJHR, 1887. H1-Session II.

Table 12: Butter prices - Auckland and Canterbury
Cointegration results: Johansen estimates, VAR=1, 1885-1913
Unrestricted intercepts and trends in levels (all trends are stochastic)

	Canterbury	
Auckland	16.5644*$^{\alpha}$	15.494*$^{\beta}$
	0.6911 $^{\alpha}$	0.6911 $^{\beta}$

Note: α- indicates trace statistics and β- maximum eigenvalue statistics. *denotes the rejection of the null of no cointegration at the 5 %.

It seems that the non-stationarity of the dairy index (for Auckland and Canterbury) was driven by butter prices rather than cheese prices. The butter prices between the two provinces appear to satisfy the properties of a long run equilibrium relationship (the LR test for a binding restriction was not rejected χ^2 (1) =0.937), while the prices of cheese among the four provinces exhibit a common cyclical process (the LM test indicated no serial (AR (1)) correlation in the residual series when testing for a common serial correlation feature). The results are subject to the chosen period since cheese prices experienced an accelerated growth earlier (the beginning of 1880's) than butter (in the mid- 1890s), it is possible that if we were to consider a longer period cheese prices would be driving the dairy sector.[36]

With regards to provincial-based tests of causality (dairy and meat sectors), the bi-variate Granger test results indicated that Canterbury was the leading province in both dairy and meat prices.

Table 12: for Bi-variate Causality: Granger (1986) Causality Tests

	Dairy price Index - Auckland	Dairy price Index - Canterbury
χ^2 LR criteria	8.84*	0.261

*indicates rejection of the null hypothesis of no causality at the 5% level; the optimal lag is 1 in the VAR based on SIC criterion.

Table 13: for Bi-variate Causality: Granger (1986) Causality Tests

	Dairy price Index - Wellington	Dairy price Index - Canterbury
χ^2 LR criteria	15.818*	0.846

*indicates rejection of the null hypothesis of no causality at the 5% level; the optimal lag is 1 in the VAR based on SIC criterion.

Turning to housing prices in Canterbury and Wellington, causality is reversed. According to the test statistics, Wellington is the leading province. This could be attributed to high rates of migration to Wellington, whose population persistently increased from the beginning of the period. Canterbury's population, on the other hand, was increasing at a much slower rate, with a net interprovincial outflow (especially during the 1891-1896 period).[37]

[36] Please refer to Greasley D., Oxley L. (2010) for results.

[37] Appendix I, Table 3

Table 14: for Bi-variate Causality: Granger (1986) Causality Tests

	Housing price Index - Wellington	Housing price Index -Canterbury
χ^2 LR criteria	3.4	9.16*

*indicates rejection of the null hypothesis of no causality at the 5% level; the optimal lag is 1 in the VAR based on SIC criterion

Analysis of the sub-index series resulted in some interesting conclusions with regards integration of the four regional markets. We have established that prices for dairy in Auckland and Canterbury share a common trend (forecasts are proportional at a fixed point in time), and meat prices converged between those two provinces. These finding carry important information on the South-North convergence, demonstrating that the refrigeration boom initially benefitted the South more than the North, which then changed from the late 1890's-1900's as the new trade reshaped agricultural production and more land became suitable for farming.[38] We also established that Canterbury and Wellington housing prices converged, where the South-North direction also seems to be present supported with data showing negative rates of net interprovincial migration in Canterbury, and positive for Wellington. The serial correlation tests suggest an existence of common cycles between Auckland and Wellington, implying that housing prices for these provinces respond to common shocks and the changes in prices follow a common dynamic cyclical pattern.

Consideration of the various price series gives support to a story of South-North convergence after 1900. This story is supported for the period 1896-1911 by trends in net interprovincial migration which showed an increase in the population moving to Auckland and Wellington provincial districts (PD), and a slight decrease in population migrating to the provincial districts of Canterbury and Otago (see Appendix I). This could be explained by the shift in productive capacity from the South to North Island. Immigration from overseas also supported this tendency, since most immigrants were from Great Britain and Australia, and the largest number undertook farming work[39]. The attraction of the North Island was promoted by the progressive clearing of the bush for farmland, the cessation of overt Maori resistance to European land settlement, the mining of gold near Thames, and above all, unprecedented scope for new developments and rationalization of agriculture.[40] The refrigeration boom stimulated diversification of agricultural production, which led to an expansion of farming in the North Island (better climate, more suitable agricultural land), and encouraged more intensive settlement.

4. Aggregate Provincial Consumer Price Indices

The period 1885-1913 is one of the most controversial in New Zealand's history exhibiting a period of depression and price deflation; rapid increase in production in the export industries (frozen meat and dairy); intensive technological change in both agriculture and manufacturing. Such factors may be well known to some, but regional variations in such national trends are less well studied or understood. The objective of this paper was to identify whether these national trends were mirrored in all the provinces and whether there were any significant differences in the standards of living at the provincial level.

[38] Between 1892 and 1900 the Liberal Government acquired 1.3 million hectares of Maori/native land which has started a transformation of North Island hill country from bush to pasture.

[39] AJHR, 1909: H11, p. IV.

[40] Warwick Neville R.J. and O'Neill James (1979), 'The population of New Zealand: Interdisciplinary perspectives'.

For the period 1888-1891, there is a universal (i.e., common to all four PDs) decline in consumer prices. There was also a, common to all provinces, increase in consumer prices from around 1903, which might be associated with a land boom in New Zealand. Finally, there was a fall in consumer prices between 1907-1909 and a subsequent increase.

The aggregate provincial indexes show strong correlation among the provinces, however consumer prices fluctuate greatly (there are noticeable differences in the price levels among these regions) before 1900 with a common peak in 1887.

Table 15. Correlation coefficient matrix of the price indices in the four regions

	Auckland	Canterbury	Otago	Wellington
Auckland	1			
Canterbury	0.9220	1		
Otago	0.8786	0.8740	1	
Wellington	0.8830	0.8950	0.7675	1

Prior to 1900, provincial differences were more apparent. In 1890, Wellington's prices were approximately 75% of the average of prices during the 1909-1913 period, and in 1894, Canterbury's price level fell to 68% of the average price level of the base period. Prices in Otago appeared to be the most stable throughout the period of study, while Canterbury experienced more fluctuations in the price level compared to the other provinces.

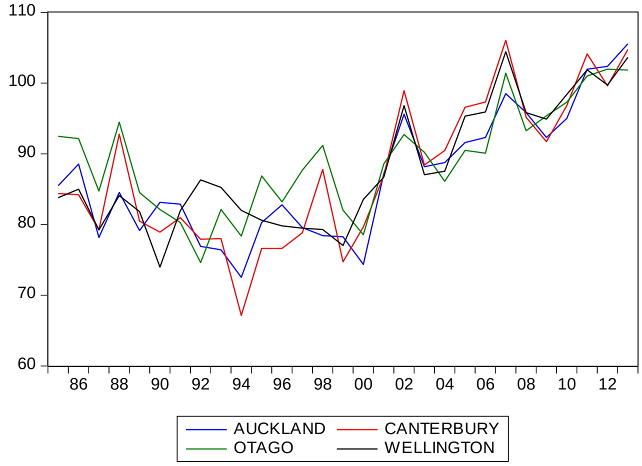
Table 16. Descriptive statistics for the aggregate provincial indexes

Variable	Obs	Mean	Std. Dev.	Min	Max
Auckland	29	86.776	9	72.53	105.55
Canterbury	29	87.417	10.29	67.14	106.06
Otago	29	89.164	7.49	74.62	102.98
Wellington	29	87.978	8.67	73.98	104.43

It seems from Figure 3 that during 1890-1899, Wellington's price index was quite static (the exception being an increase in 1893) and gradually fell to the 1890 level by 1900. The other provincial districts experienced more fluctuations: Auckland's and Canterbury's price levels decreased significantly, with a dip in 1894. Otago's prices fell in 1894, but the decrease was only by a few percentage points. From these descriptive statistics it is evident that the price indexes in Otago and Wellington had less variation (the standard deviations were lower compared to the other two provincial districts).

The aggregate index series combine all the seven sub-series (the Tornqvist formula). Food sub-series (grocery, dairy, meat) carry the largest percentage in the basket, so that the fluctuations in these series would have the most impact on the final series.

Figure 3. Aggregate (of seven sub-series) consumer price index series in the four main PDs



The four provincial aggregated series appear to have similar features, especially after 1900. Here, we will consider their time series properties including the effects of possible discontinuities. From the above plot, we might expect to see breaks around 1900, however it seems that 1895 could also be a break point year for Auckland, Canterbury, and possibly Otago.

Table 17. Unit root tests for the four aggregates (in levels) with and without breaks

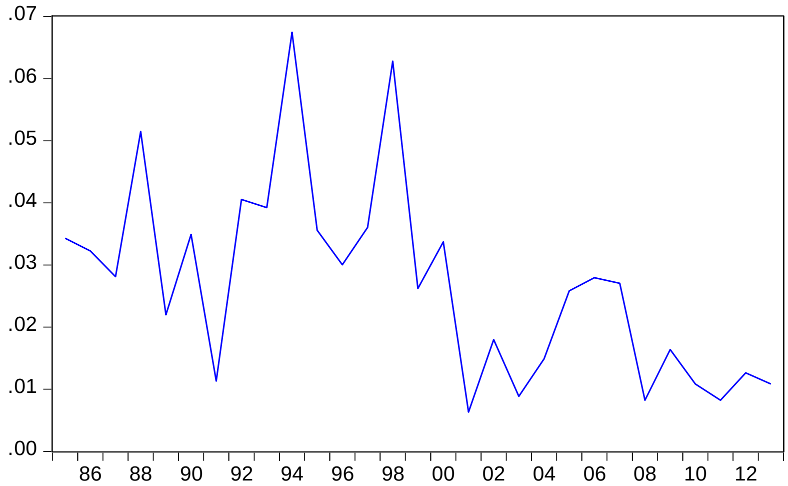
Aggregate price index	ADF: Intercept/no trend	ADF: Trend and Intercept	Zivot and Andrews: Break
Auckland	-0.846	-2.589	-5.4* (C&T-1901)
Canterbury	-1.633	-3.252	-5.41* (Trend -1895)
Otago	-1.865	-3.267	-5.78* (Trend – 1893)
Wellington	-1.085	-3.014	-4.43* (Trend -1899)

Note: *denotes rejection of the null of a unit root (with and without breaks) at the 5 % level of significance.

Individual ADF tests do not reject the null of a unit root, suggesting that all the series are non-stationary. However, when the testing procedure allows for breaks in the series, the results are overturned such that the aggregate series are stationary around the trend or/and intercept change.. The timing of the structural break differs slightly for each province. The earliest effects appear to be in Otago with a trend change in 1993. This is followed with a trend change in Canterbury in 1895; in Wellington in 1899 and a crash and trend effect in Auckland in 1901. The discontinuities materializing over time were in line with the South (Otago, Canterbury) – North (Wellington, Auckland) shift hypothesized earlier.

The price indexes show the most dispersion around 1895 and 1898-1899, and from 1901 onwards the coefficient of variation was on the lower bound with 0.015 as an average.

Figure 4. Coefficient of variation (aggregated using population weights) for the four PDs



Although we earlier argued that the series that would likely drive the aggregate index would be non-stationary, the fact that the final series are actually stationary is perhaps not unexpected. The Food group series comprise more than 50 % of the overall index with the highest weight in the grocery group (a stationary series). In addition, we identified cointegration between groups of I(1) series and finally, in applying the index formula to construct the final, aggregate series, a degree of smoothing was applied which removed the effects of certain outliers which likely affected some of the individual unit root tests.

5. A National Consumer Price Index

National consumer price indices already exist in the literature (Arnold, and Nesbitt-Savage), and the motivation of this section is to investigate whether the aggregate series derived in this paper are consistent with the previous work. As mentioned earlier, the construction of each provincial CPI was similar in construction to Arnold's national CPI, in that the same sources for the data for most sub-series were used. However, potential differences between the series are expected since, firstly, Arnold's index is a national aggregate as it included all provincial districts rather than just the four used in this paper. Secondly, her aggregate index used a different index formula. In an attempt to reduce possible discrepancies between the two indexes, the sub-indexes derived by Arnold were aggregated using the Tornqvist formula to produce a national CPI, given that the sub-index series were not constructed using the Tornqvist index.[43]

Nesbitt-Savage (1993) used Arnold's series from 1870 to 1919 as the benchmark for constructing his long run CPI (1847-1990). To obtain data prior to 1861 he used the Sauerbeck series (from Mitchell's "British Historical Statistics") from 1847-1860 arguing that there was a high coefficient of correlation between Arnold and Sauerbeck. However, Nesbitt-Savage was not the first to recognize similarities between the New Zealand and the British (Sauerbeck series) wholesale price indexes. McIlraith compared his series to the Sauerbeck series and found that "during the decade 1880-1889 the series show a remarkable coincidence."

[43] Arnold (1982) only reported the sub-series data and not the nominal prices, therefore we could not construct a true Tornqvist index.

Modern econometric techniques will allow us to compare the three indexes and make inferences for the derived series predictions. Here, we have two main goals: firstly, to identify whether our derived[44] aggregated consumer index is "similar" (in a statistical sense) to the Nesbitt-Savage/Arnold ("the best" existing historical CPI) index and the Sauerbeck (British historical index of wholesale prices), Secondly, to utilize the underlying relationship for the series for forecasting purposes. Table 18 below presents the covariance-correlation matrix which shows that indexes are highly correlated.

Table 18. Covariance-correlation coefficient matrix

Covariance Correlation	**Sauerbeck**	**Tornqvist Aggregate**	**Arnold's index**
Sauerbeck	58.30588 1		
Tornqvist Aggregate	49.6411 0.776644	70.06917 1	
Arnold's index	38.35455 0.79138	45.81227 0.862269	40.28576 1

If we plot the indexes against time, we are able to say that the fluctuations of the Tornqvist index are more pronounced with sharper falls and increases (those could be outliers that are not apparent from Arnold's index since her CPI is a weighted national average that included most provincial districts). It is clear that the jumps in values around 1902, 1907 and 1911 are present in the data. There are some historical underpinnings to explain these increases For example, manufacturing and some of the main export commodities were greatly affected by tariff changes in 1903 and 1907 (revision of the Tariff Act in 1907 imposed extra duties on the manufactured items and equipment from the countries other than Britain which led to an increased cost of production). Sauerbeck's index is a wholesale price index, the peak in 1902 in the Tornqvist index seems to lag behind Sauerbeck's by two periods.[45]

[44] Since the Tornqvist formula was used for deriving the aggregate index, we will refer to it as the "Tornqvist index" for simplicity.

[45] The indexes were all taken to the same base (1909-1913=100) to make comparisons possible.

Figure 5. Aggregate Consumer Price Indices

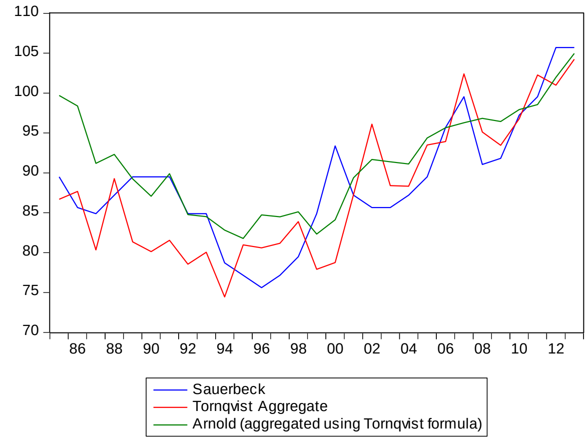
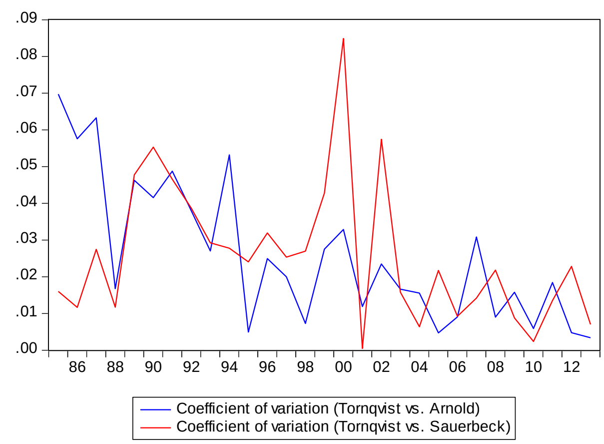


Figure 6 below presents coefficients of variation of the Tornqvist index to compare with the Arnold's and Sauerbeck's indices. There is clearly a greater degree of dispersion between the Tornqvist and the Sauerbeck indexes, with the coefficient's decay after 1903. With regards to comparison with Arnold's index, the dispersion is evident in the beginning of the period, with a subsequent decrease in the coefficient of variation post-1894.

Figure 6. Coefficients of variation



To use the series for forecasting, their stationarity properties need to be examined. As before, we will use individual ADF tests and to test for the presence of structural breaks, Zivot and Andrews (1992) will also be utilized.

Table 19. Unit root tests for the three indexes with and without breaks

Index	ADF: Intercept/no trend	ADF: Trend and Intercept	Zivot and Andrews: Break
Arnold's	-0.2038	-2.0748	-3.9993 (Crash -1901)
Tornqvist	-1.048	-2.881	-5.614* (C&T – 1901)
Sauerbeck's	-0.455	-1.6527	-3.8 (C&T – 1894)

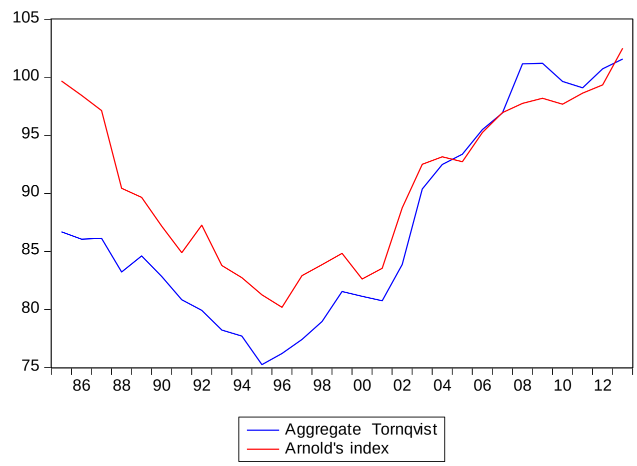
Note: *denotes rejection of the null of a unit root (with and without breaks) at the 5 % level of significance.

The results indicate that the Tornqvist index (the newly derived CPI series) is stationary around a crash and trend in 1901. The other series are, in a strict sense, non-stationary, however, Arnold's index is close to being stationary at the 5 % level, especially if we consider a 1901 discontinuity model. To smooth out the effects of the outliers, we will use Holt-Winters (no seasonality with the lowest RMSE) exponential smoothing technique.[46] If we test the derived series for a unit root in the presence of structural breaks, the null is not rejected, which means the series became non-stationary:

Table 20. Unit root test for the Aggregate Tornqvist and Arnold's index with HW smoother (in index level) with and without breaks

Index	ADF: Intercept/no trend	ADF: Trend and Intercept	Zivot and Andrews: Break
Tornqvist (HW smoother)	-0.18	-1.933	-3.58 (Crash -1902)
Arnold's (HW smoother)	-0.593	-2.05	-3.48 (Trend -1895)

Figure 7. Holt-Winters exponential smoothing: the resulting series



Given the relatively low power of univariate unit root tests, we will, as a final check, test for cointegration between our new aggregate series and Arnold's series (Johansen maximum likelihood estimation-based methods will be utilized). Table 21, below, presents the results:

Table 21: Price indexes.
Bi-variate Cointegration results: Johansen estimates, VAR=1, 1885-1913
Unrestricted intercepts and linear trends in levels

	Aggregate Tornqvist (HW)	
Arnold's index (HW)	15.4536** $^{\alpha}$	15.264* $^{\beta}$
	0.1896 $^{\alpha}$	0.1896 $^{\beta}$

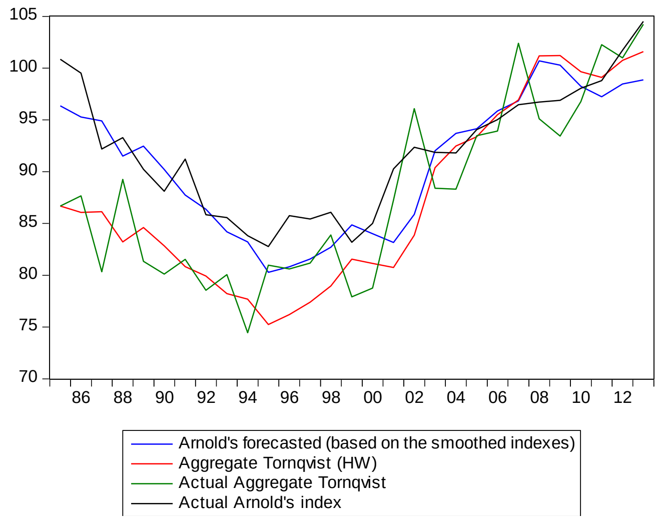
Note: α- indicates trace statistics and β- maximum eigenvalue statistics. *, ** denotes the rejection of the null of no cointegration at the 5 % and 10 % respectively.

[46] Alternatively, we could use Hodrick-Prescott filter that decomposes the series into trended and cyclical components (H-P plots are presented in the APPENDIX V).

The results show that the two indexes are cointegrated. For this period, Arnold's index is identical to Nesbitt-Savage's. The important result here is the existence of a long-run relationship between the CPI derived in this paper, and Arnold's index. The series are cointegrated with a cointegrating vector [1,-0.774], normalizing on the smoothed Arnold's index. The null for binding restrictions (LR test) on the coefficients [1,-1] was rejected at the 5 % ($\chi^2(1)$ =4.3656), suggesting that the series are not affectively, statistically, identical. It is clear that the differences occur at the beginning of the period and by the end the series share common time series features.

By establishing a cointegrating relationship between the Tornqvist and the Nesbitt-Savage (Arnold) indexes (identifying a cointegrating vector) it provides an opportunity to use the relationship to forecast and back cast the series (given that the regional consumer prices data exists from 1847) to produce a more extensive long-run aggregated CPI. The forecasted series (Arnold's index) based on Phillips-Hansen estimates[47] are presented in figure 8, below.

Figure 8. Forecasted series plot based on Phillips-Hansen estimates



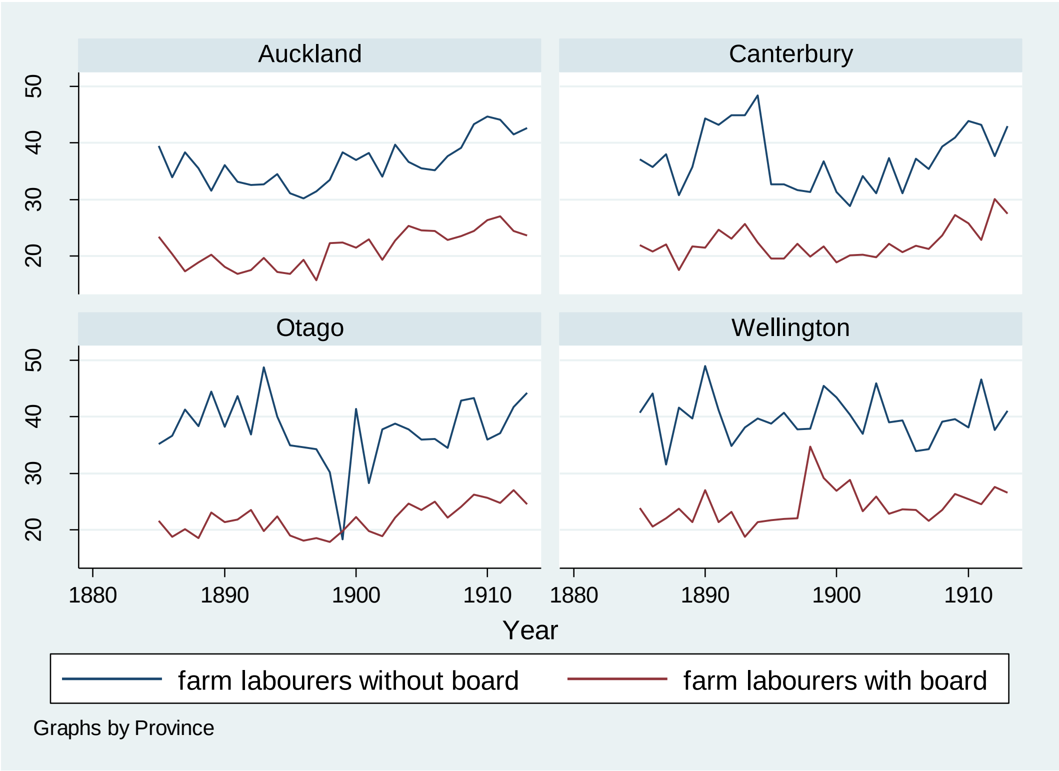
6. Future work

The results presented here relate to the period 1885-1913. One important future development would be to consider earlier periods. Some data are available from 1847 where for example, food price series for various provinces can be extracted from Statistics New Zealand publications. Creating a more reliable national CPI for the period 1847-1913 was outside the scope of this paper where the objective was to create regional CPIs for the four main provinces, and to analyze regional differences in prices of traded commodities. These regional differences in price levels are essential if we are to explore economic standard of living measures across regions via for example, real wages. A future working paper will present data and analysis of nominal wage indexes by four main regions (Auckland, Canterbury, Otago, and Wellington) for the 1885-1913 period. Previously derived data on regional consumer prices will be utilized to produce a real wages index (1885-1913) for each of the four provinces. The detailed analysis of the occupation-region specific series will also be utilized to identify regional fluctuations in each sector or region (if any), and to initiate a discussion on real wage regional convergence and home market integration of those regional economies. Some preliminary results on region specific wages for highly weighted occupations in the aggregate wage index present interesting differentials across the four

[47] Appendix V, Table 1.

provinces. According to the 1911 census (and all the censuses prior to that) the highest weighted sector was farming which was represented by farm-labourers (with and without board). The real wages of farm-labourers in the South (Canterbury and Otago) were affected by good harvests during the early 1890's (1891-1893), and their wages seemed to be higher than in previous years. In part this was due to the rapidly deflating price level during 1891-1893 period, which was reflected in the real wage increase of farm-labourers without board (farm labourers with board were less affected since the board often came with food). As with industry wages, there was a marked fall in real wages around 1894-1895. The year 1896 was favorable for New Zealand's agricultural labour as large properties prepared for grain raising in the prospect of another favorable season and there) was a surplus from wool and grain. The fall in Otago in 1899 was associated with farm-labourers without board (they were paid 3 shillings per day, while the yearly average was around 5-8 shillings a day, while wages for farmer-labourers with board did not change for that year), which could be associated with an increased cost of board, bad harvests or rounding errors where a the single number was reported for that year rather than the typical range.

Figure 9. Real wages of farm-labourers (in shillings per week)

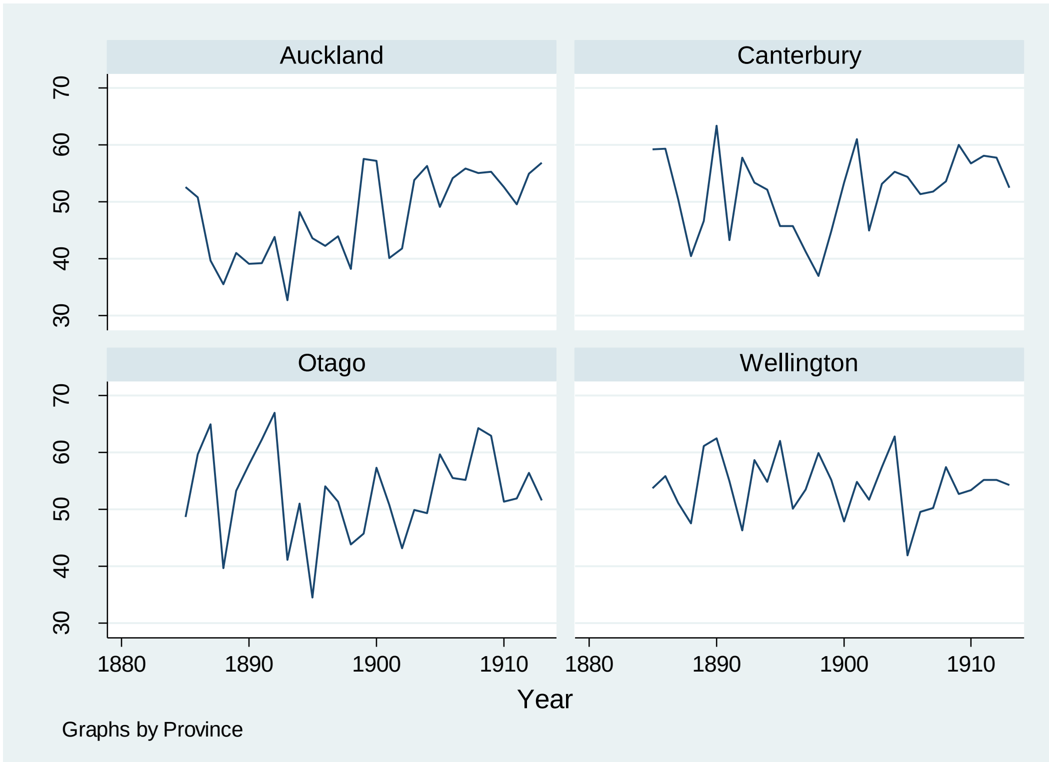


Farm-labourers without board in Canterbury and Otago were usually employed during the summer months, both for shearing and harvesting, such that during winters the demand for labour usually decreased rapidly. Unskilled workers in Canterbury were in a more challenging position in the winter months (especially after bad harvest years) since there were not many roads or railways jobs where those workers could be utilized. Therefore, the excess labour was relocated for example, the Labour Government usually assisted unemployed workers in finding jobs in other parts of the country.[48]

[48] AJHR, 1893 – The report of the Department of Labour, H.-10

Another highly weighted occupation in the food industry sector is represented by butchers' wages. This wage group experienced the largest fluctuations in the industry sector:

Figure 10. Butchers' real wages (food industry) – shillings per week



Butchers played an important role in the frozen meat industry. Some early freezing works were started by butchers in Wellington and Auckland (the industries were initially provincially based consisted of farmers, shippers, merchants etc.). Butchers were often paid for each animal killed.

In 1899, the wage-rates of butchers were first regulated in Auckland (wages were arranged on a comparatively low scale).[49] It was also noted by Clinkard that until 1912 the wage-rates in Auckland were consistently below those of butchers employed in other centers: the difference was due to the fact that in Wellington and Dunedin meat allowances were granted by the awards of the Court, while no such additions to money wages were necessarily made by employers in Auckland and Christchurch.

By analyzing each occupation group by region, we will be able to identify important trends in the leading New Zealand sectors, and also evaluate the general effect of labour legislation changes, and the development of the export trade on the standards of living of workers in the four regions.

7. Concluding remarks

This paper had two main objectives, firstly to construct regional consumer price index series for the four main provincial districts for the 1885-1913 period, and secondly to analyze provincial consumer prices in the context of New Zealand's economic landscape by identifying common trends/cycles among

[49] Clinkard, p. 19

provincial sub-series of the leading New Zealand sectors to test series for convergence, and to check whether the newly created aggregate index was consistent with the existing CPI series.

Construction of each regional index was achieved by collecting prices for each of the four provincial districts (Auckland, Canterbury, Otago and Wellington), and grouping them into the seven sub-series. The Miscellaneous sub-series deviated the most from the earlier work (e.g. used public library subsidies to proxy for education expenditure and data on hospitals' receipts to proxy for medical expenses), which can arguably be a better series (compared to Arnold (1982)) in terms of representativeness and accuracy. When aggregating the sub-series, we chose a Tornqvist formula as the most appropriate for the type of data used. Provincial CPI series were robust to the use of alternative index formulas (Laspeyres, Paache etc.).

When analyzing sub-series, we found evidence of regional price convergence for most series from the beginning of 1900. Time-series methods were utilized to statistically establish if any of the sub-series across provinces exhibited convergence.

Both meat and dairy price series (traded goods) either exhibited convergent behavior in the long run (meat series) or 'catching up' (dairy series) between Auckland and Canterbury. Prices for butter and cheese were also tested for convergence separately due to their difference in production technology. The results indicated that butter prices between the two provinces (Auckland and Canterbury) satisfied long run convergence definitions, while prices of cheese among the four provinces exhibit a common cyclical process, suggesting that the non-stationary behaviour of the dairy index was driven by butter prices rather than cheese. Granger causality tests identified Canterbury as the leading province for both meat and dairy price series. These findings are suggestive of South-North convergence, demonstrating that the refrigeration boom initially benefitted the South more than the North, which had changed from the late 1890's-1900's as the new trade reshaped agricultural production and more land became suitable for farming.[50] We also established that Canterbury and Wellington housing prices converged, where the South-North shift seems to be present in these data driven by the negative rates of net interprovincial migration in Canterbury, and positive towards Wellington). The serial correlation feature test suggested the existence of common cycles between Auckland and Wellington, implying that housing prices for these provinces respond to common shocks in a similar fashion, and that the changes in prices follow a common dynamic cyclical pattern.

Finally, the aggregate version of the national CPI was derived which was shown to be consistent with Arnold's original, national CPI series.

The paper had two particular purposes, firstly, to construct a New Zealand CPI series for the period 1885-1913 from a spatial perspective i.e., disaggregated at the level of the four major provincial districts: Auckland, Canterbury, Otago, and Wellington and secondly analysis of regional price movements and trends. Both objectives were achieved and in particular, the data created were used to establish the degree to which sectors that were important to New Zealand's growth (meat and dairy) were integrated across the four major provinces. The paper also represents a prelude to both the analysis of real wages and real incomes across the regions of New Zealand allowing us to explore questions as to whether for example, the pastoral boom lead to regional inequality and the role economic factors had on stature and wellbeing.

[50] Between 1892 and 1900 the Liberal Government acquired 1.3 million hectares of Maori/native land which has started a transformation of North Island hill country from bush to pasture.

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APPENDIX I.

Table 1. Expenditure basket (based on 1893 Household Expenditure Survey – Labour Department)

	%		%
Bread (2 lb)	8.955	Housing	10.38
Coffee (lb)	1.45	Clothing	
Flour per 25lb bag	0.995	Clothes	13.14
Rice (lb)	1.87	Boots and Shoes	4.38
Salt (lb)	0.97	Total	17.52
Sugar (56 lb)	4.03	Miscellaneous	
Tea (lb)	4.03	Washing	1.52
Oats (lb)	1.87	Books	2.83
Onions lb	1	Furniture	2.25
Carrots (dozen bunches)	0.2	Friendly Societies	3.56
Turnips (dozen bunches)	0.085	Total	10.16
Cabbages per dozen	0.085	Fuel and Light	
Potatoes per cwt. - retail	1.62	Candles	2.69
Jam lb	1	Coal/Firewood	5.39
Raisins lb	0.4	Total	8.08
Currants lb	0.13		
Dried Fruits lb	0.1		
Beer (hhd)	1.16		
Total	29.95		
Meat			
Beef	5.3088		
Mutton	2.212		
Pork	0.8848		
Lamb	2.212		
Veal	0.4424		
Total	11.06		
Dairy			
Milk	3.39		
Fresh Butter	2.305		
Salted Butter	2.305		
Cheese	1.07		
Eggs	1.31		
Bacon	1.47		
Ham	1		
Total	12.85		

Table 2. Total population for all provincial districts (urban-rural breakdown)[51]

year	urban	rural	Total
1881	291,238	194981	486,219
1886	327328	245612	572,940
1891	352097	270343	622,440
1896	391735	307294	699,029
1901	417596	350202	767,798
1906	458797	424614	883,411
1911	496779	505598	1,002,377
1916	501259	585306	1,086,565

Table 3. Population in provincial districts at successive censuses (exclusive of Maoris)[52]

Provincial District	March, 1886	April, 1891	April, 1896	March, 1901	April, 1906	April, 1911
Auckland	130379	133159	153,564	175938	211223	264520
Canterbury	121400	128392	135858	143041	159106	173185
Otago	113702	116088	119990	125341	127877	132402
Wellington	77536	97725	121854	141354	179868	199094

[51] Thorns, David (1997), extracted from Stats NZ: NZ Long term data series.

[52] Extract from Statistics New Zealand, 1911. Census, April, 1911. – *Population and Dwellings.*

Table 4. Annual rates of natural increase and net migration, net interprovincial migration and total population increase: 1886-1911[53]

		Auckland	Wellington	Canterbury	Otago
1886-1891	Natural increase and Net migration	12	20	16	13
	Net interprovincial migration	-11	29	-5	-9
	Total increase	3	45	11	5
1891-1896	Natural increase and Net migration	18	26	21	21
	Net interprovincial migration	5	19	-11	-8
	Total increase	22	43	11	14
1896-1901	Natural increase and Net migration	20	22	17	16
	Net interprovincial migration	7	10	-7	-6
	Total increase	26	30	10	11
1901-1911	Natural increase and Net migration	28	28	24	22
	Net interprovincial migration	13	6	-6	-16
	Total increase	38	33	19	10

[53] Brosnan P. (1986), Net Interprovincial Migration 1886 to 1966.

APPENDIX II.

Table 1. Alternative indexes: Laspeyres, Paache and Fisher.

Year	Province	Tornqvist index	Paache index	Fisher index	Laspeyres index
1885	Auckland	85.5	73.05	88.64942	107.58
1886	Auckland	88.55	75.67	91.25919	110.06
1887	Auckland	78.16	68.56	82.05655	98.21
1888	Auckland	84.53	72.5	87.70134	106.09
1889	Auckland	79.14	69.12	83.04694	99.78
1890	Auckland	83.13	72.29	86.70316	103.99
1891	Auckland	82.88	72.26	86.49741	103.54
1892	Auckland	76.9	68.08	81.16293	96.76
1893	Auckland	76.43	68.54	80.76479	95.17
1894	Auckland	72.53	65.24	77.2665	91.51
1895	Auckland	80.29	71.97	84.41842	99.02
1896	Auckland	82.78	74.22	86.77338	101.45
1897	Auckland	79.56	71.65	83.87251	98.18
1898	Auckland	78.44	70.99	82.85796	96.71
1899	Auckland	78.26	71.37	82.71785	95.87
1900	Auckland	74.34	67.92	79.00967	91.91
1901	Auckland	87.17	78.47	90.77087	105
1902	Auckland	95.6	85.12	98.30832	113.54
1903	Auckland	88.18	78.83	91.55753	106.34
1904	Auckland	88.77	79.32	92.00991	106.73
1905	Auckland	91.6	81.54	94.64232	109.85
1906	Auckland	92.3	82.4	95.17474	109.93
1907	Auckland	98.5	87.08	100.7301	116.52

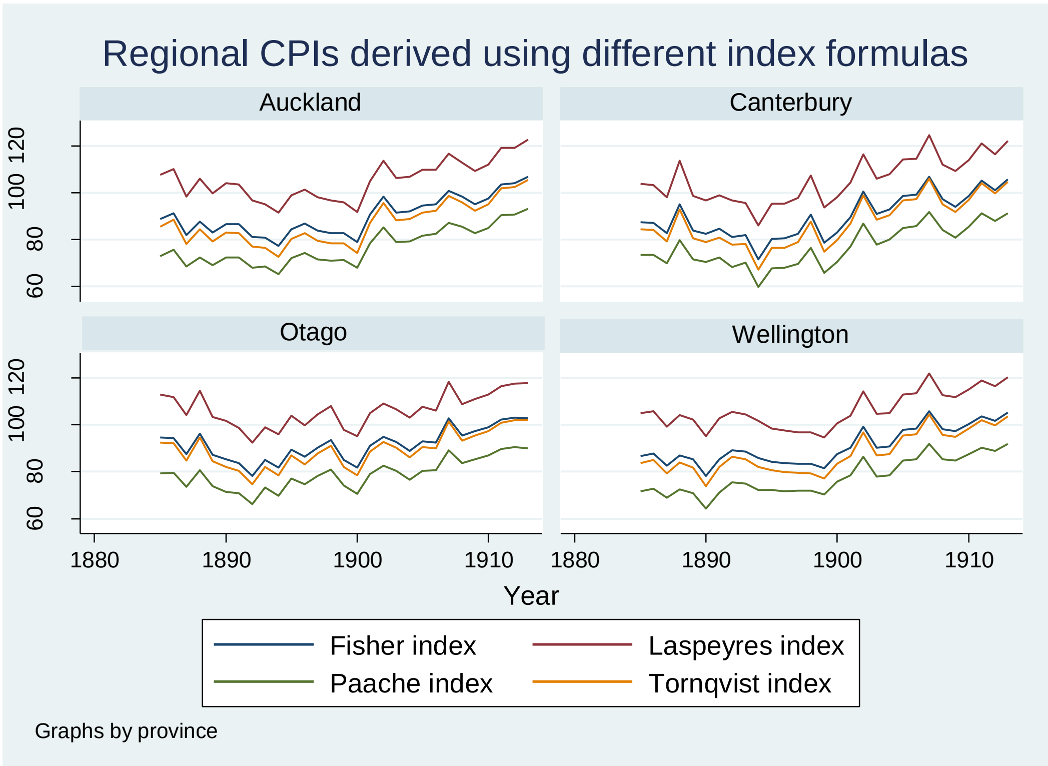
1908	Auckland	95.81	85.47	98.21479	112.86
1909	Auckland	92.31	82.71	95.03213	109.19
1910	Auckland	95.02	84.82	97.50627	112.09
1911	Auckland	101.96	90.28	103.6456	118.99
1912	Auckland	102.36	90.8	104.0485	119.23
1913	Auckland	105.55	93.21	106.8735	122.54
1885	Canterbury	84.38	73.43	87.3421	103.89
1886	Canterbury	84.21	73.5	87.1479	103.33
1887	Canterbury	79.24	70.03	82.81327	97.93
1888	Canterbury	92.77	79.63	95.07261	113.51
1889	Canterbury	80.46	71.61	83.98136	98.49
1890	Canterbury	78.94	70.57	82.60396	96.69
1891	Canterbury	80.98	72.24	84.55527	98.97
1892	Canterbury	77.93	68.22	81.18333	96.61
1893	Canterbury	78	70.19	81.85988	95.47
1894	Canterbury	67.14	59.75	71.66666	85.96
1895	Canterbury	76.61	67.78	80.37482	95.31
1896	Canterbury	76.61	67.95	80.46288	95.28
1897	Canterbury	78.83	69.53	82.45389	97.78
1898	Canterbury	87.77	76.57	90.64616	107.31
1899	Canterbury	74.72	65.93	78.5728	93.64
1900	Canterbury	79.67	70.54	83.11427	97.93
1901	Canterbury	86.86	77.07	89.65714	104.3
1902	Canterbury	98.93	86.83	100.5768	116.5
1903	Canterbury	88.41	77.83	90.86795	106.09
1904	Canterbury	90.46	79.98	92.91416	107.94

1905	Canterbury	96.59	85	98.57155	114.31
1906	Canterbury	97.32	85.73	99.10211	114.56
1907	Canterbury	106.06	91.7	106.9216	124.67
1908	Canterbury	95.17	84.24	97.16366	112.07
1909	Canterbury	91.71	80.98	94.05453	109.24
1910	Canterbury	96.83	85.52	98.70379	113.92
1911	Canterbury	104.14	91.26	105.1178	121.08
1912	Canterbury	99.61	87.94	101.1351	116.31
1913	Canterbury	104.75	91.34	105.5886	122.06
1885	Otago	92.48	79.24	94.56339	112.85
1886	Otago	92.16	79.48	94.22691	111.71
1887	Otago	84.74	73.6	87.59452	104.25
1888	Otago	94.47	80.56	96.11774	114.68
1889	Otago	84.5	73.85	87.32977	103.27
1890	Otago	82.12	71.4	85.25562	101.8
1891	Otago	80.27	70.76	83.55347	98.66
1892	Otago	74.62	66.1	78.21902	92.56
1893	Otago	82.11	73.28	85.17464	99
1894	Otago	78.36	69.73	81.80884	95.98
1895	Otago	86.87	77.12	89.52699	103.93
1896	Otago	83.21	74.66	86.32822	99.82
1897	Otago	87.68	78.17	90.34229	104.41
1898	Otago	91.17	81.05	93.50328	107.87
1899	Otago	82.02	74	85.1413	97.96
1900	Otago	78.55	70.44	81.83786	95.08
1901	Otago	88.56	79.09	91.1678	105.09

1902	Otago	92.73	82.67	94.95257	109.06
1903	Otago	90.21	80.52	92.68157	106.68
1904	Otago	86.12	76.68	88.9313	103.14
1905	Otago	90.48	80.31	93.0323	107.77
1906	Otago	90.09	80.57	92.50153	106.2
1907	Otago	101.41	89.25	102.8359	118.49
1908	Otago	93.28	83.65	95.41733	108.84
1909	Otago	95.39	85.32	97.32098	111.01
1910	Otago	97.3	86.84	99.04704	112.97
1911	Otago	101.02	89.78	102.2842	116.53
1912	Otago	101.98	90.48	103.1482	117.59
1913	Otago	101.86	89.89	102.8812	117.75
1885	Wellington	83.8	71.72	86.80382	105.06
1886	Wellington	85.01	72.81	87.82233	105.93
1887	Wellington	79.25	68.91	82.71267	99.28
1888	Wellington	84.08	72.53	86.94712	104.23
1889	Wellington	81.84	70.9	85.19825	102.38
1890	Wellington	73.98	64.18	78.14555	95.15
1891	Wellington	81.96	71	85.41639	102.76
1892	Wellington	86.3	75.49	89.26348	105.55
1893	Wellington	85.25	74.84	88.46478	104.57
1894	Wellington	82.01	72.31	85.72974	101.64
1895	Wellington	80.61	72.16	84.27757	98.43
1896	Wellington	79.82	71.74	83.66833	97.58
1897	Wellington	79.48	72.07	83.53333	96.82
1898	Wellington	79.29	71.9	83.44337	96.84

1899	Wellington	77.04	70.24	81.47626	94.51
1900	Wellington	83.54	75.88	87.43517	100.75
1901	Wellington	86.69	78.45	90.23483	103.79
1902	Wellington	96.8	86.34	99.29333	114.19
1903	Wellington	87.03	77.97	90.36481	104.73
1904	Wellington	87.54	78.41	90.77936	105.1
1905	Wellington	95.34	84.83	97.85938	112.89
1906	Wellington	95.93	85.26	98.32411	113.39
1907	Wellington	104.43	91.8	105.8065	121.95
1908	Wellington	95.81	85.42	98.09467	112.65
1909	Wellington	94.9	84.66	97.26641	111.75
1910	Wellington	98.4	87.57	100.4219	115.16
1911	Wellington	101.87	90.2	103.5344	118.84
1912	Wellington	99.73	88.79	101.6576	116.39
1913	Wellington	103.64	91.91	105.1861	120.38

Figure 1. Alternative indexes



It is apparent from the graph that all the indexes follow a similar pattern, however, as predicted by the theory, some of them are at the higher bound, some – at the lower bound. The Tornqvist and the Fisher indexes are closely approximated, and are in between the lower and the upper bound.

The coefficients of correlation, presented below, show that the Tornqvist and the Fisher indexes are almost statistically identical. The Tornqvist price index is highly correlated with both the Laspeyres and the Paache indexes.

Table 2. Correlation coefficient matrix for the four index alternatives

	Laspeyres	Tornqvist	Paache	Fisher
Laspeyres	1			
Tornqvist	0.9869	1		
Paache	0.9557	0.9892	1	
Fisher	0.9858	0.9992	0.9915	1

APPENDIX III.

Tariff and Labour legislation changes

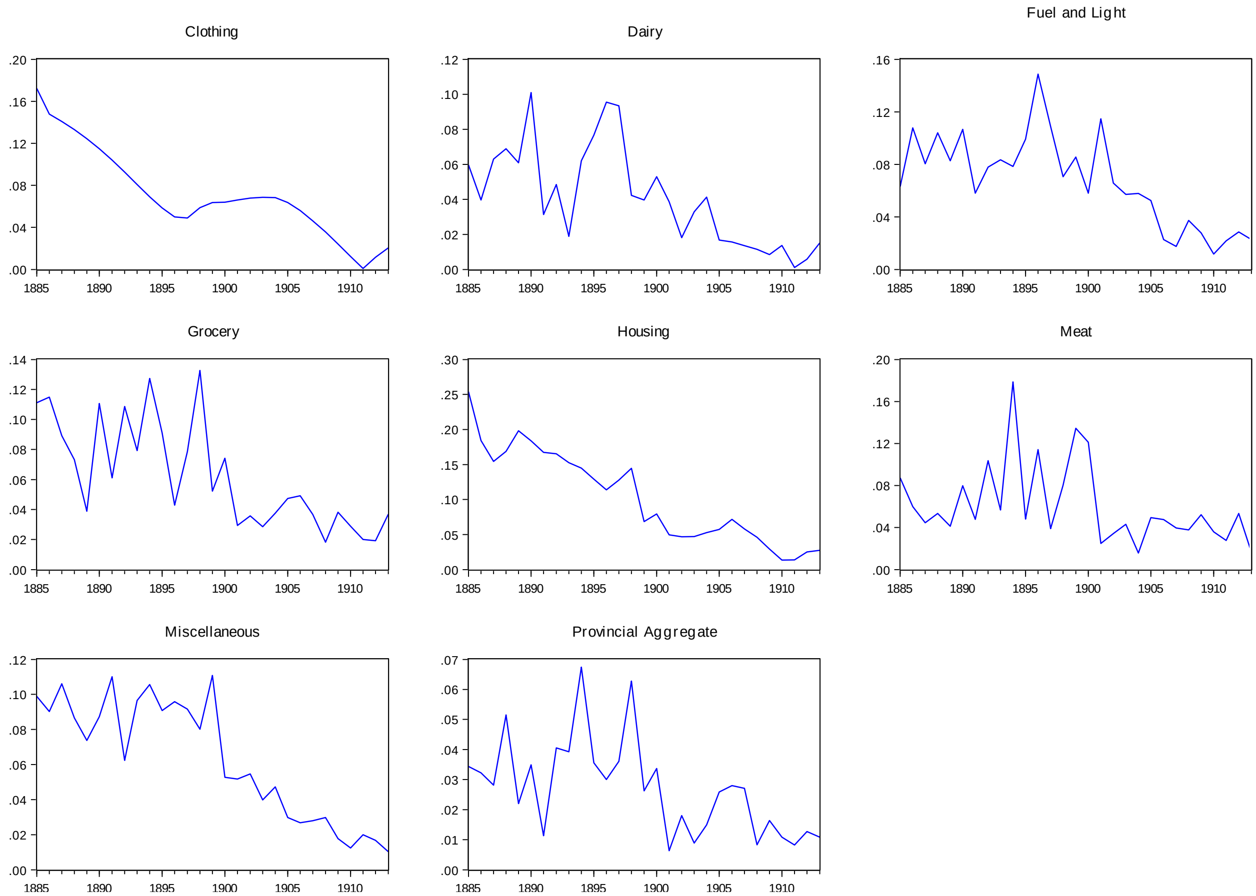
Under *the Industrial Arbitration and Conciliation Act* (1894), the regulation of wages in most industries was undertaken by Councils and a Court (this gave a legal recognition to Unions and their ability to dispute wages). Most of the unions benefited from this Act as it gave them the opportunity to dispute rates of pay and minimum working conditions. This led to an increase in wages, which were generally passed-on to the consumer in the form of higher prices for manufactured goods (e.g., clothing, furniture) and other items.

The tariff introduced in 1879 extended the number of items that were charged a duty on an *ad valorem* basis, or as the percentage of the value of the goods. From 1895, there was a steady movement towards a reduction on the duties levied upon imported foodstuffs, and an extension of the tariff levied upon imported manufactured goods. These changes were typically made to protect infant industries. Later, *The Preferential and Reciprocal Trade Act of 1903* of New Zealand introduced preferential rates of duty in favour of the produce of the British Dominions by imposing extra duties on certain imports which were the produce or manufacture of other countries. The list of preferential items was materially extended by the New Zealand *Tariff Act of 1907*, from the 31st March, 1908.[54]

[54] Official year book of the Commonwealth of Australia, tom 47 by Sir George Handley Knibbs, Australia. Commonwealth Bureau of Census and Statistics.

APPENDIX IV.

Figure 1. Coefficients of variation (among the four provinces)



APPENDIX V.

Figure 1. Filtered series (Arnold's index)

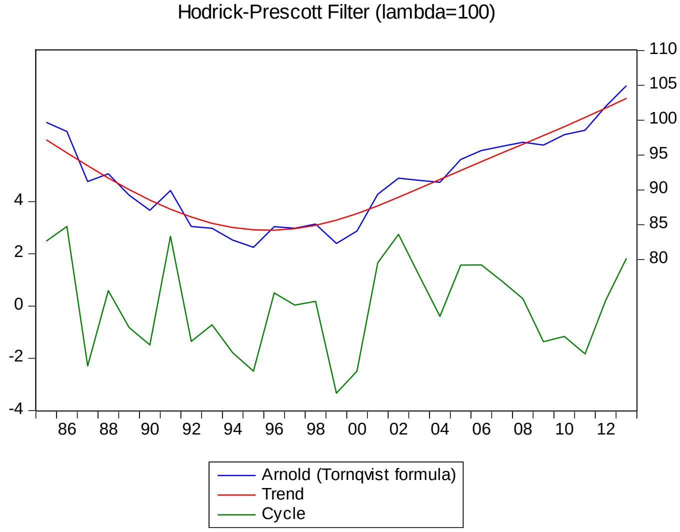


Figure 2. Filtered series (The four provinces aggregate)

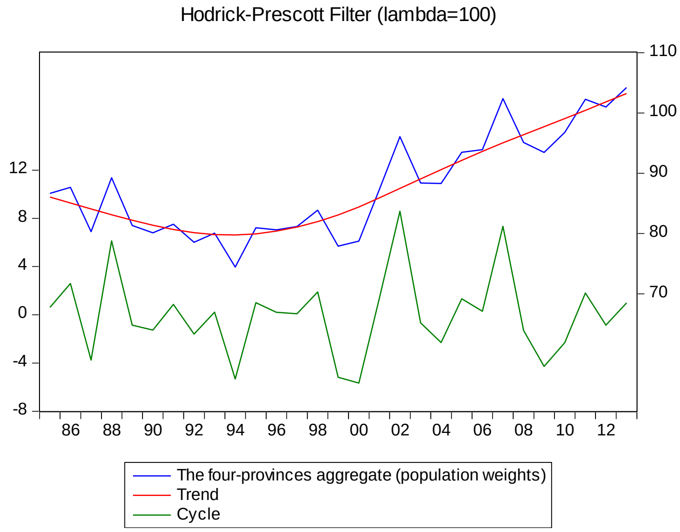


Table 1. Phillips-Hansen estimates, 1885-1913
Barlett weights, trended case

Regressor	Coefficient	t-ratio
Intercept	8.598	1.4637
Tornqvist (Aggregate)	1.012	13.085*
Trend	-0.4495	-5.324*

*denotes significance at the 5% level