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MEASURING NEW ZEALAND'S GDP 1865–1933: A COINTEGRATION-BASED APPROACH

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Official and semi-official estimates of New Zealand's national income are available on an annual basis for the years since 1932. Retrospective, non-official, estimates are available from 1859. Chiefly these are constructed following Doblin's (1951) pioneering use of money stock data, velocity, and the implications of the Quantity Theory of Money, and include the estimates of Hawke (1975), Rankin (1992) and Cashin (1995).

This paper estimates New Zealand real GDP per capita with monetary data using valid, intervention-free, cointegration methods. The new measures avoid the *ad hoc* adjustments found in Rankin (1992), yet unlike Cashin (1995), they incoporate specific New Zealand monetary features. The new time series conform well with independent benchmarks and the historiography of the pre-1914 period. Alternatively, they suggest an interpretation of New Zealand's growth experience for years around World War One which differs from that of Australia, and from the findings of Rankin (1992) and Cashin (1995).

1. INTRODUCTION

Official estimates of New Zealand's national income are available on an annual basis for the years since 1948. As for most OECD economies retrospective, non-official, estimates are available for earlier years, and in the case of New Zealand date from 1859. Maddison (1995), notes that the quality of these retrospective data vary widely. Estimates for Australia, constructed by Butlin (1962) for years since 1798, and by Feinstein (1972) for U.K. for years since 1855 appear the most credible. Although New Zealand was a British Australasian colony, she declined to join the Commonwealth of Australia in 1901, and was not incorporated in Butlin's GDP estimates for Australia. Retrospective GDP estimates for New Zealand rest largely on proximate monetary-based data, and are regarded by Maddison (1995, p.119) as among the weakest of the estimates for OECD countries. However, Maddison (1995) does include an annual GDP series for New Zealand for the years since 1870.

Some direct data for New Zealand's national income are available for years before 1948. Lineham (1968) utilised sectoral income estimates to piece together a nominal GDP series from 1918, and Easton (1990, 1997) deploys these data with a constructed GDP deflator to derive real GDP. Furthermore, spot estimates for New Zealand national income have been made for the years 1865, 1898/99–

Note: We wish to thank two anonymous referees and particularly Brian Easton for helpful comments.

1902/03, 1925/26, 1932/33, and 1938/39 see for example, Knight (1866), Arndt (1949), Fisher (1930), and Butlin (1962). Rankin (1992) questions the year to year accuracy of Lineham's data, especially for the 1920s, since some interpolation of employment levels between census dates was used. Rankin's own preference involves using proximate money-derived national income estimates, partly because such data may capture annual movements more effectively, and his data are incorporated in Maddison (1995).

The method of using money stock and velocity to construct New Zealand's national income was used first by Hawke (1975) for years since 1870, and followed the methods of Doblin (1951), Friedman (1961) and Leff (1972). Rankin (1992) revised Hawke's series by using estimates of Australian velocity based upon New Zealand data, to produce national income estimates which show greater consistency with the occasional contemporary benchmarks extant for the years to 1914. While Rankin's estimates are the most plausible published for New Zealand, he made a number of *ad hoc* modelling decisions in the construction of his series which cast some doubt on the validity of his data. In particular, World War One, and 1919–21, are omitted from the estimation period, an inter-war dummy variable is included, and the results from three separately estimated regression equations are averaged to construct a continuous series. Thus, Rankin uses a 3-piecewise estimate of Australian velocity, based upon New Zealand data, as the starting point for his calculations. Further, the resulting measures are used only to interpolate and extrapolate New Zealand national income between and beyond the contemporary spot estimates. By forcing his estimates through chosen national income benchmarks via a series of *ad hoc* weights, Rankin "fits" these benchmarks perfectly.

Cashin (1995), adds to the debate by utilising two recently available data sources. The first is a new price (CPI) series for New Zealand created by Nesbitt-Savage (1993). Price data are central to the construction of money-based national income estimates, and Easton (1990) has criticised Rankin's use of a diverse selection of price indexes. The second relates to New Zealand monetary data produced by Sheppard, Guerin and Lee (1990), that provide series for the conventional monetary aggregates, M1 and M3, and avoids Rankin's simple reliance on bank deposits. However, in contrast to Rankin, Cashin chose to follow Hawke (1975) by taking the (average) calculated velocity of Australian money balances, in Cashin's case for M1, and simply multiplying this by New Zealand M1 balances from Sheppard *et al.* (1990).[1] Cashin reports results only for selected years, and these do not always coincide with Rankin's measures, especially for the years around World War One. Neither Rankin, nor Cashin, considered how the statistical time series properties of the data may influence their estimates. Recent work in this area by for example, Dickey and Fuller (1979) and Granger and Newbold (1974) explain the need for careful examination of such issues prior to estimation.

Our approach to deriving estimates of New Zealand GDP, 1859–1933 utilises developments from the analysis of non-stationary series based upon the concept of cointegration proposed by Engle and Granger (1987). As will be seen, we adopt

[1]Hawke (1975) uses bank deposits (like Rankin) rather than M1 (Cashin). However, both Cashin and Hawke use the actual (rather than an estimated) value for Australian velocity.

the new price and money data used by Cashin, but choose to follow Rankin in allowing New Zealand factors to produce an estimate of the Australian velocity inevitably required for the calculation of New Zealand GDP.

There are two reasons for following Rankin, rather than Cashin, and allowing New Zealand's circumstances to influence the measure of velocity used to estimate New Zealand's GDP. Firstly, Rankin argues persuasively that Hawke's (and by implication Cashin's) GDP estimates based on actual Australian velocity measures are too low for the 1870s because velocity is likely to be correlated with the general price level. New Zealand prices were falling more rapidly than Australian prices during this period making Hawke's Australian velocity "proxy" inappropriate for New Zealand. The same argument holds for Cashin's estimates. Similarly, for any other period where price level changes varied between Australia and New Zealand, as for example during World War One, Australian velocity estimates would estimate inaccurately New Zealand's income. Thus, Rankin uses a New Zealand price variable in the velocity equation to capture this correlation, and we adopt a similar approach. Our work differs from Rankin's by using different data for prices and (actual) "money," which were not available to Rankin.

Secondly, our statistical estimates of velocity are more robust, less *ad hoc*, and more rigorously determined than those of Rankin, which reinforces the case for allowing New Zealand's experience to influence the measure of velocity. The statistical methods of cointegration allow one to ascertain whether New Zealand data has "power" in explaining Australian data on velocity and by implication, *vice-versa*. Cointegration looks at the velocity relationship as a long-run equilibrium concept. In effect, Australian velocity and its New Zealand explanatory variables are interchangeable (an endogenous system) if cointegration is established. The important advantage, given the idiosyncratic movements in New Zealand and Australian prices, is that short-term variations in velocity are being explained robustly by New Zealand variables.

The resulting measures avoid the need for interpolation to match the occasional contemporary income benchmarks, and put monetary-based GDP estimates for New Zealand on a firmer statistical footing. The new estimates of New Zealand GDP for the years to 1933, can be spliced readily with the semi-official income estimates for the 1930s, and Easton's (1990) data for the period 1938 to 1960 to provide a link with New Zealand's official national income estimates. Maddison (1995), alternatively, uses Clarke's (1940) data to join Rankin's estimates with the official post-1950 series.

2. Methodology

The starting point of the money-based approach to estimating national income is the Equation of Exchange and the subsequent Quantity Theory of Money:

$$MV \equiv PT$$

where M is the stock of money, V the velocity of circulation, P the price level and T the volume of transactions.

A little re-arrangement gives an expression for V where:

$$V' = PQ/M \qquad \text{or} \qquad V' = V \cdot (Q/T) = Y/M$$

where Q is output. In Rankin (1992) V' is "regarded as the ratio of GNP to per capita trading banks deposits" and "GNP estimates are based on estimating velocity (VEL) from two regressors: trading banks deposits per capita, (MPC) and the price level (PRI)." Cashin (1995) presents a more conventional view of this equation in terms of the "monetary aggregate of choice," in his case M1, and velocity is considered in relation to GDP. The use of M1 (or M3) by including currency has a much firmer basis in the traditional Quantity Theory than the use of bank deposits, particularly for the pre-1914 period when the ratio of currency to deposits shows large shifts and diverges between Australia and New Zealand. However, estimates of velocity for New Zealand cannot be made independently of some measure of national income.

In order to create a velocity series Rankin follows a three-stage process. In stage one he creates a measure of Australian velocity, from the trading bank deposits and Butlin's (1962) income data. This measure of velocity is then used in a series of regression equations where (Australian) velocity is regressed on (Australian) prices (PRI) and MPC (plus a dummy variable for the inter-war years 1919–39). Omitting the years 1914–1918, three separate regression equations are produced (his (a), (b) and (c)), which although they have "good" fit exhibit serial correlation as denoted by a low Durbin–Watson (DW) statistic indicative of a "spurious regression" problem (see Granger and Newbold, 1974).

In the second stage, New Zealand PRI and MPC data are used [again in three separate regression models, (d), (e) and (f), excluding World War One] to predict Australian velocity for the periods, 1861–1900, 1900–1913, and 1919–1939. The results show a generally good fit, with low DW statistics.

Stage three entails using New Zealand data-based estimates of Australian velocity to create a series for New Zealand velocity, and hence New Zealand GNP, using New Zealand measures of PRI and MPC. Again three models (g, h, and i) are estimated for the periods, 1859–97, 1895–1913, and 1922–33. Rankin argues applying model (i) to the period 1919–21 gives unrealistically high GNP, and adjusts velocity arbitrarily to give more "plausible" estimates. Arbitrary estimates of New Zealand velocity are also made for the years of World War One.

2.1. *Comments*:

(i) Omission of the period 1914–21 leads to the *ad hoc* creation of GNP data for these years.

(ii) Structural discontinuities are imposed on the regression equations resulting in three separate models, which may effect the efficiency of the estimation results.

(iii) The high R-squared–low DW in Rankin's results is indicative of "spurious regression."

(iv) In contrast, Cashin's (1995) use of Australian velocity in conjunction with New Zealand monetary aggregates to calculate New Zealand GDP assumes that New Zealand's velocity experience mirrors Australia's. Rankin shows that this assumption is implausible.

(v) However, while Cashin uses velocity to calculate directly New Zealand income from its money aggregates, Rankin uses his estimated velocity and income measures as a basis for interpolation and extrapolation between and beyond the benchmarks. By implication, Rankin accepts that his money-based approach estimates income inadequately.

2.2. *An Alternative Methodology*

Effective use of Quantity Theory-based calculations to measure national income requires that the time series properties of the individual elements are calculated, and that the implications of their values understood.[2] Similarly, if regression estimates are to be included as part of the calculation process only "valid" estimation methods should be used. Neither of these issues has been raised or addressed by previous authors when considering money-based estimates of New Zealand national income.

In this study we propose the following approach:

(i) Establish the time series properties of the individual series, using Dickey–Fuller (1979) tests, to determine the use of appropriate estimation methods.

(ii) Consider the relationships (cointegration if the data are non-stationary) between the data, both for Australia, and between New Zealand and Australia.

(iii) If the Australian and New Zealand data are "related" (cointegrated with $I(1)$ variables), estimate Australian-based and New Zealand-based estimates of Australian velocity.

(iv) From the New Zealand-data based velocity estimates, calculate a measure of New Zealand GDP.

2.3 *Data*

The data used in this study come from four main sources.

Firstly, the Rankin (1992) data for Australian GNP, prices, population, trading bank deposits and velocity, and New Zealand population, trading bank deposits and prices are used. Rankin cites Butlin (1962), Butlin, Hall and White (1971); Maddock and McLean (1987) and the *Official Year Book of the Commonwealth of Australia (1910)* for Australian data and McIlraith (1911), Easton and Wilson (1984), Bloomfield (1984) the *New Zealand Official Year Book (NZOYB), various issues, New Zealand Statistics for Population and Buildings (1922/23–1939/40)* for New Zealand data.

[2] A sufficient condition would be for all the variables to be integrated of the same order. However, possible cointegration between the components means this is not a necessary condition. However, it is necessary that the (sum) of each side of the identity—taking account of cointegration if it exists (or any re-arrangement to produce an "explanation" of (say) money demand/supply, velocity, real or nominal income) produces a relationship which is "balanced," i.e., the same order on each side of the equation/identity. On the econometrics of integration and cointegration see for example Cuthbertson, Hall and Taylor (1992).

The second source relates to the Nesbitt-Savage (1993) price series used by Cashin (1995).[3] For the period since 1870 this series uses Arnold's (1982) consumer price index spliced with the New Zealand Department of Statistics' consumer price index, *NZOYB* (1990), at 1919. Nesbitt-Savage extends Arnold's series backward to 1847. Following Cashin, thirdly we utilise the recently created series for New Zealand monetary data in Sheppard, Guerin and Lee (1990).

Finally, for Australia we utilise the monetary data published in Vamplew (1987), Chap. 14., and measures of Australian GDP in Vamplew (1987), Chap. 8.

2.4 *Results*[4]

2.4.1. *Rankin-revisited*

Table 1 below reports Augmented Dickey Fuller (ADF) unit root test results for the Australian data used in Rankin (1992). The null hypothesis of a unit root

TABLE 1

UNIT ROOT TESTS (LOG. DATA), AUSTRALIA, 1861–1939

Variable	ADF
Prices	–1.948
Nominal GNP	–2.380
Bank Deposits	–2.516
MPC	–2.580
Velocity	–1.833

Note: ADF(4) in all cases.

is not rejected for any of the series. As such OLS based estimation (as undertaken by Rankin) will be invalid producing "spurious regression" results typically characterised by high R^2 and low DW statistics. Estimation in this case should either be based on data transformed to a stationary $I(0)$ series, or via appropriate estimation methods such as Johansen's (1988) cointegration methods or Phillips and Hansen's (1990), Fully-Efficient methods (if, in both cases, the data are $I(1)$ and cointegrated).

Based upon these results the alternative approach we suggest considers whether Australian velocity, prices and bank deposits are cointegrated, and the relationship between these variables. Further, if Australian velocity and New Zealand monetary variables are also cointegrated, the use of Australian measures of velocity to create a New Zealand GNP series will be founded in modern, robust time series methods. Moreover, the need for *ad hoc* breaks and data deletion is

[3]For the period since 1915–33 the Nesbitt-Savage consumer price series can be compared with Easton's GDP deflator, and they show respectively 18.3 percent and 10.7 percent inflation. Although, in principle, the GDP deflator is the appropriate measure, Easton's indicator backprojects from post-1945 price relationships. Further, it is not available for the pre-1914 years. Following Cashin, we use consumer prices as the best available consistently constructed deflator.

[4]Throughout, the results are based upon the original variables transformed to natural logarithms. Furthermore, coefficients from the Phillips and Hansen (1990) approach are used to construct the New Zealand GDP series.

TABLE 2

COINTEGRATION RESULTS, AUSTRALIA, 1861–1939

Johansen (var = 2)				Variable	Normalised Coeffficient	P–H
H0:	H1:	Max. eigenvalue	Trace	Velocity	—	—
$r=0$	$r=1$	20.59*	32.00*	Intercept	—	–4.978
$r\leq 1$	$r=2$	8.18	11.41	Price	–0.208	1.176
$r\leq 2$	$r=3$	3.22	3.22	MPC	–0.982	–0.690
				IW	na	–0.135

*Denotes significant at 5% level based upon MacKinnon (1991). P–H = Phillips and Hansen (1990) normalised coefficient method results.

obviated by the long run implications of cointegration. Table 2 above establishes that the Australian data are cointegrated with a unique cointegrating vector.

The Johansen (1988) and Phillips–Hansen (1990) approaches show some differences in the estimates produced. Simply replacing the inter-war dummy (IW) of Rankin with a dummy variable to capture the 1929 crash eliminates these differences, see Table 3.

TABLE 3

COINTEGRATION RESULTS, AUSTRALIA, 1861–1939

Johansen (var = 1)				Variable	Normalised Coeffficient	P–H
H0:	H1:	Max. eigenvalue	Trace	Velocity	—	—
$r=0$	$r=1$	25.29*	36.05*	Intercept	—	–3.742
$r\leq 1$	$r=2$	8.30	10.75	Price	0.926	0.999
$r\leq 2$	$r=3$	2.44	2.44	MPC	–0.695	–0.693
				D1929	na	–0.135

*Denotes significant at 5% level based upon MacKinnon (1991). P–H = Phillips and Hansen (1990) normalised coefficient method results. B1929 = Dummy for 1929.

Table 4, below, reports ADF test results that do not reject the null of a unit root for the New Zealand data used by Rankin. By implication, the Rankin (1992) approach of using (spliced) OLS methods will be invalid.

However, based upon our use of cointegration methods, Table 5 below shows that cointegration can be established between the Australian data (Rankin measure of Australian velocity) and New Zealand price and per capita deposits, and this result makes possible a statistically robust Rankin-type measure of New Zealand income.

TABLE 4

UNIT ROOT TESTS (LOG. DATA), NEW ZEALAND, 1859–1933

Variable	ADF
Prices	–1.598
Bank Deposits	–2.335
MPC	–3.332

TABLE 5

COINTEGRATION RESULTS, AUSTRALIA, 1861–1933

		Johansen (var = 2)		Variable	Normalised Coeffficient	P–H
H0:	H1:	Max. eigenvalue	Trace	Velocity	—	—
$r=0$	$r=1$	21.94*	32.31*	Intercept	–4.806	–3.978
$r\leq 1$	$r=2$	8.77	10.37	NZ Price	1.142	0.943
$r\leq 2$	$r=3$	1.59	1.59	NZ MPC	–0.703	–0.533

*Denotes significant at 5% level based upon MacKinnon (1991). P–H = Phillips and Hansen (1990) normalised coefficient method results.

The cointegration-based estimate of Australian velocity, derived in this paper, when multiplied by New Zealand MPC, leads (without *ad hoc* scaling) to consistently lower measures for New Zealand income than the contemporary benchmarks, see Model 3 in Figure 1 below. Hence, although Rankin's data are cointegrated, the use of splices and *ad hoc* weighting are required for creating a series to match that he reports.

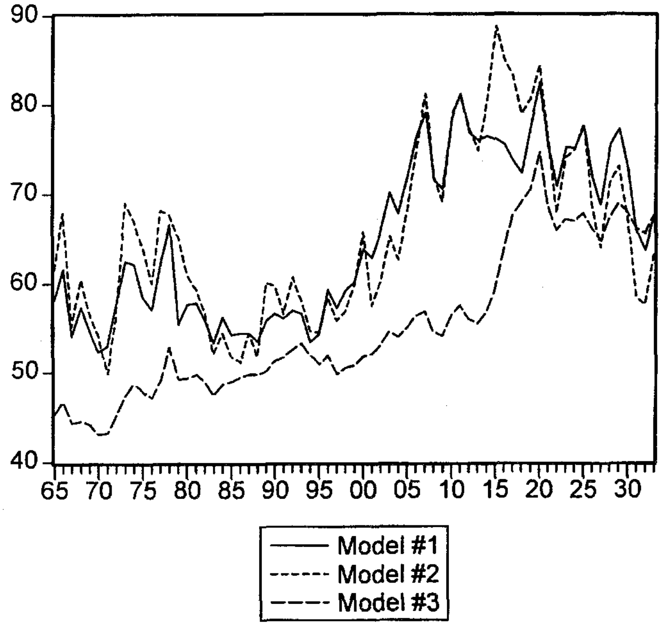

Figure 1. New Zealand real GDP per capita (Rankin-type measures), 1865–1933

2.4.2. *Some Alternative Estimation Results.*

Without *ad hoc* weights and splicing, Rankin's data cannot approximate the independent benchmark income measures on which he sets store, even when statistically valid estimation methods are used. Part of the problem may arise from his choice of monetary aggregate, trading bank deposits per capita, rather than a conventional indicator such as M1 or M3 (data on which were not available to

TABLE 6

UNIT ROOT TESTS (LOG. DATA), AUSTRALIA, 1861–1933

Variable	ADF
M1	−2.405
Velocity	−1.958

Note: ADF(4) in all cases.

Rankin). Similarly, Rankin's measure of Australian velocity is based upon bank deposits.

In this section we utilise measures of Australian M1 velocity derived from Vamplew (1987), and construct New Zealand data-based estimates for this measure. The Australian money and velocity data differ slightly from those of Cashin (1995), which were based upon Butlin, *et al.* (1971), and, as can be seen from Table 6, are $I(1)$.

TABLE 7

COINTEGRATION RESULTS, AUSTRALIA, 1861–1933

Johansen (var = 2)				Variable	Normalised Coeffficient	P–H
H0:	H1:	Max. eigenvalue	Trace	Velocity	—	—
$r=0$	$r=1$	22.31*	38.20*	Intercept	−1.838	−0.172
$r\leq 1$	$r=2$	13.0	15.85	Price	0.490	0.344
$r\leq 2$	$r=3$	2.88	2.88	M1	−0.021	−0.144

*Denotes significant at 5% level based upon MacKinnon (1991). P–H = Phillips and Hansen (1990) normalised coefficient method results.

Further, Table 7 demonstrates that these Australian data are cointegrated. Table 8 below represents the best fitting, cointegration-based model of Australian M1 velocity with New Zealand M1 per capita and the Nesbitt-Savage (1993) measure of New Zealand prices.[5] These results provide our preferred measure for

TABLE 8

COINTEGRATION RESULTS, USING NEW ZEALAND, DATA TO EXPLAIN AUSTRALIAN M1 VELOCITY, 1861–1933

Johansen (var = 2)				Variable	Normalised Coeffficient	P–H
H0:	H1:	Max. eigenvalue	Trace	Velocity	—	—
$r=0$	$r=1$	46.90*	79.33*	Intercept	—	−4.941
$r\leq 1$	$r=2$	28.67*	32.42*	NZ Price	0.516	0.579
$r\leq 2$	$r=3$	3.760	3.760	NZ M1 CAP	−0.293	−0.384

P–H = Phillips and Hansen (1990) method results. These coefficients are used in the simulation exercise. NZ Price relates to the Nesbitt-Savage measure; NZ M1 CAP refers to NZ M1 per capita. Normalised coefficients from second significant cointegrating vector are shown.

[5]The results do not suggest structural breaks in the model based upon unit root tests of the individual series or on the residuals of the cointegrating regression.

velocity from which the new estimates for New Zealand GDP are constructed, Model 5 below.

3. Implications for New Zealand GDP

Table 1A in the Appendix reports alternative series for nominal and real income per capita for New Zealand. Also in Table 1A, Cashin (nom) and (real) refer to the Cashin (1995) results for occasional years presented in his Tables 1 and 4, and "Benchmarks" refers to the contemporary income estimates presented as Table 2 in Rankin (1992). The various models in Table 1A, and others illustrated in this section, are defined in Table 9.

TABLE 9

The Alternative Method

Model	Description
1	Original Rankin (1992)
2	Rankin (1992) deflated by Nesbitt-Savage (1993) price index[6]
3	"Best-fit" cointegration-based model using Rankin data (no breaks). Nesbitt-Savage (1993) price index.
4	Vamplew (1987), monetary data for Australia. Actual Australian GNP-based velocity multiplied by NZ M1 (as per Cashin (1995))
5	Estimated velocity based on Table 8 multiplied by NZ M1.
6	Australian GNP per capita (Rankin (1992))
7	Australian GDP per capita (Vamplew (1987))

Our preferred, new, cointegration-based GDP estimates are labeled Model 5, and are now considered in relation to the contemporary benchmarks, and to Rankin's and Cashin's modern measures.[7] Looking initially at nominal values, Model 5's coincide reasonably well with the contemporary benchmarks, with values ranging between 89.3 percent and 107.8 percent relative to those of the spot estimates. The Model 5 estimate for 1932 matches near exactly the benchmark, to provide a firm basis for splicing the money-based data with the semi and official income estimates for later years. Turning to the Cashin estimates, the largest discrepancy with Model 5 arises for 1920. The nominal Rankin data also exceed Cashin's figure for 1920, by around 40 percent, even though Rankin imposed an *ad hoc* downward adjustment on his data.

Moving to real per capita values, Model 1 and Model 5 use different price deflators, since Model 5, and indeed Cashin real per capita, use Nesbitt-Savage

[6]The model results are created by simply deflating Rankin's nominal series by Nesbitt-Savage's (1993) price series. No attempt to derive a new nominal Rankin series using Nesbitt-Savage prices was undertaken.

[7]Our preference, like those of Cashin (1995) and Maddison (1995) is to regard income estimates derived from domestic money stock measures as GDP. Rankin (1992) labels his money-based income measure as GNP, to coincide with a 1939 GNP benchmark back-projected to 1932 on the basis of semi-official private income data published in *NZOYB* (1957). Rankin also uses Butlin's Australian GNP series and not his GDP series to calculate Australian velocities. The *NZOYB* (1990, p. 679) puts GNP at 99 percent of GDP in 1947, and both Easton (1990) and Thorns and Sedgewick (1997) put the same ratio in 1939 at 97 percent. Chapple (1994) and Rankin (1994) provide further discussion of the New Zealand's national accounts during the 1930s. For practical purposes the 1932 benchmark might reasonably be considered to measure GDP or GNP, and Figures 2 and 3 adopt this premise. Further, the GDP estimates in this paper are not engineered to fit benchmarks.

(1993). To illustrate the effects, Figure 1 reports Rankin's own Model 1 along side his model deflated by the Nesbitt-Savage CPI index, labelled as Model 2. The principal differences arise during World War One where use of the CPI deflator gives faster real growth, and in the 1920s where slower growth results.

Figure 1 also demonstrates how Rankin inflated his (spliced) estimates of New Zealand GNP per capita derived from monetary measures to coincide with the benchmarks. Model 3 (based on Table 5 above), relates to the statistically-valid best-fitting cointegration-based estimate of Australian velocity (using Rankin's New Zealand data). Although this (unweighted) model deploys Rankin's data it consistently underestimates the values of Models 1 and 2, and illustrates how the latter two models are fitted to the benchmarks. Interpolations and extrapolations analogous to those adopted by Rankin are needed to scale the Model 3 results to match the contemporary benchmarks.

Figure 2 compares the preferred Model 5 GDP measures with the original Rankin, Model 1, and Rankin deflated by the Nesbitt-Savage data for New Zealand prices, Model 2. The modest obvious divergence between Models 1 and 5, occurs during the years of World War One. Our preferred model shows strong per capita growth, around a 39 percent increase, between 1913–19, whereas the Rankin index appears essentially static over the same period.

To an extent the alternative price series are responsible, but Model 5 does show a considerably stronger postwar boom, irrespective of the deflator. Rankin's income estimates for 1919–20 were deflated to conform with some other indicators on the immediate postwar economy.

Our preference for the Model 5 estimates rests on their firm statistical foundations. Nevertheless, New Zealand's economic history offers evidence, which

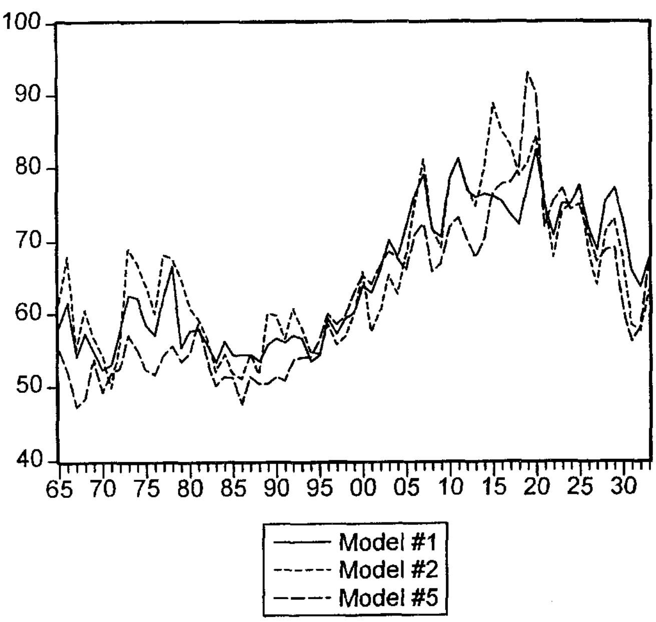

Figure 2. New Zealand real GDP per capita (Rankin and revised estimates), 1865–1933

supports the idea of a strong postwar boom. Exports surged in 1919, with their nominal values doubling, see Mitchell (1995, p. 536–7). Wool exports leaped in value from £7.5 million to £20 million between 1918 and 1919, to account for nearly 40 percent of exports. Over 80 percent of New Zealand exports in 1919 went to the U.K., and high prices were realised during the period of Britain's inflationary boom. Lineham's estimates show a 73 percent rise in New Zealand's nominal farm income in 1919, and rise in real GDP per capita of around 18 percent.[8]

With a smaller population and a higher export-GDP ratio than Australia, high wartime prices, for example during World War Two and the Korean War, have sometimes provided a relatively powerful stimulus to New Zealand's economy. World War One, and especially its aftermath during 1919–20, also appears to stimulate strongly the New Zealand economy. In 1909, on the Rankin and the Model 5 estimates, New Zealand's export-national income ratio was around 30 percent, compared to 18 percent for Australia.[9] Further, limitations on imports partly arising from a scarcity of shipping, and high export prices, led to a New Zealand export surplus equivalent to around 14 percent of GDP in 1919.

Bruce (1920) reports other indicators, including the consumption of durables and the marriage rate, to illustrate the material prosperity in New Zealand associated with World War One, though he also highlights the casualties.[10] Further, the rates of bankruptcies and new company formation illustrate the bouyancy of New Zealand's economy in the immediate post-war years, see Thorns and Sedgewick (1997, pp. 64–5). Bankruptcies, at 141 in 1919, were at their lowest recorded level, and less than half the 1900–13 average. Conversely, new company formations rose 64 percent in 1919, and a further 52 percent in 1920, before the rate fell sharply in 1921.

While a finding of wartime and 1919 prosperity has some support within the historiography, the merits of the GDP estimates based upon Model 5 rest on their statistical foundations. Most importantly, the estimates from Model 5 are statistically well founded, based on appropriate data and avoid arbitrary assumptions. Thus, they appear preferable to those from Models 1 or 2, both for the war period and more generally. Rankin's reliance on interpolation appears particularly suspect between 1902/3 and 1925/6, given the large span of years without a benchmark and the macroeconomic shocks associated with World War One.

Next we contrast the Model 5 results, in Figure 3 with those from a Cashin-type approach, labelled Model 4, which gives an annual series calculated analogously to Cashin's occasional estimates. The issue here is whether simply using an Australian measure of velocity for M1, in conjunction with New Zealand monetary aggregates, gives reasonable income estimates for New Zealand. In the longer term, the income measures from Models 4 and 5 correspond reasonably

[8]The real GDP data incoprates Easton's (1990) deflator, and relate to March years. Some uncertainty remains on the magnitude of the postwar boom since Easton (1997, p. 161) revises downward Lineham's estimate of 1919 income. Alternatively, Easton's new estimates still show a rise in real GDP in 1921, despite the sharp recession in the farm sector in that year, and the fall shown by Rankin's data (and the new estimates reported here).

[9]The trade data are from Mitchell (1995).

[10]Bruce (1920, p. 130) reports of the 110,000 men in the forces, 47 percent suffered casualty of some kind, and 13 percent were killed or died of wounds.

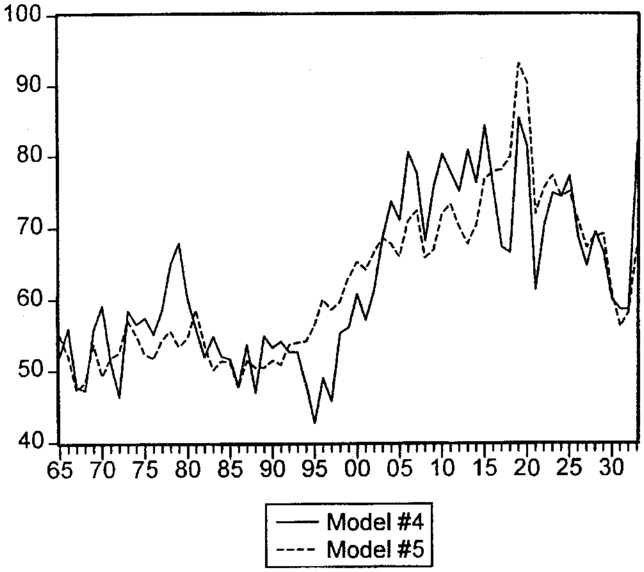

Figure 3. New Zealand real GDP per capita, 1865–1933

well, but occasionally there are clear disparities, most notably in the late 1870s and the 1890s. In both cases, the Cashin-type Model 4 measures appear to be reflecting Australian experience. Dowie's (1966), investment data are not consistent with a late 1870s boom in New Zealand, and the stimulating effects of refrigeration on New Zealand in the 1890s contrast sharply with the well-documented collapse of the Australian economy after 1891, see Greasley and Oxley (1998). Further, the Model 4 estimates show implausibly fast per capita income growth in the decade after 1895, and appear to understate the stimulating effects of World War One on the New Zealand economy, suggesting a slump that appears more reminiscent of Australian experience. Finally, the 1933 per capita level for Model 4 is significantly above the semi-official measure, unlike Model 5, which fits this figure almost exactly. Allowing New Zealand circumstances to be reflected in the velocity estimates yields, as Rankin suggests, more satisfactory estimates for New Zealand incomes.

Finally, consider the relative performance of Australia and New Zealand based upon the new estimates of New Zealand GDP created by Model 5.

Figure 4 presents results for Australian GDP per capita taken from Vamplew (1987) and the preferred Model 5-based GDP for New Zealand incorporating a measure of New Zealand population used in Greasley and Oxley (1999).[11] From this figure we can see that Australia first leads then, from the 1890s, (generally) lags behind New Zealand until the late 1920s. First World War and immediate postwar experiences appear significantly different in the two countries. This is to be contrasted with Rankin's (1992, p.54) Figure 2 which shows a similar 1900–25

[11]This measure is derived from *NZOYB* (1990, 1995), *New Zealand Official Year Book*, Wellington and incorporates Maori in the population. This, in part, overcomes some of the worries expressed in Maddison (1995), p. 134, regarding the exclusion of Maori.

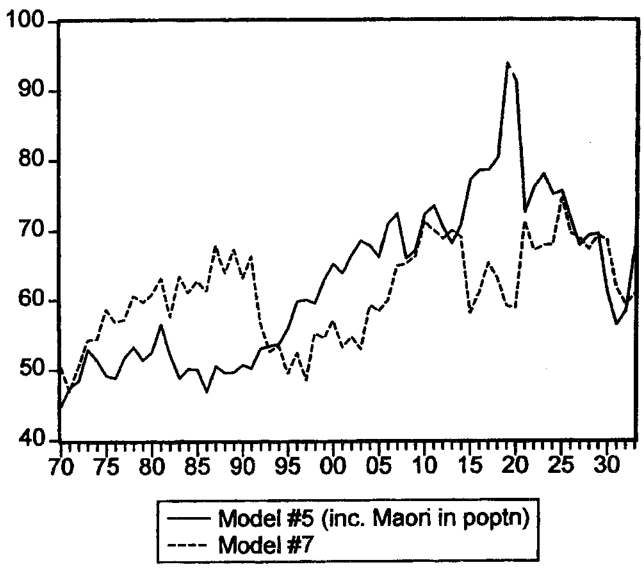

Figure 4. New Zealand vs. Australia real GDP per capita, 1870–1933

experience for the two countries, ostensibly obtained by assuming that New Zealand mirrored the Australian growth record during this period since benchmarks are not available.

4. Concluding Remarks

The new estimates of New Zealand incomes from Model 5 are founded upon a thorough and consistent methodology, which considers the time series properties of the data and appropriate estimation methods. With an absence of data on New Zealand velocity some "statistical association" has to be established between New Zealand and Australia, if the Australian data are to proxy the non-existent New Zealand data. Cointegration analysis and the results in this paper provide just that evidence.

However, New Zealand-specific influences are also given a role in constructing the income estimates, rather than simply imposing an Australian measure of velocity as in Cashin (1995) and Hawke (1975). Using a statistically valid estimate of Australian velocity based upon New Zealand data allows New Zealand conditions to shape the income estimates, and has clear effects, for example in the 1890s and during World War One and its aftermath, when Australian and New Zealand economic circumstances diverge.

The new estimates produced here do not involve *ad hoc* adjustments, splicing, scaling, or interpolation. Nevertheless, they track the contemporary benchmarks closely. The greatest uncertainty surrounding New Zealand's income estimates concerns the period 1902–25, which has no benchmarks. The ability of Model 5 to track the benchmarks in the earlier and later years militates against using *ad hoc* adjustments for the intervening years.

New Zealand pre-1950 retrospective national income data are weak by the standards of other OECD countries. In the absence of direct measures, the money-based estimate of Hawke (1975), Rankin (1992), and Cashin (1995) are central to understanding New Zealand's early growth experience. Maddison's (1995) compilation of international national income statistics incorporates Rankin's data, as the best available annual series for New Zealand. To the extent that New Zealand income estimates depend on proximate money-derived estimates, they need to be put on a firmer statistical footing.

In this paper we build on the pioneering work of Hawke, Rankin, and Cashin to provide rigorously derived, validly estimated measures of New Zealand GDP utilising the powerful implications of cointegration analysis. The latter identifies strong statistical links between the monetary transmission mechanisms in Australia and New Zealand necessary for the approach used here, but also incorporates distinctive elements from New Zealand's experience. Using consistent measures of prices and a new series on New Zealand M1 in an interpolation-free, break-free approach, we construct an income series that tracks the occasional contemporary benchmarks well, and produces statistically robust estimates for the whole period.

Appendix

TABLE 1A

NEW ZEALAND NOMINAL AND REAL GDP PER CAPITA (RPC), £M AND £

OBS	Model 1 (nom)	Model 5 (nom)	Cashin (nom)	Benchmarks	Model 1 (RPC)	Model 5 (RPC)	Cashin (RPC)
1865	15.8	14.10636		15.8	58.1498626	54.97006	
1866	18.4	14.11835			61.61941317	52.14281	
1867	16.5	14.12977			54.09176093	47.24505	
1868	18.5	14.78872			57.34483371	48.41648	
1869	16.9	16.03848			54.70387131	53.76495	
1870	16.3	14.80555			52.36078896	49.26133	
1871	16.8	17.45117	16.75		52.96007693	51.80674	52.45
1872	20.6	19.35767			57.58784795	52.58620	
1873	25.5	21.08166			62.5389334	57.07617	
1874	27.9	22.89860			62.18011216	55.03893	
1875	29	23.71925			58.47460846	52.29649	
1876	28.7	24.66299			57.06549712	51.62320	
1877	34.2	27.27698			62.4524608	54.34415	
1878	35.8	29.40568			66.60623955	55.56580	
1879	30.8	25.32503			55.3835425	53.43235	
1880	31.8	28.49947			57.64969681	54.59868	
1881	32.1	31.69405	28.85		57.83880057	58.58845	48.25
1882	32.4	30.73003			55.80316199	53.75683	
1883	30.7	29.56517			53.31067117	50.13031	
1884	32.5	30.65589			56.22738282	51.32854	
1885	30.2	29.89361			54.25210726	51.20429	
1886	30.1	28.05267			54.4116161	47.65416	
1887	30.4	28.70007			54.40205327	51.39646	
1888	29.7	28.89285			53.50144368	50.35026	
1889	33.7	28.27340			55.81653956	50.42457	
1890	33.2	28.57203			56.59376129	51.41556	
1891	33	29.66387	30.3		56.04171222	50.83979	50.3
1892	34	30.04955			56.98516301	53.65464	
1893	33.4	31.01246			56.617529	53.93358	

TABLE 1A—continued

NEW ZEALAND NOMINAL AND REAL GDP PER CAPITA (RPC), £M AND £

OBS	Model 1 (nom)	Model 5 (nom)	Cashin (nom)	Benchmarks	Model 1 (RPC)	Model 5 (RPC)	Cashin (RPC)
1894	31.6	31.28750			53.41622206	54.10252	
1895	31.7	32.76195			54.30801954	56.27897	
1896	36	36.92445			59.32499956	59.99849	
1897	35.9	37.69467			57.22016343	58.57551	
1898	36.6	38.39467		36.8	59.24994043	59.62538	
1899	37.9	39.89416			60.16001357	62.94951	
1900	43.3	42.91384	41.25	43.3	63.88631006	65.19004	58.4
1901	41	45.70638			62.88949458	64.06576	
1902	45.1	49.83784		46.2	65.88689367	66.56484	
1903	50	52.45234			70.14899631	68.51716	
1904	49.4	53.32640			67.81904458	67.67630	
1905	56.6	54.85101			71.96614656	65.97455	
1906	64.7	61.34705			76.44714956	70.94729	
1907	73.1	65.13928			79.05953716	72.31414	
1908	66.7	61.14513			71.50689506	65.84277	
1909	66.1	64.01860			70.55936785	66.92466	
1910	77.9	71.15249	74.25		78.54325378	71.93041	70.15
1911	82.4	74.52230			81.17770382	73.22344	
1912	83	75.30592			76.81076663	70.14732	
1913	84.9	76.88079			75.95258294	67.74543	
1914	94	82.64054			76.42960039	70.29422	
1915	110	94.98860			76.0875447	76.68571	
1916	113.3	103.7316			75.5088283	77.79773	
1917	120.2	112.6726			73.69300165	78.01267	
1918	127.6	129.0587			72.30130287	79.79917	
1919	148.5	171.5056			77.61880412	93.09106	
1920	184.2	197.3151	131.5		82.41721808	90.37578	64.75
1921	174.9	166.3910			74.97571629	71.90625	
1922	143	159.1934			70.81638693	75.47205	
1923	155	161.5426			75.1615907	77.18853	
1924	163.2	161.8223			75.07193278	74.33549	
1925	173.5	167.4861		175.7	77.52740474	74.97839	
1926	157.5	162.7704			71.90504218	71.04372	
1927	147.8	155.2623			68.7562553	67.21650	
1928	166.5	160.7887			75.48881305	68.79590	
1929	172.3	163.0395			77.26446762	69.12920	
1930	158.4	142.4242			72.98184022	60.86480	
1931	127.9	123.0681			65.86173757	56.12110	
1932	117.2	118.2451	117.5	117	63.72241105	58.09720	63.9
1933	123.7	131.8661		123.7	67.51462673	67.41940	

Note: RPC denotes Real Per Capita; "nom" refers to nominal and "Benchmarks" to the contemporary benchmarks referred to in Rankin (1992).

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