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Dating New Zealand Business Cycles

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DATING NEW ZEALAND BUSINESS CYCLES

KUNHONG KIM, R A BUCKLE AND V B HALL*

I. Introduction

Dating the turning points and duration of business cycles has long been associated with the construction of aggregate reference cycle indexes, and their associated leading, coincident and lagging indicators. This was along lines originally developed by Burns and Mitchell (1946), and subsequently by colleagues at the National Bureau of Economic Research (NBER), e.g. Klein (1990). More recently, identifying the turning points and duration of business cycles has been an important aspect of two further areas of business cycle research: the evaluation of theoretical and associated empirical business cycle models, e.g. King and Plosser (1989); and the analysis of the time varying characteristics of business cycles, e.g. Diebold and Rudebusch (1992).

The Burns and Mitchell technique of dating business cycles relied primarily on two sorts of information: the descriptive evidence from business publications and general business conditions indices, and the "specific cycles" found in many individual series and the tendency for turning points to sometimes cluster at certain dates. Based on this information, a set of reference cycle dates were selected that specified the turning points in "aggregate economic activity". A key feature of the Burns and Mitchell approach was to focus on the amount of cyclical co-movement or coherence among a large number of economic variables. This co-movement is the prime characteristic of their definition of the business cycle: "...a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle;...in duration business cycles vary from more than one year to ten or twelve years..." (Burns and Mitchell, 1946, p 3).

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The NBER approach is based on the view that there is no unique way of combining all these activities, and accordingly the business cycle cannot be fully depicted by a single measure, e.g. Burns (1969, p 13). Burns and Mitchell, and subsequent NBER researchers, intended therefore, before the computer age, to provide a standard technique with a set of decision rules for deriving business cycle turning points based on these two sorts of information. In practice, this involved the application of a standard format of filtering procedures to extract the turning points in each data series, and then combining this information in a judgemental way to determine a single turning point date. Other procedures, notably reference cycle indexes and coincident indexes, subsequently emerged as supplementary procedures for combining a large number of data series including various measures of output, production inputs, price series, monetary aggregates, etc, into a single composite index which have also been used to identify turning points.

The NBER approach to dating business cycles does not accord particularly well with the modern approach to business cycle research, as this is typically more firmly rooted in one or more particular theories of the business cycle, with explicit predictions about the cyclical behaviour of aggregates such as private consumption and investment demand, prices, real wages, labour productivity, and real net exports, in relation both to each other and to the cyclical behaviour of aggregate real output. Rather than subsume all available series into a single composite index, the business cycle is therefore typically defined by the cyclical movements about an appropriate trend in real gnp or gdp. A major interest for modern business cycle research is in the co-movement of different aggregative time series. This way of viewing the business cycle is clearly expressed in Lucas (1977), and underpins the recently emerging body of empirical work analysing key features of business cycles across countries and across time. A significant number of filtering procedures have now been applied in this body of research for the purpose of identifying business cycles and the cyclical component of individual series, but to date there has been relatively little systematic work done on evaluating the sensitivity of results to alternative filtering procedures[1].

The purpose of this paper is therefore to provide an evaluation of some of these issues in a New Zealand context. Its particular objectives are:

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1 However, work published quite recently has been that of King and Rebelo (1993), Blackburn and Ravn (1992), Canova and Dellas (1993), and Baxter (1991).

i) to present a set of business cycle turning points for appropriate measures of New Zealand's real gdp, utilising the transparent, quick-to-compute Bry and Boschan (BB) (1971) procedure;

ii) to compare these turning points with those previously identified for New Zealand's aggregate business cycle, and which have been obtained by NBER type business cycle dating techniques (eg. Haywood, 1972; Haywood and Campbell, 1976; National Bank of New Zealand (NBNZ), (1992);

iii) to evaluate the BB turning points against those obtained from three other relatively mechanistic "deviations from trend" methods recently used in growth cycle analyses, i.e. the Henderson moving average-based method (HMA) applied to Australian real GDP data by Salou and Kim (1992), the structural time series-based method (STAMP) proposed by Harvey and Jaeger (1993), and the Hodrick-Prescott (HP) method utilised for deriving key features of New Zealand business cycles by Kim, Buckle and Hall (1992); and

iv) to provide some empirical 'benchmark' turning points and business cycle duration characteristics[2] for New Zealand, against which it will be possible to evaluate small modern open economy theoretical business cycle models with known properties (e.g. Kim, 1991,1992).

It is important to acknowledge at the outset that *some* degree of *a priori* judgement will always be required, no matter which procedure is used; also that there is no *a priori* reason why precisely the same turning points should emerge from procedures as diverse in nature as those which are NBER multiple series based, and those obtained from the application of BB and other deviations from trend dating techniques applied to a single real aggregate output measure, such as real gdp. This means in turn that one has to make transparent, and recognise the extent to which publicly available empirical results are sensitive to the methodology used to produce them.

So, to establish the extent of such sensitivity in a New Zealand context, section 2 summarises key aspects of major previous and ongoing NBER-type attempts at dating New Zealand business cycles. Section 3 summarises essential elements of the Bry and Boschan dating procedure, and reports our results from applying it to four representative New Zealand real gdp and real gdp per capita series. Section 4 presents and compares the

2 We have focussed solely on duration, rather than both duration and amplitude, characteristics to assist with presenting a manageable set of results.

turning point outcomes from the three relatively more mechanistic "deviations from trend" procedures. Then in section 5, some 'benchmark' business cycle turning point and duration characteristics are then presented, and the latter are contrasted with some for Australia, the United States (US), and selected statistical processes. Section 6 contains a summary of the main conclusions.

II. Previous dating of New Zealand business cycles

The papers by Haywood (1969, 1972) provided the first attempts to date quarterly turning points in the New Zealand business cycle[3]. The approach used was to derive NBER style reference cycle indexes from existing nominal and real data series, with the aim of extracting leading indicators of the New Zealand business cycle. The index produced in 1972 covered the period 1946 to 1970; it was derived from 30 seasonally adjusted quarterly series available in 1946, with 67 series being available by 1970[4]. Haywood's first reference cycle index would appear to be derived from a simple unweighted summation of the number of series that are expanding from one quarter to the next less the number contracting, although this is not made clear. Nor, despite Haywood's (1972, p 9) explaining that "The dating of peaks and troughs from the reference cycle was determined largely by the size of the movement to and from the 50 per cent line.", is it clear what precise method was used to finally select the turning points, since the reference cycle is published only in chart form.

These publication deficiences are partially rectified in the subsequent paper by Haywood and Campbell (1976) which introduced three modifications to the earlier procedure: (a) subjectively weighting each series from 1 to 10 where the weights were assigned on the basis of a somewhat arbitrary notion of "relative economic significance" (p 6) of each series; (b) each series was expressed in standard deviation units rather than the direction of change, where standard deviation units are the number of standard deviations from a simple (undefined) trend of the series; (c) the use of an alternative 75 month moving trend to derive the standard deviation units. Three reference cycles were derived. The procedure applied in the 1972 paper together with modification (a) provided the

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3 Previous attempts to date business cycles in New Zealand by Simkin (1960) and Preston (1964) concentrated on identifying peak and trough years. Simkin's dating was based on percentage changes in annual real income per capita. Preston used 51 economic indicators to derive what he referred to as years of peak rise in economic activity and years of least increase in economic activity.

4 The 1972 paper is a development of the 1969 paper which only covered the period 1957 to 1968. The 1969 paper identified two turning points which were subsequently eliminated in the 1972 paper: 1965:4 (October) as a peak and 1965:4 (December) as a trough.

"weighted crude deviation cycle"; procedures (a) and (b) provided the "weighted static deviation cycle"; procedures (a) and (c) the "weighted dynamic deviation cycle".

Table 1 shows the dates of the business cycle turning points that emerged from the four reference cycle indexes derived by Haywood (1972) and Haywood and Campbell (1976). A comparison of all four reference cycles reveals that only 2 of the 12 selected turning points for the period 1947 to 1968 correspond precisely, the peak of 1951:3 and the trough of 1959:1. Differences in the selection of turning points can be as much as four quarters. Haywood and Campbell's three weighted deviation cycles have 4 identical turning points out of the 12 selected up to 1968, and 5 out of 15 selected for the period to 1974. The closest correspondence is between the static and dynamic deviation cycles which correspond exactly in 12 of the 15 turning points.

The reference cycle indexes developed by Haywood and Campbell provided the basis for the development of composite leading and coincident indicators of particular phases of the business cycle, as defined by the weighted dynamic deviation cycle. These were for several years regularly published in the NZIER's *Quarterly Predictions* (Haywood and Campbell, 1977), although the reliability of the initial indicators came into question during the late 1970s, forcing a revision of the composition of the leading and coincident indicators (Campbell, 1979a) [5].

Although Haywood and Campbell's leading and coincident indicators were no longer published by the NZ Institute of Economic Research after September 1980, there remained a demand for reliable indicators of turning points in the business cycle. Kay (1982, 1984) showed that, up to 1980, turning points in an aggregate manufacturing production capacity utilisation variable derived from responses to the NZ Institute of Economic Research's *Quarterly survey of business opinion* corresponded closely, but not precisely, with turning points in Haywood and Campbell's weighted dynamic deviation cycle.

The NBNZ, in collaboration with the Centre for International Business Cycle Research (CIBCR) at Columbia University, currently derives coincident and leading indexes of the New Zealand business cycle, and much less frequently also identifies business cycle turning points. The indexes have been published monthly since early 1992 (NBNZ,

5 The reference cycles developed by Haywood and Campbell also provided the basis for a range of other research on the New Zealand business cycle, including the relationship of the domestic cycle to external cycles and the influence of fiscal policy on that relationship (Morgan and Haywood, 1977), the role of international conditions on the New Zealand cycle and the development of 'super' leading indicators based on international data (Campbell, 1979b), and an analysis of the cyclical behaviour of prices over the business cycle (Campbell and Haywood, 1978).

1992), with the procedure used to derive the coincident index being described in detail in CIBCR(1992). It is similar to that applied by Haywood and Campbell (1976) to construct their weighted dynamic deviation cycle, though currently includes only five data series: quarterly expenditure based real gdp, quarterly real national disposable income, quarterly employment from the household labour force survey, monthly registered unemployment, and monthly real retail trade.

To identify business cycle turning points, a somewhat different several-stage procedure is applied by the CIBCR to this same data. Key aspects of this procedure are its use of the Phase-Average Trend (PAT) method explained in OECD(1987) and in Klein and Moore(1985), and then closely replicating Burns and Mitchell-type dating procedures. Its first stage is to use the BB computer programme to select preliminary turning points in the five data series and the coincident series; its second (PAT) stage (Klein and Moore, 1985, p 32) produces for each series (including their Coincident Index) a "...refined and flexible [final] trend estimate to calculate deviations of the original, seasonally adjusted data from this final trend."; and the eventual choice of turning point for the aggregate business cycle is then selected judgementally by the CIBCR according to the way the turning points for each individual series are clustered. Typically the turning point is selected close to the median of each cluster. Clearly, as with the reference cycle index approach used by Haywood and Campbell, the particular set of data used for the dating procedure and the judgement of the individual researcher in choosing a single date from the cluster of turning points will have an important influence on the eventual choice of business cycle turning point dates.

Two further studies by Massey (1990) and Vandersyp (1990) have attempted to identify turning points in the New Zealand business cycle. In contrast to the NBER methodology, these papers focus on fluctuations in real gdp only. Massey applied two definitions of a cycle to the Reserve Bank of New Zealand's expenditure based estimate of seasonally adjusted quarterly real gdp for the period 1968 to 1987. One definition specified a recession as any period of two or more successive quarters of decline in the level of real gdp, so that a full cycle is then determined as the period between successive troughs, with the peak quarter evidently being determined by the quarter of highest real output, although this is not made clear. This procedure, which appears to be based on a misinterpretation of the NBER definition of a recession, generated quite different cycle turning points from those identified by Haywood and Campbell and subsequently by the CIBCR. Eleven troughs were identified between 1968 and 1987 compared to the six identified by the CIBCR.

The second procedure used by Massey was based on deviations about a *linear* time trend for real gdp. This produced one less cycle than the first procedure, but still more than Haywood and Campbell and the CIBCR. Moreover, Massey does not provide an explanation of the criterion used to date the turning point quarters. Massey's conclusion that cycles have become more frequent and of shorter duration since the mid-1970s when judged against the Haywood and Campbell dating of cycles from 1947 to 1974 arises from an attempt to compare the results of two fundamentally different dating procedures and fails to recognise that his dating procedure also generates more cycles than was identified by Haywood and Campbell over the years covered by both studies prior to 1974.

Vandersyp identified cycle turning points as part of a comparative analysis of the cyclical behaviour of the Department of Statistics expenditure and production based estimates of quarterly real gdp. The basis for identifying turning points was the deviations about a linear trend of the seasonally adjusted data for both series. Vandersyp found it necessary to further "smooth" the expenditure based series, in a manner undefined, before selecting turning points. Again, clear specification of the criterion for choosing turning points is not provided. Nevertheless, Vandersyp identified a trough in the production based series in 1983:1 which was not evident in the expenditure based series, a peak for both series in 1986:3 and a subsequent trough for both series in 1990:1.

To summarise, dating New Zealand business cycle turning points based on NBER type composite reference cycle or coincident indexes is well established for New Zealand and provides turning points from 1947 to 1991, although the more recent dates are still tentative. Where the periods analysed overlap, the turning points identified by Haywood and Campbell (using the dynamic series) and by the CIBCR correspond exactly in four of the 15 dates and differ by no more than one quarter in 10 cases. The largest difference is the 1965/1966 peak where the dating differs by four quarters. The number of peaks and troughs identified between 1955 and 1980 correspond exactly: eight peaks and seven troughs. In contrast, the dating of cycles based on real gdp alone, which would be more appropriate from the standpoint of modern business cycle analysis, is not well developed and it is to this approach to dating business cycles that we now turn.

III. Bry and Boschan dating procedure applied to real gdp

A difficulty with the Burns and Mitchell/NBER/CIBCR approach to specifying reference cycle turning points is that it requires the use of many series, and significant use of quite detailed judgemental analysis. This poses a considerable problem from the point of view of using such dates to guide the development of theoretical models and model evaluation, since the business cycle "facts" to emerge from the NBER procedure could rest excessively upon the particular researcher. Fortunately, therefore, in the early 1970s the NBER sought to automate their method of dating turning points in individual data series, by developing a computer algorithm that would replicate the Burns and Mitchell procedure. This algorithm was that of Bry and Boschan (1971), and its key features are summarised in Table 2.

The general concept underlying the BB procedure involves searching for turning points in some smoothed version of a seasonally adjusted series, so as to avoid being misled by so-called "erratic" movements. The procedure is also intended roughly to parallel the NBER sequence of first identifying major cyclical swings, then delineating the neighbourhoods of their maxima and minima, and eventally narrowing the search for turning points to specific calendar dates. Extreme values are checked for, and where relevant are replaced by equivalent (Spencer curve) smoothed observations[6]. Lower bound restrictions imposed on the selection procedure are that business cycles must be no less than 15 months long, and that all phases (expansions and contractions) must be at least 5 months in duration [7]. No upper bound restrictions seem to have been explicitly imposed.

The OECD (1987, pp 34-36) has since argued both that the BB procedure could tend to produce a trend which is somewhat too flexible for when medium-term growth cycles are being considered, and that its own PAT-based procedure (developed for the NBER by Boschan and Ebanks, 1978) copes better with cycles of different length and with non-constant trend growth. However, our presenting additional PAT-type business cycle turning points in this paper would add little new of significance, amongst other things because as pointed out above, the CIBCR/NBNZ turning points are essentially PAT/NBER-based.

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6 The extreme values are defined as those outside a range taken as 3.5 standard deviations of the ratio of the original (seasonal adjusted) observation to its equivalent from a 15 month Spencer curve. The relevant Spencer curve filter weights for the terms (t-7) to (t+7) are -3/320, -6/320, -5/320, 3/320, 21/320, 46/320, 67/320, 74/320, 67/320, 46/320, 21/320, 3/320, -5/320, -6/320, -3/320.

7 Bry and Boschan present two types of evidence of the ability of this algorithm to replicate the NBER method. They compare the turning points of a series that was evidently extensively studied by Burns and Mitchell; monthly bituminous coal production from 1914 to 1935. The thirteen turning points selected by Burns and Mitchell correspond exactly to the ones selected by the program in all cases but one, and this was a dating difference of three months. The second test was to compare the turning points selected by their programme in over fifty series covering the period 1947 to 1966 to the turning points selected by the NBER staff. Almost 95% of the 435 turning points identified by the staff were identified by the programme and 90% had identical dates. The only systematic discrepancy arose because the Bry and Boschan programme tended to find about 15% more turns than the staff.

Romer (1992, pp 13-14) has recently criticised Burns Mitchell rules and BB procedures, arguing that the former are "complex and cumbersome" and that the BB algorithm is "...complicated and involves various *ad hoc* adjustments." She has therefore advanced her own (single series) algorithm, suitable for identifying cycles and choosing turning points from monthly index of industrial production data. The potential usefulness of her (still parsimoniously judgemental) "notion of output loss" method is also not investigated in this study.

The business cycle turning points, obtained by applying our programmed BB procedure to four representative quarterly New Zealand real gdp series, are presented in Table 3. The four series, all seasonally adjusted using the X-11 US Bureau of Census method via the EZX11 program, are: the linked Reserve Bank of New Zealand and Statistics New Zealand quarterly expenditure based series, on an actual and a per capita basis for the period 1966(4) to 1993(2); and Statistics New Zealand's quarterly production based series, also on an actual and a per capita basis, but for the much shorter period 1977(2) to 1993(2). The linked expenditure based series has the advantage of covering a longer time period, the production based actual series is currently deemed by the Government Statistician a more reliable measure than its expenditure based equivalent, while the characteristics of the per capita series are probably the more appropriate empirical measures for theoretical representative agent business cycle models. As the BB programme is written for monthly observations, we followed BB's procedure for quarterly data by simply repeating the quarterly number for each month in the relevant quarter.

From Figures 1 and 2, a simple visual inspection shows that the BB procedure captures turning points <u>in the relevant data series</u> well[8]. Where there are turning point differences in Table 3, these generally reflect the significantly different behaviour of the expenditure and production based series, especially from around the mid-1980s (see also Figure 1). This means that our preferred choice of turning points (except for the trough in 1978(1) and the peak in 1986(3)) is dependent on the perceived relative reliability of the two series, rather than being conditioned by aspects of the BB method.

More particular empirical features of the results worth noting at this stage are:

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[8] Despite the presence of a significant number of spikes in the (seasonally adjusted) expenditure based series, no extreme values were detected for replacement by equivalent Spencer curve values. However, significant numbers of eliminations, based on the criteria set out in Section V of Table 2, did occur for each series.

- In each case, the per capita series exhibited more turning points than their non-per capita counterparts;

- For both the expenditure and production based series, where the actual and the per capita series have turning points around the same time, the respective actual and per capita turning points are identical. There is therefore no evidence of the per capita series peaking or troughing prior to the actual series, in contrast to King and Plosser 's (1989, pp 9-10) findings for the US that peaks in the per capita series tended to occur earlier than those for the non-per capita series;

- Focusing on the period since the late 1970s:

  - the trough in the first quarter of 1978 and the (somewhat spiked pre-GST boost to activity) peak in the third quarter of 1986 are picked for all four series, and the most recent second quarter of 1991 trough is evident from three of the four series[9];

  - except for the peak of 1986(3) and the trough of 1991(2), the peak and trough results from the expenditure and production based series for the post-1984 period are noticeably different from each other;

  - the "false" peak produced for the 1992(2) quarter by the two expenditure based series is almost certainly due to the officially disowned 1992(3) observation noted in footnote 9;

- For the period since the late 1970s, and despite the sample period being somewhat shorter, we believe preference should be given to the results obtained from the two production based series. The per capita series provides one extra trough (in 1988(2)) and one extra peak (in 1989(2));

- Perhaps not surprisingly, our (production based) BB turning points are not particularly similar to those presented in the CIBCR column in Table 1. The troughs of 1978(1) and 1991(2), and perhaps 1983(1) or (2) can be considered as picked in common, but overall for New Zealand one is forced to conclude that

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9 The exception is the least satisfactory expenditure based series, and this is almost certainly associated with the exceptionally sharp fall in activity recorded for the 1992(3) quarter for that series. This particular quarterly figure has, in essence, been disowned by the Government Statistician (see the September quarter 1992 release by the Department of Statistics of "Expenditure on Gross Domestic Product in Constant Prices", Catalogue No. 08. 515).

NBER/CIBCR reference cycle and BB real GDP turning point analyses are not direct substitutes[10].

IV. Bry and Boschan, relative to "Deviations from Trend", Turning Points

There has been increasing use of the Hodrick-Prescott and other filters for trend removal, as part of recent research describing the stylised facts of business cycles and designed to effect theoretical model comparisons. Many of these "deviations from trend" based studies seem to have been useful in reaffirming or establishing new key stylised facts for a range of countries, but comparatively less attention seems to have been paid to how useful the underlying filters could be for business cycle dating purposes. A preliminary contribution towards the latter issue is therefore the primary focus of this section. The key features and conditioning assumptions underlying each of the relatively mechanistic HMA, STAMP, and HP methods are discussed next, followed by a comparison of relevant empirical results obtained with those from the BB method.

IV.1 Key Features of the HMA, STAMP, and HP Methods

Modern 'growth cycle analysis' is focussed on fluctuations in aggregate economic activity relative to an appropriate long term trend rate. In this analysis, a business cycle is defined in terms of deviations of aggregate real output from trend. It is therefore necessary first to estimate an underlying trend and then to remove it from the series considered. Here, we consider three different approaches for estimating the trend; (1) the Henderson Moving Average (HMA) method, (2) a Structural Time Series Modeling (STAMP) method, and (3) Hodrick-Prescott (HP) filtering.

As a general principle, it is possible for time series to be broken down into their seasonal variations, irregular short-term movements, long-term trend and, finally, their business cycle component. For the purposes of this paper, we abstract from the issue of seasonal adjustment, by using the same data set corrected for seasonal variation by the U.S. Bureau of Census X-11 method.

10 King and Plosser (1989, Figures 1a, 1b and Table 2) present NBER and BB results for US real and real per capita GNP. For their real GNP data, the BB procedure did not recognise two NBER recessions. However, dates for NBER and BB per capita troughs were shown to coincide almost exactly, in contrast to those for a number of per capita peaks.

1. Henderson Moving Average Method

Estimates of the different time series components are obtained by using Henderson moving average filters. The irregular short-term movements are eliminated by applying a 7 term Henderson moving average, with the resulting series being called the 'smoothed series'. A 'long-term trend' is then derived by applying a 33 term Henderson moving average to the 'smoothed series'. Finally, the 'business cycle component' is defined and derived as the deviation of the 'smoothed series' from the 'long-term trend'.

The general formula for calculating a set of filter weights, $W_1, W_2, \ldots, W_n$, with $\sum_{i=1}^{n} W_i = 1$, for an n-term Henderson moving average, can be found in Macaulay (1931, p 54), and is given by:

$$W_r = \frac{315\{(\frac{n+3}{2} - 1)^2 - r^2\}\{(\frac{n+3}{2})^2 - r^2\}\{(\frac{n+3}{2} + 1)^2 - r^2\}\{(3(\frac{n+3}{2})^2 - 16) - 11r^2\}}{8\,\frac{n+3}{2}\,\{(\frac{n+3}{2})^2 - 1\}\,\{4(\frac{n+3}{2})^2 - 1\}\,\{4(\frac{n+3}{2})^2 - 9\}\,\{4(\frac{n+3}{2})^2 - 25\}}$$

$$r = 1, 2, \ldots, n. \qquad (1)$$

For observations at the start and, more importantly, at the end of a series, Henderson moving averages cannot be used directly. For example, for a 33 term Henderson moving average, the first 16 periods and the last 16 periods cannot be smoothed because there are not sufficient observations available for the calculation. This is called the ‘end point problem’. To produce results at the ends of the series, *surrogate* Henderson moving averages that approximate the properties of the desired moving average have to be used. A formula for calculating surrogate Henderson moving average weights can be found in Doherty (1993). For an n-term Henderson moving average filter, a set of weights for the surrogate filter with m terms (m < n), is given by:

$$U_r = W_r + \frac{1}{m}\sum_{i=m+1}^{n} W_i + \frac{(r - \frac{m+1}{2})\gamma}{1 + \frac{m(m-1)(m+1)}{12}\gamma}\sum_{i=m+1}^{n}(i - \frac{m+1}{2})W_i$$

$$r = 1, 2, \ldots, m$$

where $\gamma = \frac{4/\pi}{(\bar{I}/\bar{C})^2}$. $\bar{I}$ and $\bar{C}$ are the average period to period changes without regard to sign of the estimated 'deviation from trend' and 'trend' component of the series, respectively.

This procedure has been used by the Australian Bureau of Statistics in its analysis of 'business cycle turning points' and 'leading indicators' (Salou and Kim, 1992; Australian Bureau of Statistics, 1993). Their 7-term and 33-term Henderson surrogates are based on $\bar{I}/\bar{C}$ values of 4.5, and we have used this same value in our empirical work reported below. Their visual selection of turning points was supplemented by two simple rules (see Salou and Kim, pp xii, xiii), and their 7 term/33 term HMA choice essentially bounds their empirical cycles to being between 2 and 8 years (ABS, p 2; Salou and Kim, p xi).

One possible inflexibility of the Henderson Moving Average method is that, although there is some scope for adjustment (e.g., adjusting the value of γ), the same procedure is essentially applied irrespective of the properties of the series.

2. Structural Time Series Modeling

Rather than applying a predetermined mechanical procedure to each series, this approach decomposes each particular time series into its components through use of the maximum likelihood estimation method. A univariate structural time series model can be formulated in terms of components

$$y_t = \mu_t + \psi_t + \varepsilon_t, \tag{2}$$

where y_t is the logarithm of the observed series, μ_t is a trend, ψ_t is a cyclical, and ε_t is an irregular component. It is assumed that the cyclical component ψ_t follows a stationary linear process, the irregular component ε_t is a white noise disturbance term with variance σ_ε^2, and all of the components are uncorrelated with each other.

A stochastic linear trend can be modeled as

$$\begin{aligned} \mu_t &= \mu_{t-1} - \beta_{t-1} + \eta_t, \\ \beta_t &= \beta_{t-1} + \zeta_t, \end{aligned} \tag{3}$$

where η_t and ζ_t are uncorrelated white noise disturbance terms with variances σ_η^2 and σ_ζ^2, respectively. The level of the trend is given by μ_t, with β_t being its slope. If $\sigma_\zeta^2 = 0$, the trend reduces to a random walk. If furthermore, $\sigma_\eta^2 = 0$, the trend becomes deterministic.

When $\sigma_\eta^2 = 0$, but $\sigma_\zeta^2 > 0$, the trend is a process integrated of order two. A trend component with this feature tends to be relatively smooth.

Let the cyclical process ψ_t take the form

$$\begin{bmatrix} \psi_t \\ \psi_t^* \end{bmatrix} = \rho \begin{bmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{bmatrix} \begin{bmatrix} \psi_{t-1} \\ \psi_{t-1}^* \end{bmatrix} + \begin{bmatrix} \omega_t \\ \omega_t^* \end{bmatrix}, \tag{4}$$

where ω_t and ω_t^* are uncorrelated white noise disturbance terms with variances σ_ω^2, and ψ_t^* appears by construction. The parameters λ and ρ have a direct interpretation as the frequency of the cycle and the damping factor on the amplitude, respectively. $2\pi/\lambda$ represents the period of a cycle. The disturbances make the cycle stochastic rather than deterministic.

Estimation of the parameters, $(\sigma_\eta^2, \sigma_\zeta^2, \sigma_\omega^2, \lambda, \rho, \sigma_\varepsilon^2)$, can be carried out by maximizing the prediction error decomposition form of the likelihood function. Once this has been done, estimates of the trend, cyclical, and irregular components are obtained from a smoothing algorithm. Our empirical calculations were carried out on a PC using the STAMP package, as referred to in Harvey and Jaeger (1993).

3. Hodrick-Prescott Filter

Hodrick-Prescott filtering requires computation of the trend component, μ_t, of a (seasonally adjusted) actual variable, y_t, from the expression:

$$\min_{\{\mu_t\}} \sum_{t=1}^{T} (y_t - \mu_t)^2 + \lambda \sum_{t=2}^{T-1} [(\mu_{t+1} - \mu_t) - (\mu_t - \mu_{t-1})]^2 \tag{5}$$

for an appropriately chosen positive value of the smoothing parameter, λ. The first term is the sum of squared deviations of μ_t from y_t, or degree of fit of μ_t. The second term involves the sum of squares of the trend component's successive differences, reflects the degree of smoothness of the trend component, and penalises variations in the trend growth rate at the rate λ. Almost all of the existing quarterly empirical modern business cycle literature that has applied Hodrick-Prescott filtering, including that of Kim, Buckle and Hall (1992) for New Zealand, has chosen the value for λ as 1600.

Harvey and Jaeger (1993) show that Hodrick-Prescott filtering is equivalent to postulating the structural time series model (2) and imposing the restrictions $\sigma_\eta^2 = 0$, $\psi_t = 0$, and $\sigma_\varepsilon^2/\sigma_\zeta^2 = \lambda$, where λ is a positive real number. It is clear that, for the class of structural time series models that can be represented by (2) and (3) with $\sigma_\eta^2 = 0$ and $\psi_t = 0$ imposed, ε_t, β_t and ζ_t represent the deviation from trend, the growth rate of trend and the change in the growth rate respectively. It is also interesting to note that a value of $\sigma_\varepsilon^2/\sigma_\zeta^2$ set equal to λ is exactly the reason for Hodrick and Prescott (1980) to have chosen $\lambda = 1600$ for their quarterly US time series. They argue that a 5% 'deviation from trend' (ε_t) per quarter is moderately large as is a one eighth of a 1% 'change in the growth rate' (ζ_t) in a quarter, so that

$$\lambda = \frac{5^2}{(1/8)^2} = 1600.$$

The Hodrick-Prescott estimate of the cyclical component is given simply by the smoothed ε_t. It is therefore possible for the cyclical component obtained from Hodrick-Prescott filtering to be more volatile and quite erratic compared to those obtained from the Henderson Moving Average Method or the Structural Time Series Modeling. This is because its cyclical components can include significant irregular movements as well as the cyclical movements. Hence, Harvey and Jaeger (1993) have argued that it is possible for mechanical detrending based on the Hodrick-Prescott filter to lead investigators to report spurious cyclical behaviour, and have stressed the need for a model that fits both components at the same time.

IV.2 Empirical Results

Due to the relatively mechanistic nature of the deviations from trend methods just described, it is appropriate that their business cycle turning points be chosen by simple "visual selection", i.e. by "eyeballing"[11] the peaks and troughs shown in Figure 3 (the production based non-per capita[12] series) and Figure 4 (the corresponding expenditure

11 This means that, although the HMA cycles are effectively bounded to be between 2 and 8 years (with the latter unlikely to be a binding constraint), no similar bounds are implicit within or have been explicitly imposed on the results from the STAMP and HP methods. These can be contrasted with the assumptions built into the BB programme, of a minimum cycle length of 15 months and a minimum phase length of 5 months.

12 Unlike for the BB method, the HMA and STAMP per capita results are almost identical with those for the non-per capita series.

based series), and their associated deviations from trend numerical values. The outcomes are presented in Table 4, along with the preferred BB based turning points selected from Table 3.

From Figures 3 and 4, the most immediately obvious feature is that the turning points produced from the HMA and STAMP methods are very similar to each other. For the production based (but not the expenditure based) series, this similarity extends to "cycle" results from the HP1600 method[13].

But how do the deviations from trend turning points eyeballed from Figures 3 and 4 compare with appropriate BB turning points chosen from Table 3, and summarised in Table 4? The BB points have been marked on Figures 3 and 4 with a circle (non-per capita series) or a square (any additional points from relevant per capita series).

For the production based series represented in Figure 3:

- The BB turning points listed in Table 4 are supported by the deviations from trend results, apart from some minor timing differences associated with the HMA method;

- Relative to those produced from the BB method, two possible extra cycles can be supported from all three deviations from trend methods. These could mean an additional peak somewhere in the period 1979:1 to 1980:1 and associated trough in either 1980:4 or 1981:1, and a further peak in 1984:1 or 1984:2 with corresponding trough in 1985:4 or 1986:1;

- The HP results are surprisingly close to those from the STAMP method, given the potential in theory for additional influence from irregular components. This outcome suggests that our New Zealand business cycle dating results using the HP method are unlikely to suffer from Harvey and Jaeger's "spurious cyclical behaviour" problem.

For the expenditure based series portrayed in Figure 4:

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13 Harvey and Jaeger (1993, p 237) have also reported very similar deviations from trend results for US real GNP , utilising the STAMP and HP1600 methods.

- As might have been expected from this relatively more volatile gdp series, some timing differences emerge amongst the HMA, STAMP, and BB results, including in relation to some of the "major" turning points;

- Perhaps surprisingly, however, the HP results are quite similar to those from the BB method, especially from the peak of 1974:3 onwards.

Hence, overall:

- It is further confirmed that there are probably greater differences caused by the data in the alternative two real gdp series than by the business cycle dating methods employed, and consequently that the only advantage from using the expenditure based series is that it extends back further in time;

- The business cycle turning points reported are surprisingly consistent between methods employed, especially amongst the deviations from trend methods;

- Somewhat more precise demands are placed by turning point analysis on deviations from trend results produced by the HP1600 method. It is therefore encouraging that the results presented here are sufficiently credible to provide additional evidence that "key characteristic" conclusions reached from the use of cross correlation and other results produced from HP1600 detrending (eg Kim, Buckle and Hall, 1992) are likely to be reasonably robust;

- The relatively consistent turning point outcomes enable us to present some "benchmark" turning points and duration characteristics in Table 5, for discussion in the next section. This is because, from the standpoint of modern business cycle analysis, these characteristics are more appropriate than the turning points identified by NBER/CIBCR-type procedures.

V. Some "Benchmark" Turning Points, and Cycle Duration Characteristics

The benchmark turning points presented in Table 5 are put forward as a credible set of benchmark turning points for the period 1966(3) to 1993(2). They reflect New Zealand's lack of a consistent longer-term quarterly real gdp series. From 1978:1 onwards, therefore, the turning points are essentially taken from BB production (and appropriate expenditure) based results; while prior to that they have come basically from the BB expenditure series outcomes. There are two additional sets of points: the relatively recent 1988:2 trough and 1989:2 peak are from the BB production per capita series, with backing from the deviations from trend methods; the initial 1966:3 peak and 1968:2 trough provide evidence for one extra individual cycle, and are supported from a combination of the CIBCR results appearing in Table 1 and the deviations from trend outcomes in Table 4.

As also shown in Table 5, the average benchmark cycle duration has been 15.3 quarters. The durations of the corresponding individual cycles have varied considerably over time, from a minimum of 10 quarters to a maximum of 21 quarters.[14]

The second key feature from Table 5 is that the average expansion phase of 10.5 quarters has been more than double that of the average contraction phase of 5.1 quarters. These averages in turn, of course, reflect significant differences amongst their underlying individual cycles: the individual expansions having varied considerably, from 4 to 17 quarters; while the individual contractions have varied between only 3 and 8 quarters. The most recent full T-P-T cycle from 1988(2) to 1991(2) has been both relatively short at three years, and has had a contraction phase of 8 quarters which has been double that of its expansion phase. This is in contrast to its immediately preceding much longer 7 year cycle, with expansion and contraction phases of 14 and 7 quarters, respectively.

These average and individual cycle duration results are a pointer towards the issue of asymmetry between expansions and contractions needing exploration in further work. The further work is required because the issue is not simply one of comparing raw expansion and contraction phase duration figures. For example, DeLong and Summers (1986, pp 173-74) have concluded for US real GNP and industrial production series that, after taking proper account of trend growth, "..little evidence remains of cyclical asymmetry.". This is in contrast to the view, based on more recent tests conducted by McQueen and Thorley (1994, p 361), that "..business cycles should *not* be viewed as symmetric oscillations around a trend." Moreover, there is now quite a range of definitions and tests for business cycle asymmetries, including those for each of 'steepness', 'deepness', and 'sharpness'.

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14 The somewhat less meaningful (BB derived) average, minimum, and maximum durations for each individual series are: 18.8, 11 and 32 quarters for expenditure; 11.5, 5 and 20 for expenditure per capita; 26.5, 20 and 33 for production; and 17.7, 12 and 21 for production per capita. Shorter durations are evident for the per capita series.

Are the <u>average</u> business cycle characteristics we have obtained for New Zealand significantly different from those for other countries? Exact comparisons between countries are seldom possible in any area of economics, but in Table 6 some comparable figures are presented for Australia and the United States. They show that our benchmark average cycle duration of 15.3 quarters for New Zealand's full sample period is close to the corresponding Australian figure of 14.9 quarters derived from HMA results; but that Australia's average expansion and contraction phases of 8.6 and 6.3 quarters have been much closer together than New Zealand's 10.5 and 4.8 quarters. In contrast, for the periods closest to two of the U.S. BB average durations of 22 and 16 quarters, New Zealand's average cycle lengths of around 15 quarters are somewhat shorter.

Finally, in order to gain some appreciation of what types of model might be capable of replicating the cycle, expansion and contraction average duration characteristics seen in our New Zealand data, in Table 7 we set our benchmark duration characteristics against those obtained from a number of potentially relevant statistical processes. The model simulations are for a period of 107 quarters, consistent with the length of the sample period for our "benchmark" series. Quarterly observations were simulated for the 107 quarter period, and figures for the number of cycles and the three duration categories were computed. Each process was then replicated 50 times, and the resulting average figures are those reported in Table 7. The standard deviation of the normally distributed innovation in the white noise and the AR(1) models was taken as that of the data for the logarithm of our expenditure based real GDP series. Relevant business cycle characteristics generated by these models were not sensitive to changes in the value of the standard deviations. For the I(1) models, the standard deviation of the innovation was taken as that of the first difference of the data. Illustrative results for several different values of the drift term are presented, with the figure of 0.38% being the average quarterly growth rate of our expenditure based real GDP series.

The first point noticeable from Table 7 is that, even with a purely random white noise process, we can produce reasonably credible business cycle characteristics. However, this process also produces too many cycles (i.e. 9) of too short an average cycle duration. We continue to get too many short cycles when substantial serial correlation is put into the data, i.e. the AR(1) process with AR parameter of 0.8. But when we turned to I(1) processes, we see the number of cycles becoming much closer to the figure of 6 for our benchmark series. However, our I(1) process without drift fails to capture a salient feature of our data that there is a very large difference between the average length of our expansions (10.5 quarters) and contractions (4.8 quarters). So, the final three rows of Table 7 reveal that the addition of suitable illustrative drift terms produces results that mimic quite closely the asymmetry (in raw terms) of our benchmark average expansion and contraction durations.

Hence, our reported simulation results show that, in order for a business cycle model to be successful in capturing the duration characteristics found in our New Zealand data, it should be constructed in such a way that output generated from the model be close to an I(1) process with drift. This result is consistent with preliminary results reported by Pagan (1992) for US business cycles. Also, King and Plosser (1989) have shown that a suitably calibrated real business cycle model, implying that real output grows 0.4% per quarter and with a first order serial correlation coefficient of 0.97, does well in capturing the duration characteristics found in actual US business cycles.

VI. Conclusions

Consistent with the methodology of modern business cycle analysis, we have presented in Table 5 a set of "benchmark" business cycle turning points for New Zealand's real gdp, for the period 1966(3) to 1993(2). These turning points, and their associated business cycle duration characteristics, have been derived essentially from use of the relatively simple and transparent Bry and Boschan method, with preference being given for the period since 1977(2) to estimates from the production based real gdp series.

The BB programme seems robust with respect to different types and lengths of series, and the results obtained are not dissimilar to those obtained from three relatively more mechanistic deviations from trend methods. In fact, it could well be the case that there were greater differences between the results for our production based and expenditure based series, and between those for the per capita and non-per capita series, than between the results for our four relatively mechanistic dating methods. It has also been shown that our benchmark (BB based) turning points for New Zealand do not correspond as closely to those currently available from the relatively more judgemental multiple series-based CIBCR method, as turning points obtained from BB procedures for the US do with those obtained from NBER methodology. A number of relative strengths and weaknesses associated with each method were noted in the early parts of this paper, but in this area too considerable further work would have to be undertaken before a preference could be expressed for one methodology over the other. It might also be the case that they should be regarded as complements rather than substitutes.

Our benchmark turning points have provided an average cycle length of 15.3 quarters, consisting of an average expansion phase of 10.5 quarters around double that of the average contraction phase of 4.8 quarters. The ranges around these averages, for the underlying individual cycles, are 10-21, 4-17 and 3-8 quarters respectively.

Preliminary experimentation with some "I(1) with drift" integrated processes has suggested that the benchmark average cycle duration characteristics should be reproducible with an appropriately stochastic small modern open economy business cycle model, although discrimination between competing theoretical models would be a much more challenging task.

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Table 1: Previously identified New Zealand business cycle turning points

Cycle Points P = Peak T=Trough	Haywood, (1972)	Haywood and Campbell, (1976)			CIBCR [2]
		Crude	Static	Dynamic [1]	
P	1947:3	1947:4	1947:4	1947:4	
T	1949:2	1949:1	1949:2	1949:3	
P	1951:3	1951:3	1951:3	1951:3	
T	1953:1	1953:2	1953:2	1953:2	
P	1955:3	1955:4	1955:3	1955:3	1955:4*
T	1956:2	1956:4	1956:3	1956:3	1956:3*
P	1957:3	1958:1	1958:2	1958:2	1957:4*
T	1959:1	1959:1	1959:1	1959:1	1959:2*
P	1961:2	1960:4	1960:4	1961:2	1961:2*
T	1962:2	1962:4	1962:3	1962:3	1962:3*
P	1966:3	1965:4	1965:3	1965:3	1966:3
T	1967:4	1968:2	1967:4	1967:4	1968:3
P		1970:3	1970:3	1970:3	1970:2
T		1971:4	1972:1	1972:1	1971:4
P		1973:3	1974:3	1973:3	1973:4
T				1975:3	1975:1
P				1977:1	1976:4
T				1978:1	1978:1
P				1979:2	1980:1
T					1980:4
P					1981:3
T					1983:2
P					1987:3**
T					1989:3**
P					1990:3**
T					1991:2**

Notes: 1. The turning points from 1975:3 to 1979:2 were obtained from Chart 1 in Kay (1984).

2. The CIBCR specifies the turning point month, but the turning points have been specified here as the quarter in which the turning point month lies. * These dates were calculated without the full set of 5 indicators. ** These are tentative dates based on the coincident index only, and therefore do not additionally reflect the final stage "cluster" information referred to in section II.

Table 2: Bry and Boschan procedure for programmed determination of turning points in individual monthly data series

I Determination of extremes and substitution of values.

II Determination of cycles in 12-month moving average (extremes replaced).

A. Identification of points higher (or lower) than 5 months on either side.

B. Enforcement of alternation of turns by selecting highest of multiple peaks (or lowest of multiple troughs).

III Determination of corresponding turns in Spencer curve (extremes replaced).

A. Identification of highest (or lowest) value within ± 5 months of selected turn in 12-month moving average.

B. Enforcement of minimum cycle duration of 15 months by eliminating lower peaks and higher troughs of shorter cycles.

IV Determination of corresponding turns in short-term moving average of 3 to 6 months, depending on MCD (months of cyclical dominance).

V Determination of turning points in unsmoothed series.

A. Identification of highest (or lowest) value within ± 4 months, or MCD term,whichever is larger, of selected turn in short-term moving average.

B. Elimination of turns within 6 months of beginning and end of series.

C. Elimination of peaks (or troughs) at both ends of series which are lower (or higher) than values closer to end.

D. Elimination of cycles whose duration is less than 15 months.

E. Elimination of phases whose duration is less than 5 months.

VI Statement of final turning points.

Note: This table is taken from Bry and Boschan (1971), p 21.

Table 3
Turning Points for Alternative Quarterly Measures of Real Aggregate Output: BB Procedure

Cycle points	Real Expenditure Based Series*		Real Production Based Series**	
	GDP	GDP/Capita***	GDP	GDP/Capita***
T	-	**1968:2**		
P	1970:1	1970:1		
T	1970:4	1970:4		
P	-	**1971:3**		
T	-	**1972:1**		
P	1974:3	1974:3		
T	1975:2	1975:2		
P	1976:4	1976:4		
T	1978:1	1978:1	1978:1	1978:1
P	-	**1982:3**	1982:2	1982:2
T	-	**1983:1**	1983:1	1983:1
P	1985:1	1985:1	-	-
T	1986:1	1986:1	-	-
P	1986:3	1986:3	1986:3	1986:3
T	1989:3	1989:3	-	**1988:2**
P	-	**1990:1**	-	**1989:2**
T	-	**1991:2**	1991:2	1991:2
P	1992:2	1992:2	-	-

T denotes a trough, P a peak

* Quarterly linked RBNZ/Statistics New Zealand series, sample period 1966(4) - 1993(2)

** Quarterly Statistics New Zealand series, sample period 1977(2) - 1993(2)

*** Quarterly Average of total population series

Table 4

Turning points for BB procedure, relative to those chosen from two "deviations from trend" methods

Cycle Points	Real Expenditure Based Series 1966(4) - 1993(2)				Real Production Based Series 1977(2) - 1993 (2)			
	BB[1]	HMA[2]	STAMP[2]	HP1600[2]	BB[1]	HMA[2]	STAMP[2]	HP1600[2]
T	[1968:2]	1968:3	1968:2	1969:1				
P	1970:1	1969:4	1969:4	1970:1				
T	1970:4	1970:4	1970:4	-				
P	[1971:3]	1971:2	1971:3	-				
T	[1972:1]	1973:3	1972:4	1973:3				
P	1974:3	1974:2	1974:2	1974:3				
T	1975:2	1975:2	1975:3	1975:2				
P	1976:4	1977:1	1977:1	1976:4				
T	1978:1	1978:1	1978:1	1978:1	1978:1	1978:1	1978:1	1978:2
P	-	1978:4	1979:1	-	-	1979:1	1980:1	1980:1
T	-	1980:3	1980:3	-	-	1980:4	1981:1	1981:1
P	[1982:3]	1981:2	1981:3	1982:3	1982:2	1982:1	1982:2	1982:2
T	[1983:1]	1983:2	1983:2	1983:1	1983:1	1983:1	1983:1	1983:1
P	1985:1	1985:1	1984:4	1984:1	-	1984:2	1984:1	1984:1
T	1986:1	1985:4	1986:1	1986:1	-	1985:4	1986:1	1986:1
P	1986:3	1986:3	1986:3	1986:3	1986:3	1986:3	1986:3	1986:3
T	-	1987:2	1987:2	-	-	-	-	-
P	-	1988:4	1988:4	-	-	-	-	-
T	1989:3	1989:3	1989:3	1989:3	[1988:2]	1988:3	1988:2	1988:2
P	[1990:1]	1990:2	1990:2	1990:2	[1989:2]	1990:3	1989:2	1989:2
T	[1991:2]	1991:2	1991:2	1991:2	1991:2	1991:3	1991:2	1991:2

1 As presented in Table 3, with [ ] denoting additional turning points from relevant per capita series, and omitting 1992:2 expenditure based outlier.

2 Based on "eyeballing" peaks and troughs from Figures 3 and 4 , and associated numerical values for percentage deviations from trend. Results presented are for the non-per capita series, and are almost identical to those for the per capita series.

Table 5

Some "Benchmark" Turning Points and Cycle Duration Characteristics for the period 1966(3) to 1993(2)

Cycle Points	"Benchmark" Date(s)[2]		Comments
P	**1966:3**		CIBCR based
T	**1968:2**	(or 1968:3)	Support from CIBCR 1968:2
P	**1970:1**	(or 1969:4)	
T	**1970:4**		Not supported by HP
P	**1974:3**	(or 1974:2)	
T	**1975:2**		
P	**1976:4**	(or 1977:1)	
T	**1978:1**		
P	**1982:2**		
T	**1983:1**		
P	**1986:3**		
T	**1988:2**		STAMP, HP1600, HMA support
P	**1989:2**		STAMP, HP1600 support
T	**1991:2**		

Dates of "Benchmark" Points[2]			Durations, in Quarters		
T	P	T	Expansion	Contraction	Cycle[3]
	66:3	68:2	-	7	-
68:2	70:1	70:4	7	3	10
70:4	74:3	75:2	15	3	18
75:2	76:4	78:1	6	5	11
78:1	82:2	83:1	17	3	20
83:1	86:3	88:2	14	7	21
88:2	89:2	91:2	4	8	12
		Mean	10.5	5.1	15.3

1 Date(s) chosen from BB turning points in Table 4, unless otherwise indicated, with production based dates being preferred from 1978:1 onwards

2 For the above composite series dates in bold type

3 Calculated on a T-P-T basis

Table 6

Quarterly business cycle duration characteristics for New Zealand, Australia and the United States

	T	P	T	Expansion	Contraction	Cycle[3]
New Zealand						
	-	66:3	68:2	-	7	-
	68:2	70:1	70:4	7	3	10
	70:4	74:3	75:2	15	3	18
	75:2	76:4	78:1	6	5	11
	78:1	82:2	83:1	17	3	20
	83:1	86:3	88:2	14	7	21
	88:2	89:2	91:2	4	8	12
			Mean	10.5	5.1	15.3
Australia[1]						
	-	65:1	66:2	-	5	-
	66:2	70:3	72:2	17	7	24
	72:2	73:4	75:3	6	7	13
	75:3	76:3	77:4	4	5	9
	77:4	78:4	80:2	4	8	12
	80:2	82:1	83:1	7	4	11
	83:1	85:3	86:4	10	6	16
	86:4	89:4	91:3	12	7	19
United States[2]						
	-	60:1	60:4	-	3	-
	60:4	69:1	70:4	33	7	40
	70:4	73:1	75:1	9	8	17
	75:1	78:4	80:3	15	7	22
	80:3	81:1	82:4	2	7	9

Some average durations

		Expansion	Contraction	Cycle[3]
New Zealand	1968:2 - 1991:2	10.5	4.8	15.3
Australia	1966:2 - 1991:3	8.6	6.3	14.9
New Zealand	1978:1 - 1991:2	11.7	6.0	17.7
Australia	1977:4 - 1991:3	8.3	6.0	14.5
New Zealand	1968:2 - 1983:1	11.3	3.5	14.8
Australia	1966:2 - 1983:1	7.6	6.2	13.8
United States	1960:4 - 1982:4	14.8	7.3	22.0
	1970:4 - 1982:4	8.7	7.3	16.0

1 Salou and Kim (1992, p xii), HMA based.

2 King and Plosser (1989, p10), BB based, for real per capita GNP data

3 Calculated on a T-P-T basis.

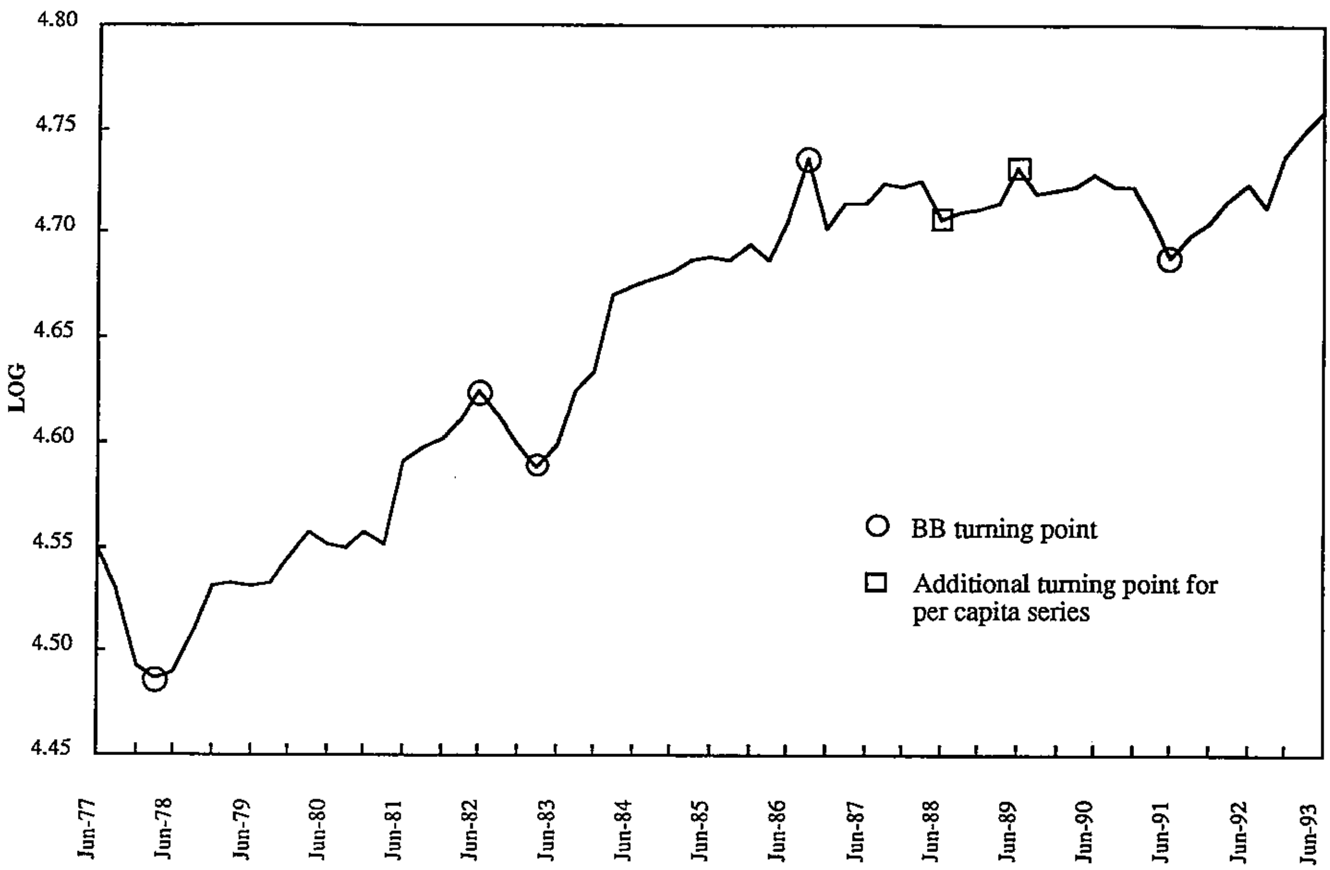
Table 7

Business Cycle Characteristics for Selected Processes: 1966(4) - 1993(2)

	Number of Cycles	Average Duration (quarters) Expansion	Contraction	Cycle
"Benchmark" series	6	10.5	4.8	15.3
White noise	9	5.7	5.7	11.4
AR (1), $\rho = 0.8$	9	6.0	5.7	11.7
I (1)	7	7.1	7.3	14.4
I (1) with drift				
drift = 0.38%	7	8.4	6.2	14.6
drift = 0.58%	7	9.3	5.7	15.0
drift = 0.78%	6	10.5	5.7	16.2

FIGURE 1: REAL GDP, SEASONALLY ADJUSTED, 1977(2) TO 1993(2)

PRODUCTION BASED MEASURE



EXPENDITURE BASED MEASURE

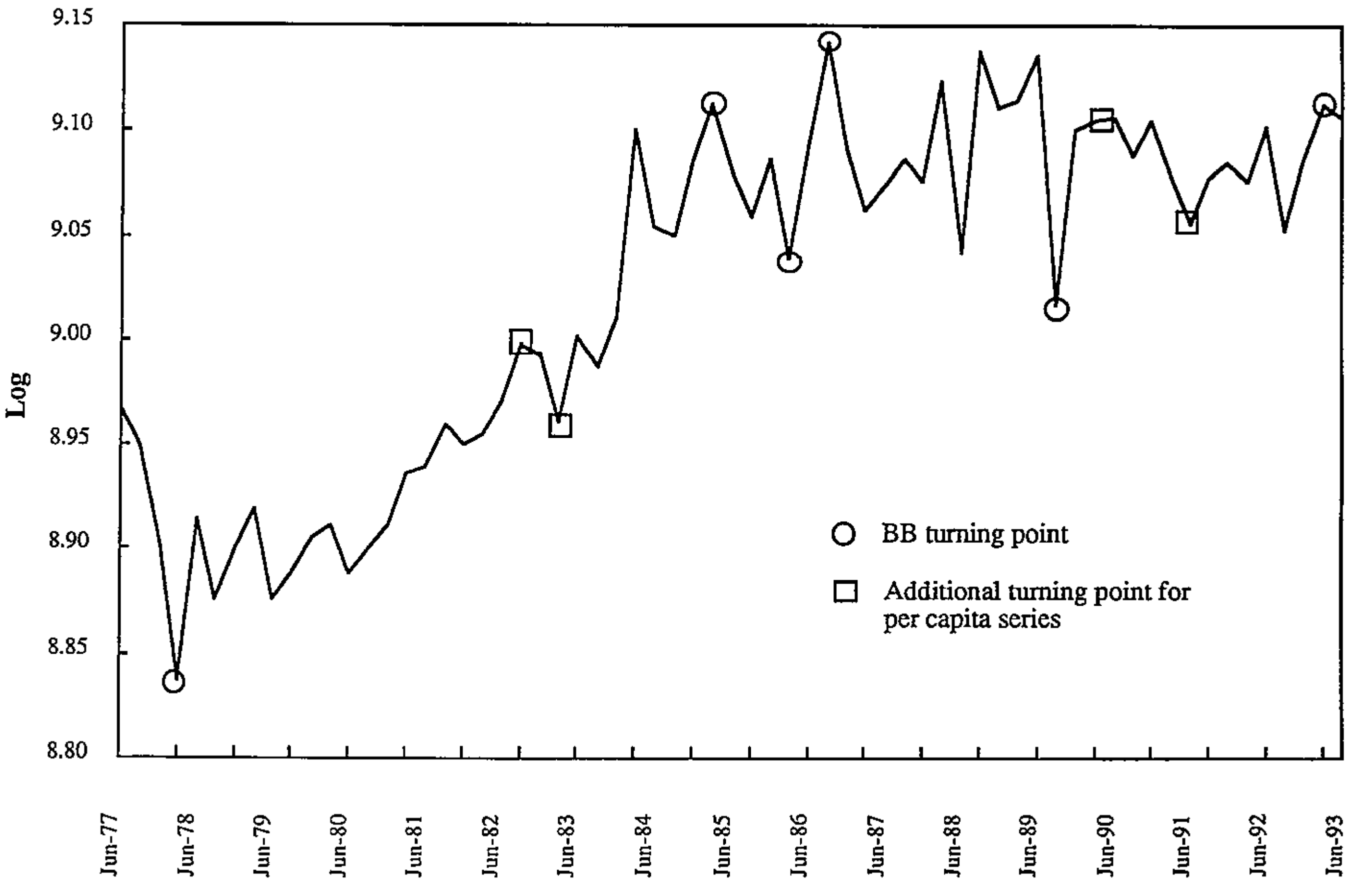
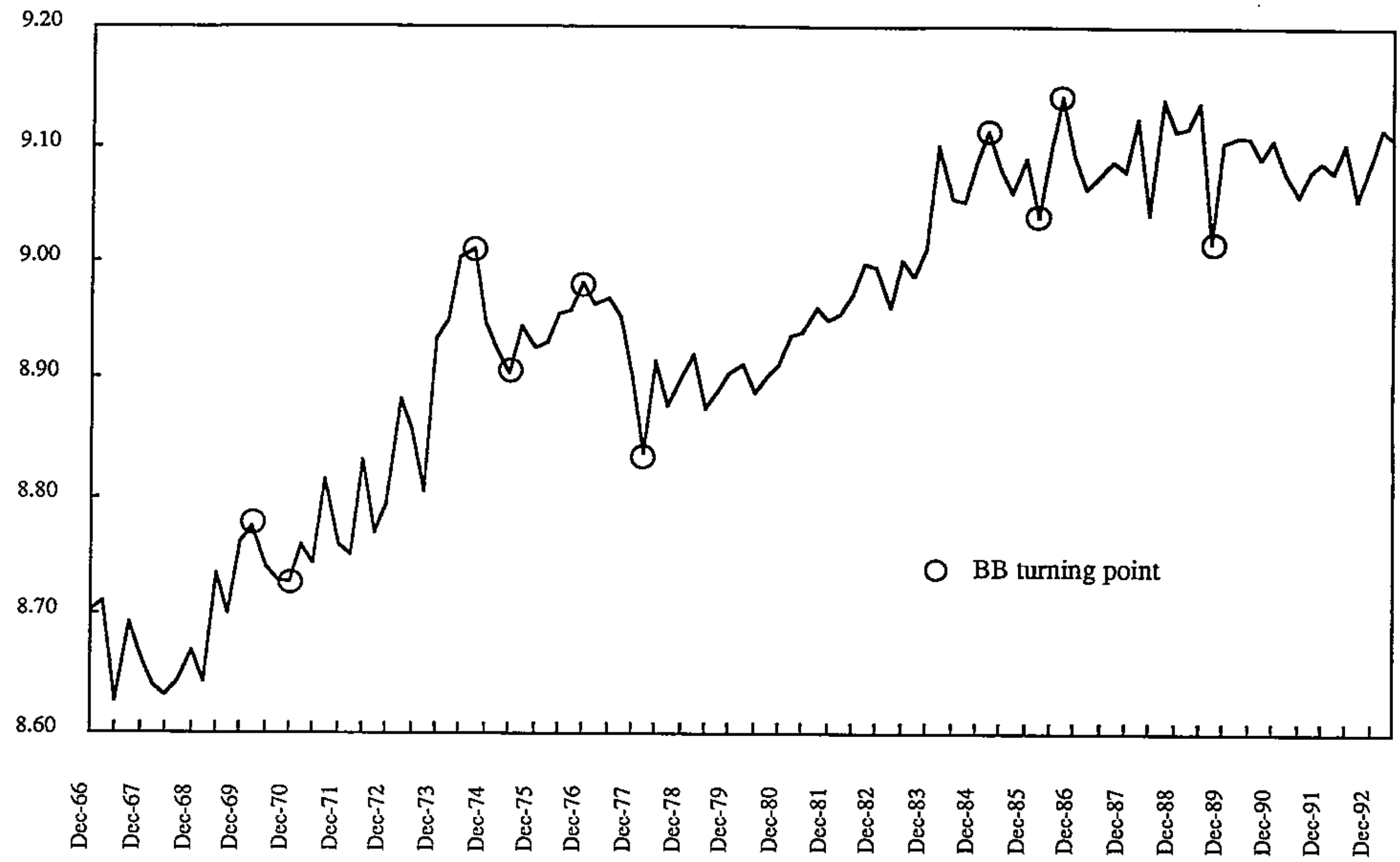


FIGURE 2: EXPENDITURE BASED MEASURES, 1966(4) TO 1993(2)

REAL GDP



REAL GDP PER CAPITA

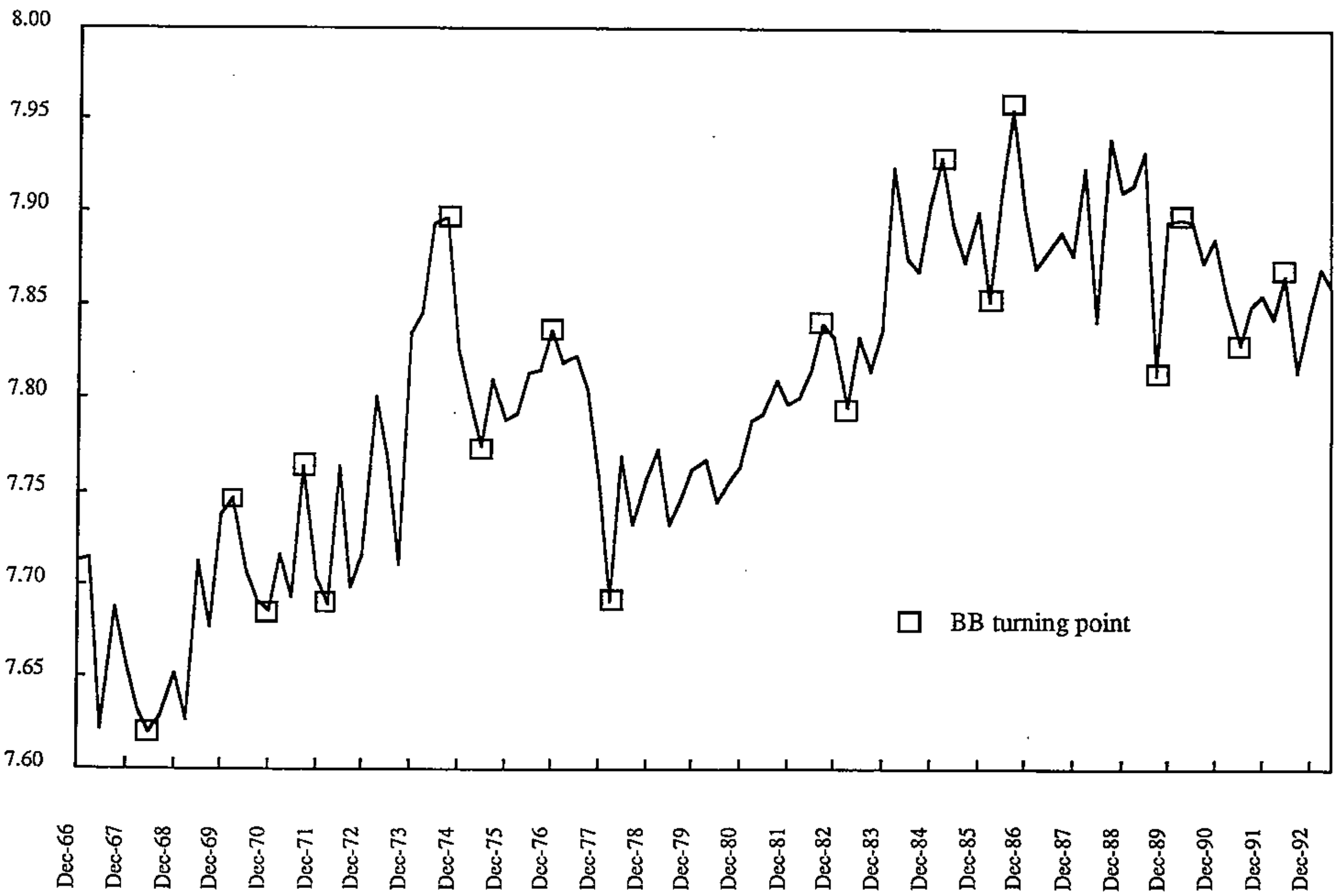


FIGURE 3: PRODUCTION BASED MEASURE

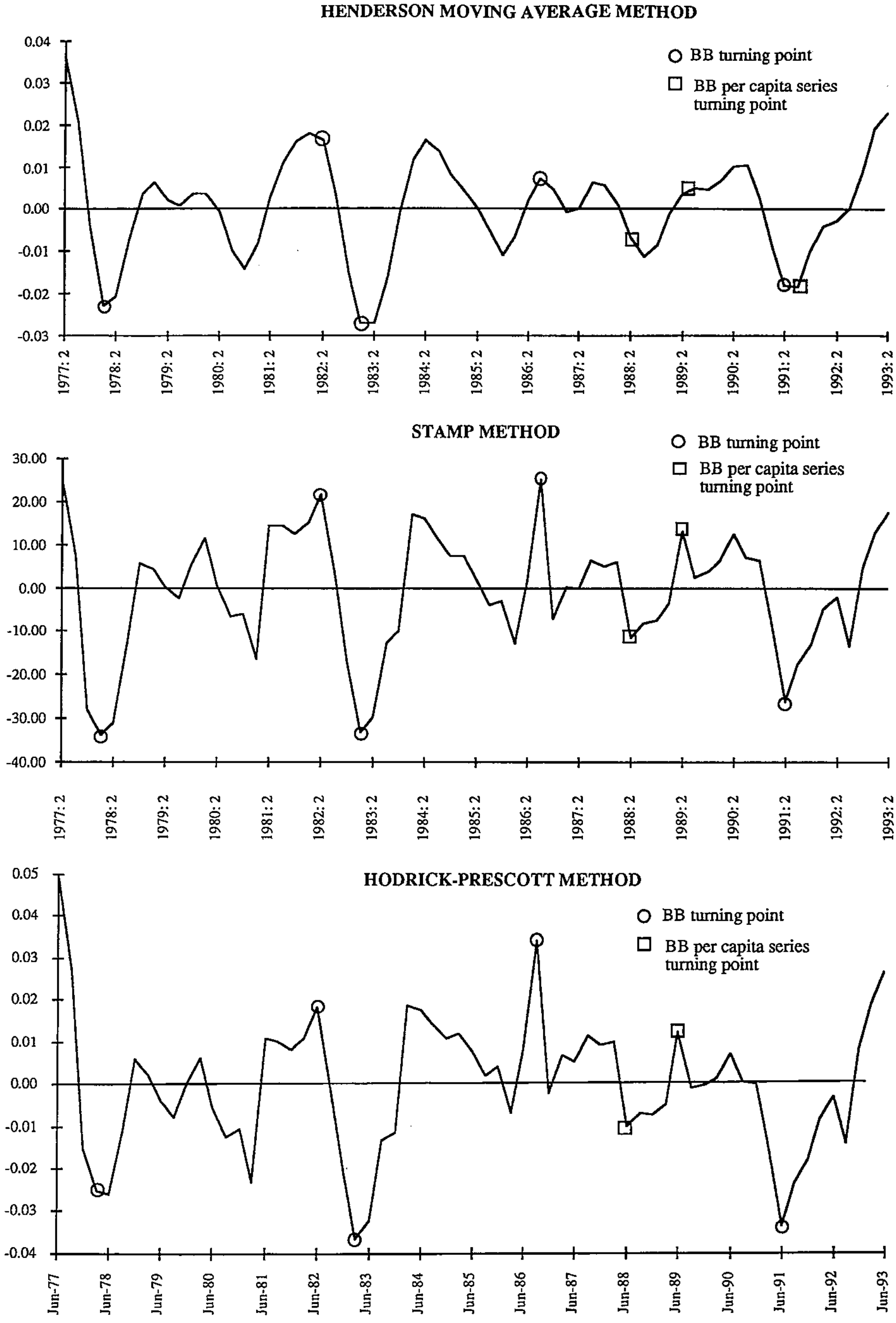
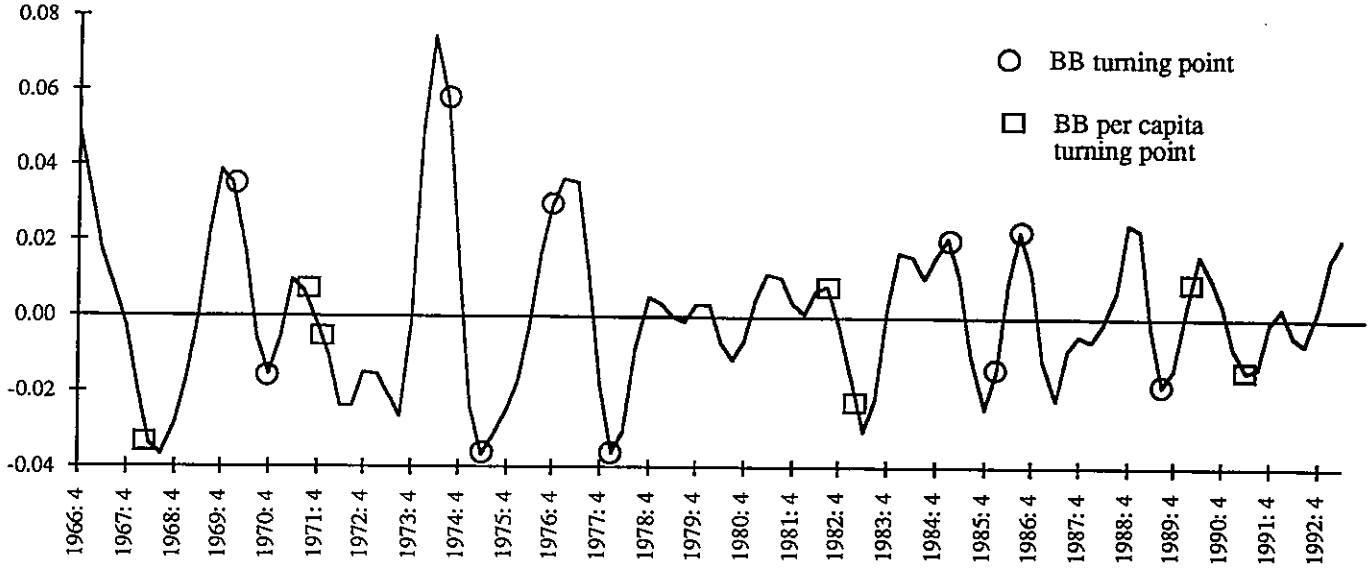
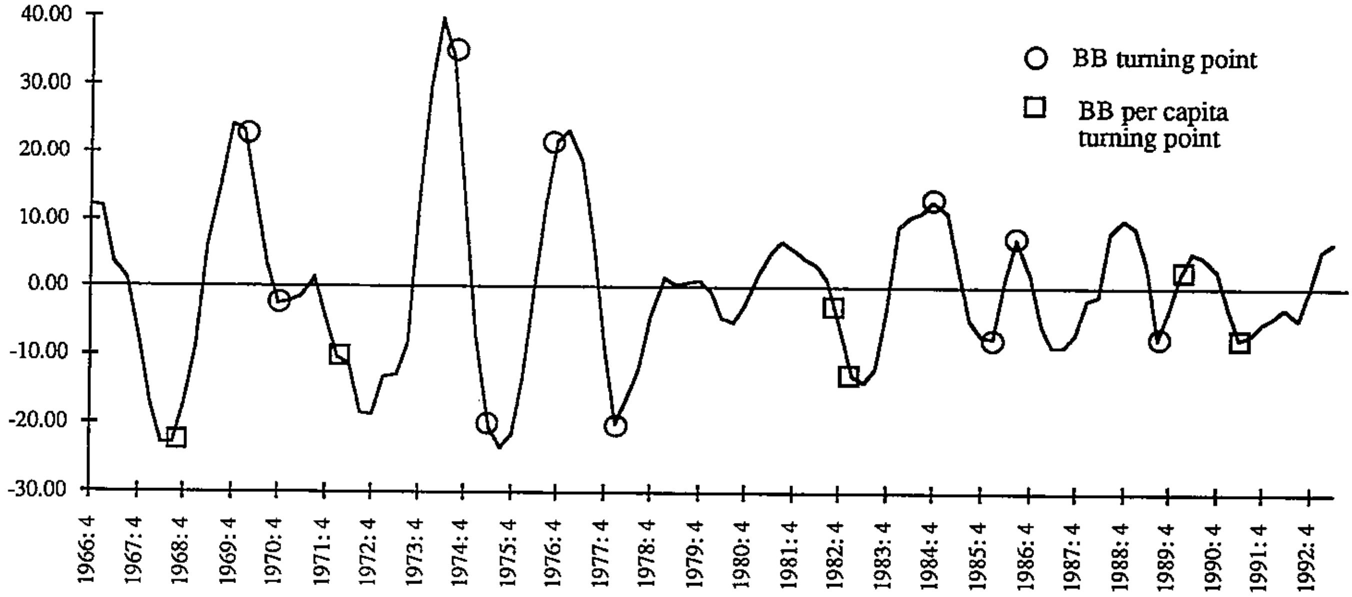


FIGURE 4: EXPENDITURE BASED MEASURE

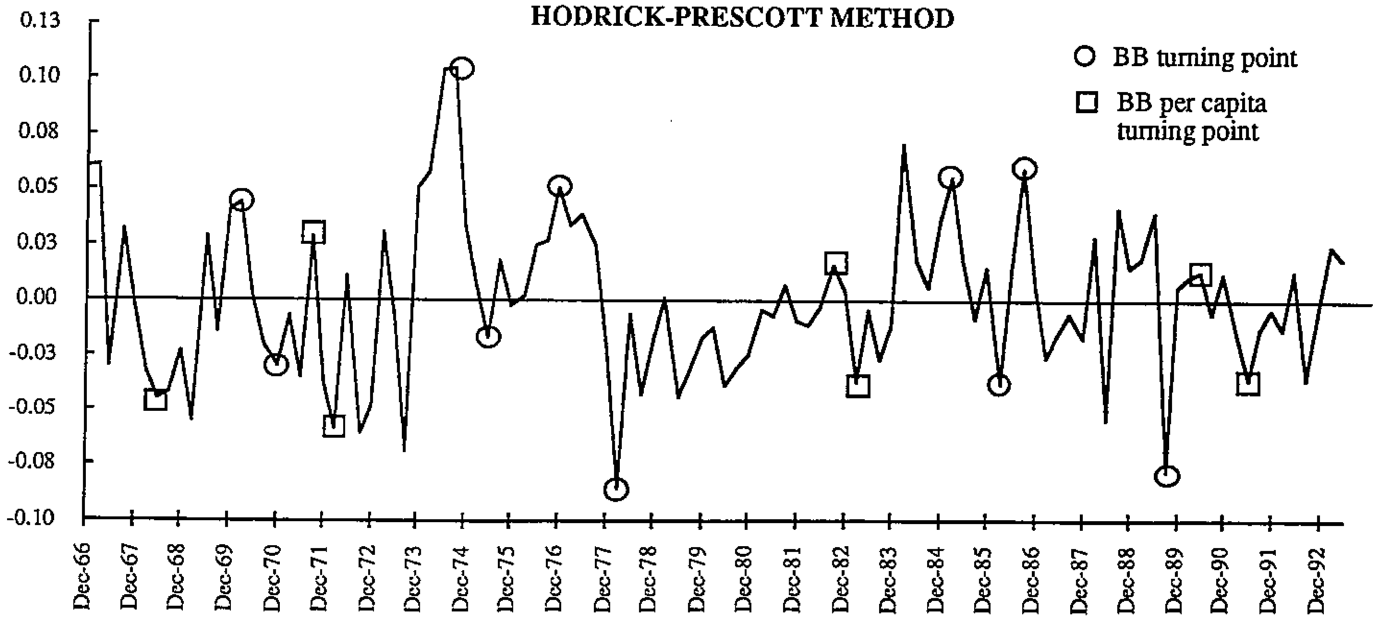
HENDERSON MOVING AVERAGE METHOD



STAMP METHOD



HODRICK-PRESCOTT METHOD



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