Testing for Asymmetry in the Measured and Underground Business Cycles in New Zealand *

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Abstract:

In this paper we consider the cyclical component of the underground economy in New Zealand, and compare some its characteristics with those of the corresponding cycle in real measured GDP. Comparisons are made between the turning points of the two cycles, and formal tests for cyclical asymmetry (in terms of both "steepness" and "deepness") are conducted. The turning-point comparisons reinforce earlier results of Giles (1996a) on the causal linkages between the measured and underground economies. We find that there is no evidence of asymmetry in the cycles for either measured or underground output.

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I Introduction

There is a long-established interest in the behaviour of economic variables over different periods of the business cycle. In particular, the possibility that such variables may fluctuate in a manner which is asymmetric with respect to business cycle phase, has been mooted at least since Mitchell (1913), and is echoed in subsequent work by Keynes (1936) and Friedman (1964), for example. Whether or not an economic aggregate contracts more steeply than it expands, for instance, as the business cycle unfolds, is an important empirical issue. It has implications for the timing and magnitude of policy changes, and it also has implications for the way in which we model the economy.

The usual linear structural and time-series models that we use in our empirical analysis are not generally consistent with asymmetric responses, given that we typically assume Normal stochastic behaviour[1]. Most microeconomic models are structured in such a way that responses to shocks are inevitably symmetric, and modern cointegration analysis is based largely on the premise that error-correction mechanisms apply in a symmetric fashion[2]. So, if there is empirical evidence to suggest that economic responses are *asymmetric* over different phases of the business cycle, then this necessitates a re-consideration of many of our *theoretical* economic models, as well as our empirical econometric models. In particular we need to consider models which are non-linear and have asymmetric disturbances. This issue has been addressed lately by various authors. For example, Bertola and Caballero (1990), Boldrin and Woodford (1989), Burgess (1992), Dixit (1989) and Hamilton (1989), among others, have developed theoretical models of various sorts which are capable of generating cyclical behaviour which is asymmetric in different ways.

A number of approaches have been used to address the empirical issue of detecting possible asymmetries in observed economic time-series data. The more recent work takes proper account of non-stationarity issues, and can be grouped loosely into three categories. Neftçi (1984), Hamilton (1989) and Kähler and Marnet (1992) have used techniques based on Markov processes; various authors have adopted the self-exciting, threshold, autoregressive (SETAR) models of Tong and Lim (1980); Brock and Sayers (1988) use techniques based on chaos theory; and Sichel (1993) and Holly and Stannett (1995) have extended earlier work by DeLong and Summers (1986) in constructing simple robust tests of distinctive types of cyclical asymmetry.

In this paper we follow the latter approach in our investigation of the cyclical component of the underground economy in New Zealand, using data constructed by Giles (1995). This appears to be the first empirical examination of asymmetry issues with respect to *unobservable* economic activity. In the next section we discuss the specific tests that we use, and section III deals with some issues to do with de-trending non-stationary time-series. Section IV describes the data for our analysis. The results are described in section V, and section VI contains some further discussion and concluding remarks.

II Testing for Cyclical Asymmetry

The approach of Sichel (1993) and Holly and Stannett (1995) presumes that a time-series, y_t, can be expressed in the form[3]:

$$y_t = \tau_t + c_t + \epsilon_t \,, \qquad \textbf{(1)}$$

where τ_t is the non-stationary trend component of the series, c_t is its (stationary) cyclical component, and ϵ_t is the irregular component, such that $E(\epsilon_t) = 0$, $E(\epsilon_t^2) = \sigma_\epsilon^2$, and $E(\epsilon_t \epsilon_s) = 0$ (for all $t \neq s$). We will focus on the cyclical component of y_t, and the associated de-trending and stationarity issues are discussed below. Assuming, for the moment, that the c_t can be appropriately isolated, two different types of asymmetry will be considered. Sichel (1993) distinguishes between "deepness" in the cycle, and "steepness". A series which displays "deepness" is one which is negatively skewed relative to its mean, or trend. It should have fewer values below its mean than above its mean, but the average deviation of the former values should exceed that of the latter observations. On the other hand, a series which displays "steepness", is one whose first-differences are negatively skewed. This means that contractions in the cycle are sharper than are expansions. A graphical illustration of these characteristics is given by Sichel (1993, p.226)

The sample skewness statistics for c_t and $\Delta c_t = (c_t - c_{t-1})$ provide measures empirical measures of "deepness" and "steepness" respectively:

$$D(c) = [\, \sum (c_t - \overline{c}\,)^3\,] \,/\, [\, T\, \sigma(c)^3\,] \qquad \textbf{(2)}$$

$$S(\Delta c) = [\, \sum (\Delta c_t - \overline{\Delta}\,\overline{c}\,)^3\,] \,/\, [\, T\, \sigma(\Delta c)^3\,] \qquad \textbf{(3)}$$

where T is the sample size; $\overline{c}$ and $\overline{\Delta}\,\overline{c}$ are the sample means of c_t and of Δc_t respectively; and $\sigma(c)$ and $\sigma(\Delta c)$ are the associated sample standard deviations.

While equations (2) and (3) provide point estimates of the desired skewness measures, in order to test the significance of these estimates of deepness and steepness (even with asymptotic validity), we need to construct standard errors which will be valid even though the sample values for c_t and Δc_t clearly will be serially dependent. The robust, consistent, estimator of the covariance matrix for the least squares coefficient vector estimator that is suggested by Newey and West (1987), provides a simple way of dealing with this problem. So, following Sichel (1993) and Holly and Stannett (1995), a computationally convenient way of obtaining an asymptotically valid standard error for the measure in (2) above is to construct a series whose t'th element is

$$c^*_t = (c_t - \overline{c}\,)^3 \,/\, \sigma(c)^3\ , \qquad \textbf{(4)}$$

regress c^* against just a constant vector, and compute the Newey-West standard error for the regression coefficient[4]. An asymptotically robust standard error for the skewness measure in (3) can be obtained by proceeding in the same way, but with Δc replacing c everywhere in (4).

III De-Trending the Data

The above measures of asymmetry relate to the cyclical component of the data, and so the original series, y_t, must be de-trended prior to the calculation of (2) or (3). Some care must be taken over the way in which this is done, especially in view of the likely nonstationarity of the particular time-series that we are concerned with in this study. Various de-trending procedures have been considered by other authors in the context of examining the symmetry or turning points of business cycles. Canova (1994) provides a comprehensive study of the relative merits of eleven such techniques in the context of various U.S. macroeconomic time-series. His results suggest that the filter proposed by Hodrick and Prescott (1980), hereafter the "HP filter", is one of the two best procedures in terms of producing cycles with turning points that match the NBER classification. The HP filter is used in the context of asymmetry tests by Holly and Stannett (1995), and is one of the filters used by Sichel (1993) in the same context.

The HP filter obtains the trend series, τ_t, which solves the inter-temporal optimization problem:

$$\min. \sum \{ (y_t - \tau_t)^2 + \lambda [(1 - L)^2 \tau_t]^2 \}, \qquad \textbf{(5)}$$

where "L" is the usual lag-operator, and λ is a "smoothness" parameter whose value is set in advance. If $\lambda = 0$ then $\tau_t = y_t$, and τ_t approaches a linear trend series as $\lambda \rightarrow \infty$. Traditionally, a value of $\lambda = 1600$ has been used in the context of (de-seasonalised) *quarterly* time-series data (*e.g.*, Danthine and Girardin (1989), Kydland and Prescott (1990) and Brandner and Neusser (1992), Sichel (1993), and Holly and Stannett (1995)). Nelson and Plosser (1982) suggest that values in the range [1/6,1] may be more appropriate for their annual data, and Canova (1994) considers $\lambda = 4$ as one choice. Clearly, the choice of a value for λ is quite arbitrary, and in this study we consider the sensitivity of our results to this choice.

If one accepts the relevance of a quadratic penalty function, the HP filter provides an optimal way of extracting a trend that evolves smoothly over time and is uncorrelated with the cyclical component of the data. However, the HP filter has been somewhat controversial, and has been shown to have characteristics which can be undesirable in certain contexts. For example, Harvey and Jaeger (1993) show that the HP filter can introduce spurious cyclical behaviour, and more particularly, Cogley and Nason (1991) show that if this filter is applied to a series that is integrated of order one (*i.e.*, I(1)) then the cyclical frequencies can be amplified. However, this may be an advantage in our situation, as such amplification should make it easier to detect any asymmetries in the cycle. Moreover, as the HP filter is a linear filter, it cannot introduce spurious asymmetries where none exist, or distort existing asymmetries. Finally, Cogley and Nason (1991) also show that, even in the presence of a unit root, the HP filter will tend to induce stationarity in the data, and this is important in view of our discussion above concerning the construction of an asymptotic standard error for the skewness estimators. If the HP filter is used to de-trend the data, then the usual asymptotics based on the standard central limit theorems can be used to construct confidence intervals. The non-standard asymptotics associated with non-stationary data will not have to be taken into account.

This all suggests that, notwithstanding its known limitations, the HP filter may be a very good choice for de-trending our data. This is the method that we use below. The principal obvious alternative approach would be to use the decomposition suggested by Beveridge and Nelson (1981) (hereafter "BN"). However, as this is based on fitting an ARIMA model to the data, the short span of data that we have available in this study makes this impractical. Sichel (1993) finds that in the case of U.S. real GNP and industrial production, the BN filter has less of a tendency to detect "deepness" asymmetry[5] than has the HP filter. Accordingly, as we report no evidence of such asymmetry in real output data when using the HP filter in section V below, the use of the BN filter in our case may well have been redundant in any case.

IV Data Issues

Our primary interest is in some of the characteristics of the cyclical component of real activity in the underground economy in New Zealand. By way of comparison, we also analyze the corresponding real *measured* output, and real total (measured plus underground) output in a corresponding manner.

An annual time-series for the ratio of real underground activity to real measured GDP has been constructed by Giles (1995). These data were obtained by estimating a latent variable structural model for the underground economy, and using a non-linear currency-demand model to provide a benchmark for the predicted index. This ratio is readily converted into a series for the size of the underground economy itself. Figure 1 shows the *levels* of (official) measured and (estimated) underground GDP data, in real (1982/83) millions of dollars, on a calendar year basis[6] over the period 1968 to 1994. The cyclical nature of the latter series is quite evident, and the major downturn (in actual terms, as well as relative to measured GDP) in 1987 is interesting in view of the introduction of the Goods and Services Tax (GST) in October 1986, and the simultaneous substantial reductions in the personal and company income tax rates.

The *logarithms* of measured, underground, and "total" real output are shown in Figures 2a, 3a and 4a respectively, together with the corresponding trend lines fitted by the HP filter with $\lambda = 100$. To illustrate the sensitivity of the de-trended data (*i.e.*, the cyclical components) to the choice of λ, the cycles of the logarithms of measured, underground and total real output are shown in Figures 2b, 3b and 4b respectively for, $\lambda = 10$, 100, and 1600. The HP filter was applied by using the HPFILTER procedure supplied with version 4.0 of the RATS (Doan (1992)) econometrics package.

V Results

Table 1 presents the results of testing for unit roots in the logarithms of the measured, underground and total output series, as well as in the cyclical components shown in Figures 3. Augmented Dickey-Fuller (ADF) tests were used to test if the series are I(1), or are stationary (*i.e.*, I(0)). We have a total of twenty seven observations (before lagging or differencing the data). Dods and Giles (1995) show that for samples of size 25, using the default method in the COINT command in the SHAZAM (1993) econometrics package to choose the augmentation level for the ADF test, is a preferred strategy in terms of minimizing the size-distortion of the test. We use this latter approach here, but the results are not sensitive to this decision. We see from Table 1 that we cannot reject the hypothesis of a unit root in (the logarithms of) each of the three output series. In the case of the cycles, the ADF tests which are of primary interest are those which *do not* include a drift or trend in the Dickey-Fuller regressions, as each of the purpose of including these terms is to allow for any deterministic trend in the series. We see, from the last column of Table 1, that the cycle components of (the logarithms of) measured, underground, and total real output appear to be stationary, regardless of the choice of smoothing constant when applying the HP filter to extract the trend from the data. Accordingly, conventional limit theorems apply when analyzing the cyclical data, and so asymptotic confidence intervals or p-values for the skewness measures in equations (2) and (3) can be constructed by using the associated standard errors in conjunction with the Standard Normal distribution.

Giles (1996a) discusses the issue of causality between measured and underground activity in New Zealand. He shows that these data are cointegrated and that there is clear evidence of Granger causality from the measured economy to the underground economy[7]. Cointegration and causality issues are not our real concern in the present paper, but they relate to the results in Table 2, where we show the dates for the turning points (peaks, "P", and troughs, "T") in the cyclical components of the various output series. These dates were obtained by using the "rule" outlined by Canova (1994), and used previously by Wecker (1979) and Zellner and Hong (1991), for example - a "trough" occurs where two consecutive declines in the cyclical component are followed by an increase. A "peak" is defined where two consecutive increases in the cyclical component are followed by a decline.

In Table 2 we see that the dates for the turning points in the cycles are quite robust with respect to the choice of filter for de-trending the data. This is helpful with respect to the asymmetry test results described below, especially in view of the relative subjectivity associated with the choice of the smoothing parameter when applying the HP filter. Focussing on the results for $\lambda = 100$, the cycle for the measured economy generally "leads" that for the underground economy by zero to two years, and this is consistent with the causality results noted above. As the only available data for underground output are on an annual basis, a more detailed analysis is precluded.

Table 3 presents the main results from our study. There we see the outcomes of the tests for asymmetry in the cycles for the measured, underground and total real output series over the period 1968 to 1994. From the two-sided p-values reported there (based on the assumption of asymptotic normality) it is clear that there is no evidence of significant "deepness" or "steepness" in any of the cycles, regardless of the choice of value for the smoothing parameter in the HP filter. This is quite consistent with the results of Sichel (1993) with respect to U.S. measured real GNP.

VI Concluding Remarks

In this study we have distinguished between conventional (measured) GDP, its "underground" counterpart (as constructed by Giles (1995)), and the sum of these two components. We have been unable to detect any evidence of asymmetry in the cyclical component of real GDP in New Zealand over the period 1968 to 1994. While our finding with respect to measured real aggregate output is consistent with other international evidence, this appears to be the first such investigation of the cyclical characteristics of output in the underground economy for any country. It would be interesting to undertake a corresponding investigation with respect to reported and "hidden" employment (were data on the latter available), as the cyclical component of the former of these variables generally has been found to exhibit asymmetries in some other countries.

The fact that outputs in the measured and underground economies have cyclical components which are both symmetric (rather than exhibiting different types of asymmetry, perhaps) has important policy implications. This is especially so when taken in conjunction with the evidence of Giles (1996a), and in section V above, that measured activity in New Zealand does *not* "lag" behind underground activity. Changes in fiscal or monetary policy whose timing and intensity are selected on the basis of an understanding of the measured and observed business cycle can be refined, if desired, so as not to conflict with desired impacts on the underground cycle. Similarly, specific policy changes (such as a change in the "tax-mix" as between personal direct tax and an indirect consumption tax) that may be designed to reduce the size of the underground economy, can be implemented in the light of their likely effect on measured (and hence total) real activity.

TABLE 1

Augmented Dickey-Fuller Unit Root Tests

Series		t_{dt}	t_d	t
Measured	Actual	-2.49	-1.57	4.70
	Cycle (λ = 10)	-2.58	-2.69*	-2.77*
	Cycle (λ = 100)	-1.99	-2.06	-2.12*
	Cycle (λ = 1600)	-2.34	-2.33	-2.37*
Underground	Actual	-2.87	-1.35	1.90
	Cycle (λ = 10)	-4.12*	-4.24*	-4.35*
	Cycle (λ = 100)	-3.11	-3.22*	-3.31*
	Cycle (λ = 1600)	-2.98	-3.03*	-3.11*
Total	Actual	-2.40	-1.41	4.37
	Cycle (λ = 10)	-2.45	-2.57	-2.65*
	Cycle (λ = 100)	-1.92	-1.99	-2.06*
	Cycle (λ = 1600)	-2.25	-2.50	-2.30*

Notes: "t_{dt}", "t_d" and "t" denote ADF t-statistics for the "drift and trend", "drift, no trend" and "no drift, no trend" cases.

"*" denotes significant at the 10% level, using the critical values of MacKinnon (1991).

The preferred augmentation level was zero in all cases, so T=26.

TABLE 2

Turning Point Dates for the Cycles
(Calendar Years)

Measured		**Underground**		**Total**	
T	**P**	**T**	**P**	**T**	**P**
λ = 10					
1972	1974	1971	1974	1972	1974
1978	1982	1979	1984	1978	1981
		1982		1983	
1986		1986		1986	
1991		1992		1991	
λ = 100					
	1974	1971	1974		1974
1978	1982	1979	1984	1978	1982
		1982			
		1986		1986	
1991		1992		1991	
λ = 1600					
	1975	1971	1974		1974
1978	1982	1979	1984	1978	1982
		1986		1986	
1991		1992		1991	

Note: "T" denotes "Trough"; "P" denotes "Peak".

TABLE 3

Tests for Asymmetry of the Cycles

λ	Measured			Underground			Total		
				Deepness					
	D(c)	**a.s.e.**	**p-value**	**D(c)**	**a.s.e.**	**p-value**	**D(c)**	**a.s.e.**	**p-value**
10	-0.07	0.56	0.90	0.56	0.49	0.27	0.10	0.55	0.85
100	0.29	0.55	0.53	0.49	0.50	0.98	0.32	0.52	0.54
1600	0.56	0.18	0.63	0.29	0.49	0.56	0.18	0.57	0.75
				Steepness					
	$S(\Delta c)$	**a.s.e.**	**p-value**	**$S(\Delta c)$**	**a.s.e.**	**p-value**	**$S(\Delta c)$**	**a.s.e.**	**p-value**
10	0.19	0.53	0.72	0.16	0.39	0.69	0.16	0.56	0.29
100	0.09	0.61	0.88	0.09	0.42	0.83	0.09	0.67	0.90
1600	-0.03	0.56	0.95	0.06	0.40	0.88	-0.03	0.61	0.96

Notes: "a.s.e." denotes "robust asymptotic standard error".

"D(c)" and "$S(\Delta c)$" are as defined in equations (2) and (3) respectively.

Footnotes

***** This paper stems from work that is being undertaken as part of a major study into various aspects of the New Zealand taxation system by the New Zealand Inland Revenue Department. I would like to thank Patrick Caragata of that Department for initiating and supporting my work on the underground economy in New Zealand, and for his numerous insightful suggestions. I am also grateful to Judith Giles for her own very helpful comments and suggestions on this work.

1. For example, see Sichel (1993, p.225) and Blatt (1980).

2. For an exception to the latter, see Granger and Lee (1989).

3. We use annual data in this paper, so there is no need to allow for seasonality in the series. Our analysis proceeds with the (natural) logarithms of the data, so effectively we are assuming a multiplicative decomposition of the series into its components.

4. We have done this with the AUTCOV option on the OLS command in the SHAZAM (1993) package to obtain the results below. The results are not sensitive to the choice of value chosen with this option.

5. Sichel does not use the BN filter in testing for "steepness".

6. The latent variable modelling in Giles (1995) uses calendar year data in view of the change in the timing of the financial year for Government accounts in New Zealand during the sample period.

7. He also finds that there is some mild evidence to suggest *bi-directional* causality between the two series.

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